AWARD NUMBER: W81XWH-12-1-0386

TITLE: A Model for Predicting Cognitive and Emotional Health from Structural and Functional Neurocircuitry Following Traumatic Brain Injury

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REPORT DATE: OCT 2018

TYPE OF REPORT: Annual Report

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

DISTRIBUTION STATEMENT: Approved for Public Release;
Distribution Unlimited

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REPORT DOCUMENTATION PAGE

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OMB No. 0704-0188

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1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
OCT 2018	Annual Report	15 SEP 2017 – 14 SEP 2018

4. TITLE AND SUBTITLE
A Model for Predicting Cognitive and Emotional Health from Structural and Functional Neurocircuitry Following Traumatic Brain Injury

5a. CONTRACT NUMBER
W81XWH-12-1-0386

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

University of Arizona
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Tucson, AZ 85719-4824

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for Public Release; Distribution Unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Mild traumatic brain injury (mTBI) is one of the major health problems facing military servicemembers returning from deployments. White matter axonal damage, as measured by neuroimaging techniques like Diffusion Weighted Imaging (DWI), is one of the hypothesized mechanisms contributing to the cognitive and affective sequalae of mTBI. Presently, many of the findings in the literature examining the association between DWI and neuropsychological outcome are contradictory, possibly due to differences in stage of recovery at the time of assessment. This study will address this problem by collecting measures of white matter integrity and concomitant neuropsychological status at five time points in the first year following an mTBI. During the first year, study preparations, including ethical approval, hiring and training of new staff, purchasing of equipment and materials, and validation of neuroimaging protocols, were completed ahead of schedule. During the past year, we have collected usable data from a total of 8 participants. These data have been cleaned and preliminary analyses suggest that we are able to identify meaningful trends in the data, although the sample is still far too small to make valid conclusions.

15. SUBJECT TERMS

TBI, traumatic brain injury, concussion, DWI, Diffusion Weighted Imaging, white matter, brain imaging, neuropsychological performance, neurocognitive performance, structural connectivity

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			USAMRMC
Unclassified	Unclassified	Unclassified	Unclassified	354	19b. TELEPHONE NUMBER *(include area code)*

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1. INTRODUCTION:

Over the past 18 years, military personnel have sustained over 383,000 traumatic brain injuries (TBIs) (DVBIC Report, June 21, 2018). Of these injuries, the vast majority, exceeding 82% of all TBIs, are in the mild category. In addition to the impact on military readiness, mild traumatic brain injury (mTBI) represents a major health concern and economic burden in the United States (Humphreys, Wood, Phillips, & Macey, 2013). While most individuals who sustain an mTBI will recover fully within a matter of days (McCrea et al., 2003), a significant proportion of individuals with mild TBI will experience a prolonged recovery with persistent post-concussive symptoms, and it is yet unclear why some individuals will show a good injury outcome, whereas other will not (Bogdanova & Verfaellie, 2012; Lange et al., 2012; Lange, Brickell, Ivins, Vanderploeg, & French, 2013; Leong, Mazlan, Abd Rahim, & Ganesan, 2013). Structural damage to white matter axonal tracts has been suggested to underlie many of these persistent behavioral changes (Arenth, Russell, Scanlon, Kessler, & Ricker, 2013; Jorge et al., 2012; Morey et al., 2012; Spitz, Maller, O'Sullivan, & Ponsford, 2013; Yeh et al., 2013). Yet due to differences in brain imaging methods, neuropsychological testing approaches, and sample characteristics, this has not been consistently demonstrated at different recovery stages. Furthermore, the relationship between structural connectivity, functional connectivity and neuropsychological performance remains unclear. The present study aims to systematically assess structural connectivity, functional connectivity and neuropsychological functioning at five recovery stages (i.e., two weeks, one month, three months, six months and 12 months) following mild TBI relative to healthy controls. We hypothesize that structural white matter tract disintegrity will underlie abnormalities in functional connectivity, neurocognitive performance and post-concussion symptom severity, but that these metrics will vary with time since injury. The primary aim of the proposed study is therefore to investigate whether measures of white matter disintegrity following mild TBI would explain abnormalities in functional connectivity of the brain, cognition and emotional disturbance, and whether white matter integrity (or lack thereof) could serve as a reliable biomarker of mild TBI. This will allow conclusions on the utility of measures of white matter integrity in the diagnosis of mild TBI. As the study incorporates five time points of measurement to represent different recovery stages of mild TBI, this will allow conclusions on the natural recovery course of mild TBI and the utility of white matter integrity measures in the prediction of injury outcome. In brief, we aim to collect data from 180 participants, including 30 healthy controls and five separate samples of 30 participants at various time points following injury, ranging from 2 weeks to one-year post-concussion (see Figure below). During, participants will attend a single assessment session comprising a series of neuroimaging scans, including diffusion tensor imaging (DTI), structural volumetric scan, and resting state functional connectivity (rsFC). Additionally, participants will also undergo a comprehensive neuropsychological assessment battery. We will analyze differences in structural and functional connectivity across these various stages of recovery and associated differences in neurocognitive performance and symptom expression.

Basic Study Design. A total of 180 participants will be assessed. Six (6) groups of 30 participants with mTBI will be scanned at various time points ranging from 2-weeks to 12-months post-injury. We will also collect diffusion weighted scans from 30 healthy controls (HC).

2. KEYWORDS:

TBI, traumatic brain injury, mTBI, mild traumatic brain injury, concussion, DWI, Diffusion Weighted Imaging, white matter, brain imaging, neuropsychological performance, neurocognitive performance, structural connectivity, brain injury, head injury

3. ACCOMPLISHMENTS:

Major Task 1: Study Preparation, Staff Hiring, and Materials Acquisition - Ongoing

- Sufficient study materials and equipment remain available to gather data for the remainder of the project period.
- All testing protocols remain in place and all staff members involved in the study continue to receive proper training to ensure protocols are adhered to throughout the duration of the study.
- As in previous years, we continue to have a normal rate of staff turnover. New technicians continue to be trained to replace those who have left.

Major Task 2: Human Subjects Approval – Complete

- The project protocol was approved by the University of Arizona Institutional Review Board and the U.S. Army Human Research Protections Office (HRPO) and continues to remain open throughout the course of data collection. Amendments are submitted as needed and all annual continuing review reports continue to be submitted to the UA IRB Office and HRPO prior to their annual due dates.

Major Task 3: Advertisement and Subject Recruitment – Ongoing

- As in previous years, recruitment for the study continues at a modest but fairly consistent pace, with the exception that recruitment slowed this past year during a nearly 6-month period when the MRI scanner was deactivated and moved across campus to a new location. Recruitment efforts have increased substantially since the scanner was brought back on line earlier this year.
- One of our major sources of recruitment is through local flyering. Flyers for the study are placed throughout local businesses, university and college campuses, federal buildings, clinics, churches, and social media pages. We have greatly expanded our recruitment 'net' to advertising at businesses all over the Tucson area, while still utilizing the University of Arizona campus, and 'word of mouth,' as a major recruitment source.
- Recruitment via approved University of Arizona Listservs (email lists) has led to an increased number of screened people, and has made the screening process more streamlined.

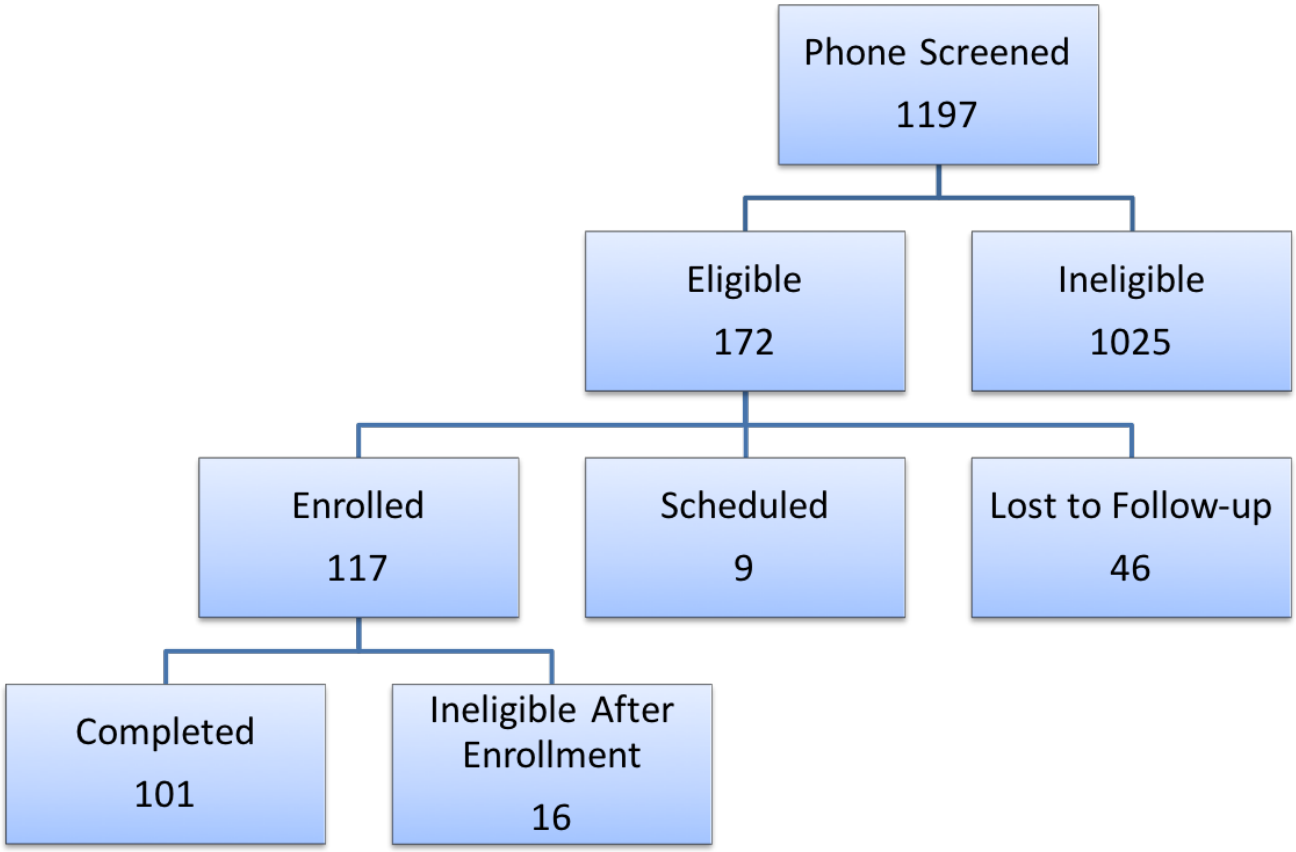
- This past year, the University Hospital switched from using the EPIC electronic medical records system to the Cerner system. This new system enables us to recruit participants recently admitted to the emergency room at the Banner/University of Arizona Medical Center in Tucson. This database has also made obtaining head injury documentation more streamlined, as all individuals with a diagnosed concussion in the database have medical documentation.
- The Research Assistant Program is a volunteer program that operates in the Banner Emergency Department. Volunteers get experience talking to patients and their families by explaining various research studies. If the patient or family member is interested the volunteer obtains basic personal information and consent to contact the participant at a later date. Our project has been a part of this study for the last two months and we have seen an increase in potentially eligible participants due to this recruitment effort.
- In August 2018 we began to recruit subjects through the University of Arizona, Psychology 101 student research pool. As of 15 SEPT 2018, 61 potential subjects completed the screening form, 38 were deemed eligible, 1 was scheduled, and 36 are pending follow-up.
- Use of paid advertisements over the reporting period included local newspapers, such as Tucson Weekly and the Daily Wildcat, and radio stations in Tucson and Phoenix. Additionally, during the last year we utilized a paid recruitment service for clinical trials called "Studykik."
- A minor change in the protocol was made to remove handedness as an exclusionary criterion in July 2018. Since the protocol changed, six additional people were eligible for the study who would have previously been excluded.
- A total of 150 individuals were phone screened or completed on-line screening questionnaires during this annual reporting period, resulting in 27 eligible mTBI and healthy control participants.

Major Task 4: Data Collection – Ongoing

- As mentioned in previous reports, the neuroimaging scanner was deactivated during a four-month relocation to a new building, which resulted in an unavoidable interruption of all data collection from mid-December of 2017 until March of 2018, ultimately resulting in nearly a 6-month overall disruption in data collection efforts once troubleshooting, recruitment and scheduling issues are considered. This relocation of the scanner was initiated by the University administration and was beyond our control. However, the scanner was back up and fully functional on March 5th, and, as such, we have been actively recruiting and running participants again. We completed a post-move validation scan on March 13th, 2018 to assure that the move did not cause any changes to our parameters or the data we collect.
- Data collection for the mTBI and healthy control groups has continued with good success over this past year. In this reporting year, we have enrolled a total of 9 participants. Of those enrolled, 8 completed the study and 1 were deemed ineligible upon further evaluation.
- MTBI Sample: Of the 17 participants deemed eligible after phone screenings during this past year:
    - 5 were enrolled (4 completed the study, and 1 was ineligible after enrollment).
    - 8 are scheduled for data collection next quarter.
    - 4 were lost to follow-up.

- Healthy Control Sample: Of the 10 healthy control individuals that were deemed eligible after phone screenings during this past year:
    - 4 were enrolled (4 completed the study).
    - 1 is scheduled for data collection next quarter.
    - 5 were lost to follow-up.

- In total, 72 people completed the study since data collection started at the University of Arizona on April 15th, 2017. Each of the study groups are being populated fairly evenly. At present these groups include:
    - 24 healthy controls
    - 7 mTBI at 2-weeks post-injury
    - 12 mTBI at 1-month post-injury
    - 7 mTBI at 3-month post-injury
    - 9 mTBI at 6-month post-injury
    - 13 mTBI at 1-year post-injury



Consort diagram of cumulative participant numbers for this study (including McLean and Arizona sites). Lost to follow-up refers to individuals who could not be reached or who were no longer interested in participating.

- As of the date of this report, no negative outcomes have been reported by any of the study participants.
- Behavioral data are regularly entered into the REDCap database by two independent research assistants. This enables the study coordinator to identify and correct any potential data entry errors.
- Neuroimaging data are uploaded to laboratory computers, and all identifying information is removed (de-identified) the same day of scanning. Diffusion tensor imaging (DTI) data

are pre-processed within 4 business days.

- Before data collection started at the University of Arizona on April 15th, 2017, 31 participants were run and had data collected from them as part of the data set for the study. These participants were grouped in the following way:
    - 3 healthy controls
    - 2 mTBI at 2-weeks post-injury
    - 6 mTBI at 1-month post-injury
    - 5 mTBI at 3-month post-injury
    - 10 mTBI at 6-month post-injury
    - 3 mTBI at 12-months post-injury
    - 2 mTBI were deemed ineligible after enrollment

Major Task 5: Quality Control Checks – Ongoing

- We maintain a high level of quality control checks to ensure that the data are being collected correctly.
- Each neuroimaging scan is visually checked for movement and artifacts during data acquisition and throughout the pre-processing pipeline. This ensures proper scan sequences are selected and allows us to track corrections. Neuroimaging data are also checked for correct acquisition parameters during acquisition and during the pre-processing pipeline. Any deviations from standard protocol are noted in writing. Data collected with parameters that deviate from standard are labeled and segregated for further processing.
- We continue to note any details found in head injury documentation before running subjects to confirm date of injury during study visit and avoid injury date discrepancies.
- Behavioral data are quality checked upon entry. Two independent scorers check all behavioral data for completeness and correctness before entering into the database. After scoring is validated, data are entered twice into REDCap by independent research assistants and then cross-validated for correctness in order to avoid error.
- We also continue to focus on maintaining high inter-rater reliability for our test administrators. Focused staff training was provided by a postdoctoral researcher and clinically licensed Speech-Language Pathologist to ensure reliability and validity of data collection.

Major Task 6: Preliminary Analysis – Ongoing

- Although the final data set is still incomplete, during the past year, we have performed several preliminary analyses which allow us to ensure data is being collected correctly and to report emerging data to the communities affected by mTBI. We summarize the findings from these preliminary analyses below:

  <u>Cortical Measures Across Time Since Injury</u>

  Previous investigations have extensively studied the functional and structural recovery of the brain following mild traumatic brain injury (mTBI). Despite prior work, the field still lacks a consistent larger picture of brain recovery over a longer time-period. The primary goal of this study was to better understand the complex brain mechanisms that unfold over a time-period of 18 months following mTBI. Therefore, we sub-categorized mTBI participants from the present study, as well as another sample of mTBI patients with injuries extending out to 18

months into three groups depending on their time since injury (i.e., at time-point (TP) 1: 0-3 months, TP2: 3-6 months and TP3: 6-18 months) followed by an estimation and comparison of cortical measures within the three groups as well as compared to healthy controls (HCs).

Cortical thickness (CT): We identified several brain areas, which showed significantly thicker cortex in mTBI individuals (at TP 1 and 2) compared to HCs. We also found that the CT within two areas – the right post central gyrus (R.PostCG) and the left rostral middle frontal gyrus (L.RMFG) – showed significant differences in CT between HCs and mTBI individuals at TP2, and was negatively associated with attention abilities (R.PostCG: r = -0.44, p = 0.03 and L.RMFG: r = -0.41, p = 0.05). These findings are summarized in **Figure 1A**.

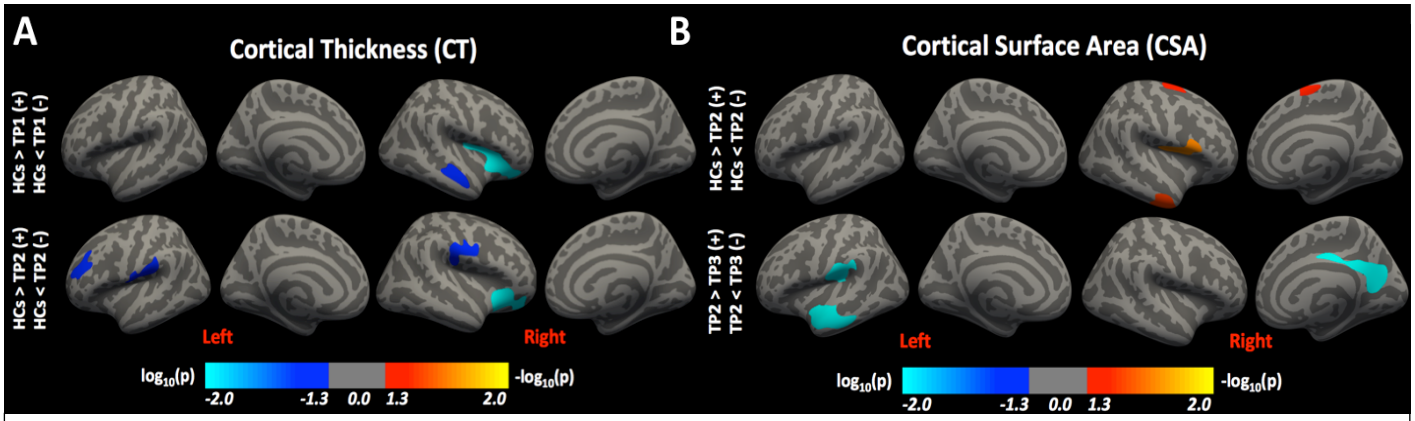


Figure 1. Comparison of cortical thickness (A) and cortical surface area (B) between HCs and individuals with mTBI at different time-points post-injury.

Cortical surface area (CSA): We found that at TP2, individuals with mTBI had significantly lower CSA within several areas as compared to HCs. However, at TP3, mTBI individuals showed greater surface area within several regions as compared to mTBI individuals at TP2. These findings are summarized in **Figure 1B.**

Summary: Overall, our findings suggest that the differences in CT and associated attention abilities may be prominent during the acute stage of mTBI, however, differences in CSA may indicate compensatory structural recovery during the later stages of mTBI. These findings were recently published in the peer-reviewed journal, *Human Brain Mapping (2018).*

<u>Post-Concussion Aggression and Reduced White Matter Integrity</u>

One aim of this project is to identify the association between white matter abnormalities and emotional functioning and behavioral control following mTBI. Upwards of 40% of individuals with mTBI report high levels of aggression, however the extent to which white matter abnormalities are associated with aggression in mTBI remains unknown. These preliminary analyses focused on aggression in individuals 6-months to 12-months post-injury (i.e. *chronic* mTBI).

Aggression: We found elevated aggression in the mTBI group compared to healthy controls. These findings suggest the presence of persistent and potentially long-lasting post-concussion symptoms associated with brain injury. Furthermore, we found that males with mTBI

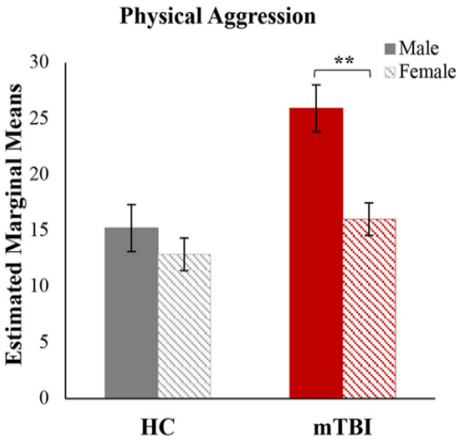


Figure 2. Significantly elevated physical aggression in males with mTBI.

reported significantly higher levels of physical aggression compared to females with mTBI on the Buss-Perry Aggression Questionnaire (see **Figure 2**). One interpretation of these findings is that mTBI exacerbates a pre-existing gender difference, leaving males particularly prone to dysregulated emotional responses.

White Matter: With regard to microstructural differences, we found significantly reduced white matter integrity in the corpus callosum of individuals with mTBI, compared to healthy controls. Furthermore, elevated aggression was associated with reduced integrity of the corpus callosum (see **Figure 3**).

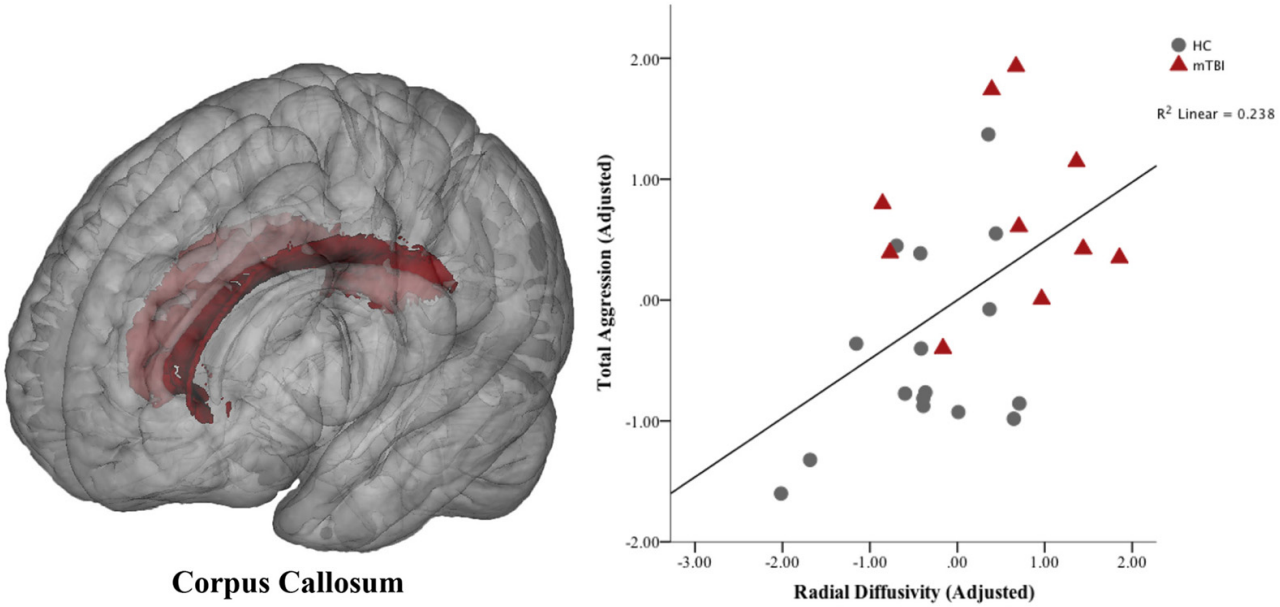


Figure 3. Association between aggression and white matter in the corpus callosum. Voxels of the corpus callosum included in the analysis are shown in red overlaid on a standard brain. A significant partial correlation (controlling for age, gender, and depression) was found between total aggression on the Buss-Perry Aggression Questionnaire and radial diffusivity (RD) in the corpus callosum ($p < .05$; FDR-corrected). HC, healthy controls; mTBI, mild traumatic brain injury.

Summary: Overall, we provide preliminary findings regarding the possible loci of persistent post-concussion symptoms and demonstrate a need for therapeutic interventions aimed at effectively managing affective states following mTBI. These findings were recently published in the peer-reviewed journal, *Frontiers in Behavioral Neuroscience (2018).*

<u>Functional Connectivity as a Biomarker of Aggression in mTBI</u>

In addition to disrupted structural connectivity, previous research has reported disrupted functional connectivity within the default mode network (DMN). However, the majority of research focuses on the acute and subacute recovery stages (i.e. less than 3-months post-injury). The goal of this preliminary study was to explore the association between DMN function and aggression in individuals in the chronic stage of recovery (i.e. at least 6-months post-injury). For this preliminary analysis, we analyzed a subset of the data, including 17 individuals with mTBI and 17 healthy controls completed the Buss-Perry Aggression Questionnaire and a resting-state functional magnetic resonance imaging scan.

Network Connectivity: Functional connectivity strength between each of the nine regions of the DMN was measured. We found similar DMN connectivity strength in those with mTBI compared to healthy controls. The metrices in **Figure 4** show within-network DMN connectivity between seed and target regions in healthy controls and individuals with mTBI, separately.

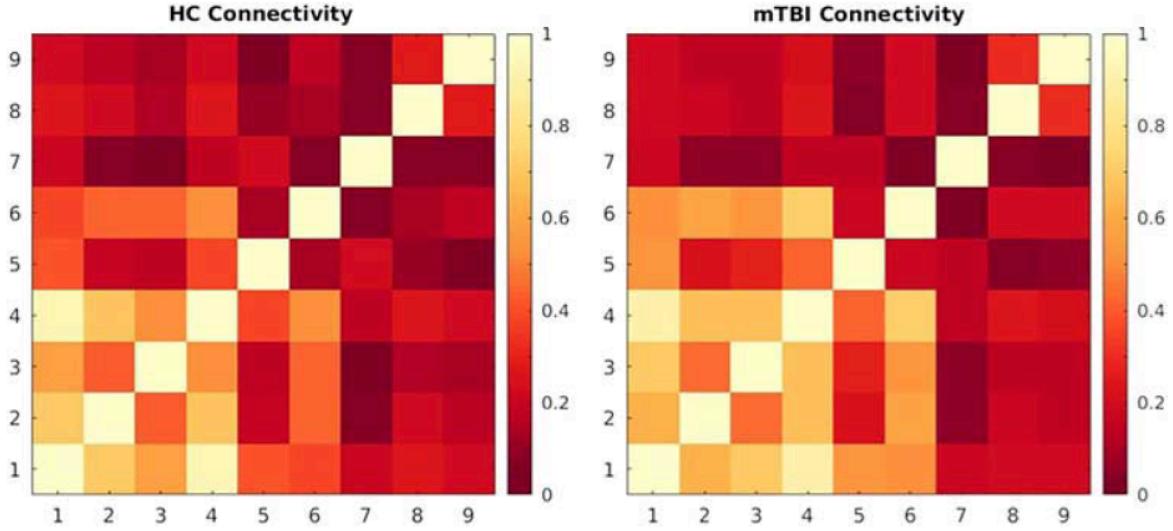


Figure 4. Functional connectivity within regions of the default mode network for healthy controls and individuals with mild traumatic brain injury.

Aggression: We found significant group differences in the association between DMN connectivity and aggression. Connectivity between aggression and the right hippocampus (rHPC) to midcingulate cortex (MCC), as well as the rHPC to medial prefontal cortex (mPFC)was significantly greater in those with mTBI relative to healthy controls (see **Figure 5**).

Summary: Our preliminary findings suggest that mTBI-related aggression may be associated with altered DMN connectivity, a large-scale intrinsic neural network. These findings were recently published in the peer-reviewed journal, *NeuroReport (2018).*

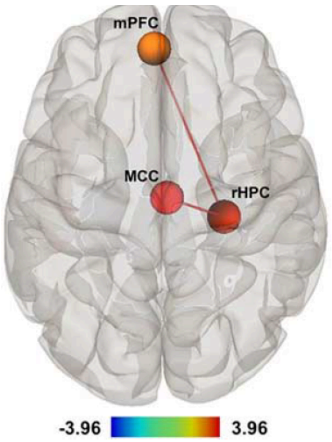


Figure 5. Significant between-group differences in DMN connectivity associated with aggression. Contrast mTBI>HC.

<u>Learning and Memory Abilities in Acute and Chronic Recovery Stages</u>

Impaired cognitive functioning is frequently reported after mTBI. However, little is known about neurocognitive performance throughout various stages of the recovery processes. The cross-sectional design of the study enables us to compare performance in initial and later stages of recovery following mTBI. These preliminary analyses were conducted to assess verbal recall in acute and chronic stages of mTBI recovery, relative to healthy controls. Serial and semantic clustering are two types of self-initiated recall strategies that can improve performance on verbal recall tasks. The California Verbal Learning Test (CVLT) were used to assess verbal recall strategies in those with mTBI. Serial clustering refers to the tendency to recall items that were located together in the same order they were learned from a list, while semantic clustering refers to the tendency to recall items together based on their conceptual

associations (e.g., fruits, furniture, etc.), regardless of serial position in the list.

Serial Clustering: We found significantly lower scores on serial clustering in the acute mTBI group, compared to the healthy control and the chronic mTBI groups. This finding suggests the acute mTBI group was unable to recall words in the order in which the words were presented. These findings are summarized in **Figure 6A**. Furthermore, we calculated the percentage of correct words recalled from the beginning, middle, and end of the list. In our preliminary analyses, we found that the acute mTBI group recalled significantly more words from the middle of the list compared to the chronic mTBI group.

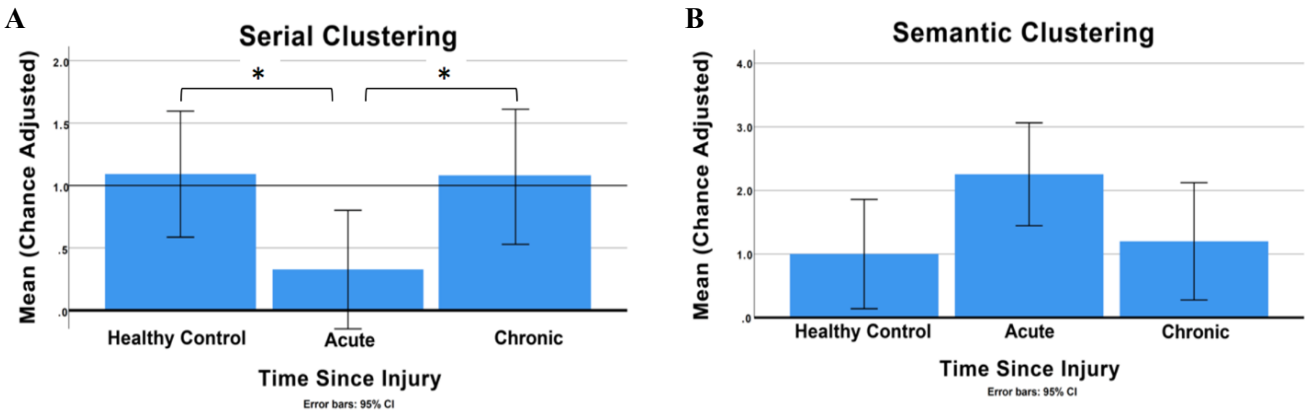


Figure 6. Raw scores on serial (A) and semantic (B) clustering for healthy control, acute mTBI, and chronic

Semantic Clustering: Through these preliminary analyses, we observed a tendency for those in the acute mTBI group to rely more heavily on semantic clustering (see **Figure 6B**). These preliminary findings suggest that individuals in the acute recovery stage employ a different self-initiated recall strategy compared to healthy controls and individuals in the chronic recovery stage.

Neural Correlates: The neural mechanisms of serial and semantic clustering were investigated in a subset of the participants included in the aforementioned analyses. The superior longitudinal fasciculus (SLF) and uncinate fasciculus (UF) were targeted and separate stepwise linear regressions were calculated to determine the relationship between white matter integrity and time since injury on the use of serial and semantic clustering. Serial clustering was associated with reduced white matter integrity in the left SLF, and increased integrity in the right UF, whereas semantic clustering was associated with increased integrity in the left UF.

Summary: Overall, these preliminary findings suggest individuals in the acute and chronic recovery stages employ different verbal recall strategies. Furthermore, these strategies appear to rely on different pathways in the brain, suggesting the potential use of compensatory mechanisms during learning and memory.

Information Processing and Attention in mTBI

A primary aim of the ongoing study is to determine whether cognitive deficits are present throughout various stages of recovery. We used the Psychomotor Vigilance Test (PVT) to measure information processing speed and sustained attention of individuals with mTBI in the acute and chronic stages of recovery. We predicted reduced processing speed and attention in adults with mTBI compared to healthy controls. For those with mTBI, we hypothesized that adults in the acute stage of recovery (i.e. 3-months or less post-injury) would exhibit greater deficits in processing speed and sustained attention, compared to adults in the chronic stage

of recovery (i.e., 6-months or more post-injury).

Results: In our preliminary analyses, there were a significant effect of group on reaction time ($F(2,27) = 4.99$, $p = .01$, $\eta^2 = .27$). Post hoc analyses revealed significantly longer reaction times in the chronic mTBI group (M = 323.91; SD = 63.02) compared to healthy controls (M = 280.20; SD = 43.54) (see **Figure 7**). All groups performed similarly on the measure of attention.

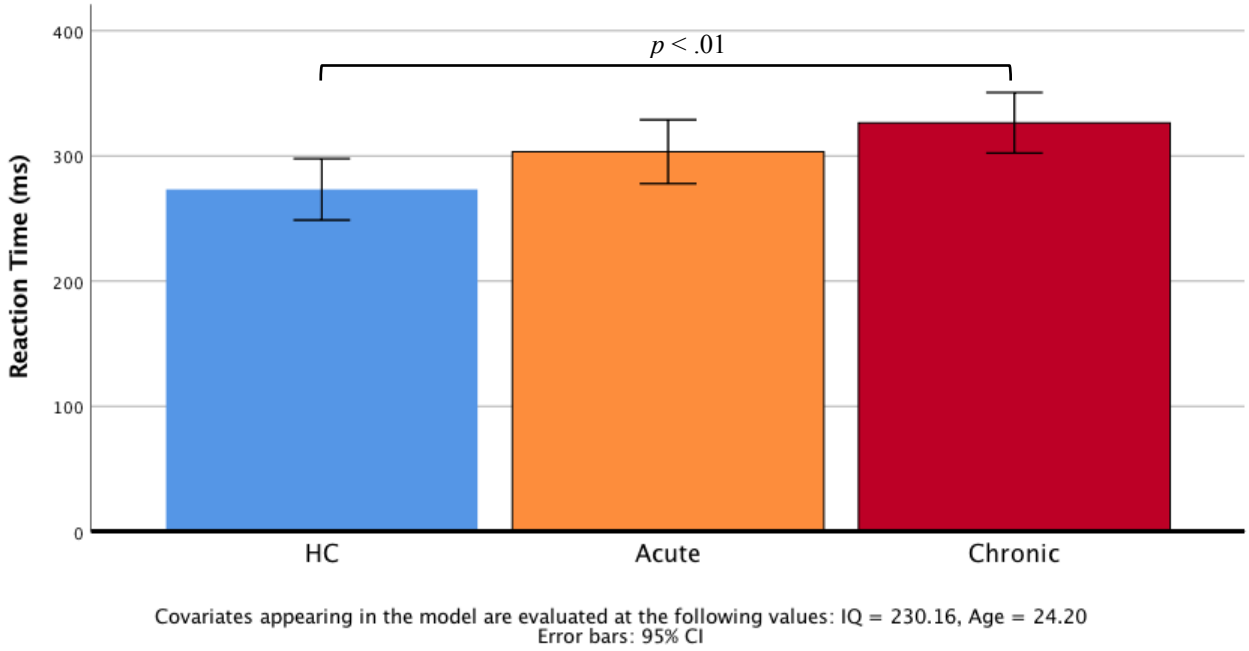


Figure 7. Reaction time on the Psychomotor Vigilance Test (PVT) for healthy control (HC), acute mTBI, and chronic mTBI groups. Significantly longer reaction times were observed in the chronic mTBI group compared to healthy controls (*$p < .01$).

Summary: Overall, we found that adults with mTBI, who are in the chronic stage of recovery, displayed reduced processing speed, but intact sustained attention. Contrary to our hypotheses, individuals with mTBI who are in the acute stage of recovery did not exhibit deficits in processing speed or sustained attention, responding similar to healthy controls. One possible explanation for the observed discrepancy between acute and chronic mTBI groups is that adults who are in the chronic phase of recovery may be more likely to participate in research studies if they continue to experience mTBI-related symptoms, while those in the acute mTBI group may be more likely to participate regardless of symptomology. Another interpretation of the current findings is that recovery from mTBI may represent a dynamic process in which symptoms present during the acute phase may not be present in the chronic phase and vice versa. Ongoing research is necessary to identify potential underlying neural mechanisms associated with the onset and duration of injury-related deficits. Furthermore, the manifestation of cognitive deficits at different times post-injury suggests that individuals may benefit from clinical support and/or intervention at different times following an mTBI.

Impact of mTBI on Lexical-Semantic Retrieval

The aforementioned preliminary findings, in conjunction with previous studies, provide convergent evidence that individuals with mTBI suffer a range of cognitive deficits. However, the extent to which mTBI-related deficits impact lexical-semantic retrieval has yet to be fully explored. Therefore, we aimed to (1) identify verbal fluency skills in mTBI compared to healthy

controls and (2) determine lexical-semantic and/or executive function factors that best predict verbal fluency in those with mTBI.

Verbal Fluency: The Delis-Kaplan Executive Functions System (D-KEFS) was used to measure verbal fluency in a subset of the current data, including 20 healthy controls and 33 individuals with mTBI (16 in the acute phase and 17 in the chronic phase). Participants were required to provide as many words as possible in 60 seconds, when given a letter (e.g. F, A, and S). Primary measures included clustering (the use of semantic categories to generate words) and switching (changing from one semantic category to another). In our preliminary results, we found a significantly reduced number of unique clusters in the chronic mTBI group compared to healthy controls. These results are shown in **Figure 8A**.

Predictors of Lexical-Semantic Retrieval: In the mTBI, we found that digit span, a measure of working memory, significantly predicted switching, whereas number of reported mTBIs, significantly predicted clustering. These results are shown below in **Figure 8B**.

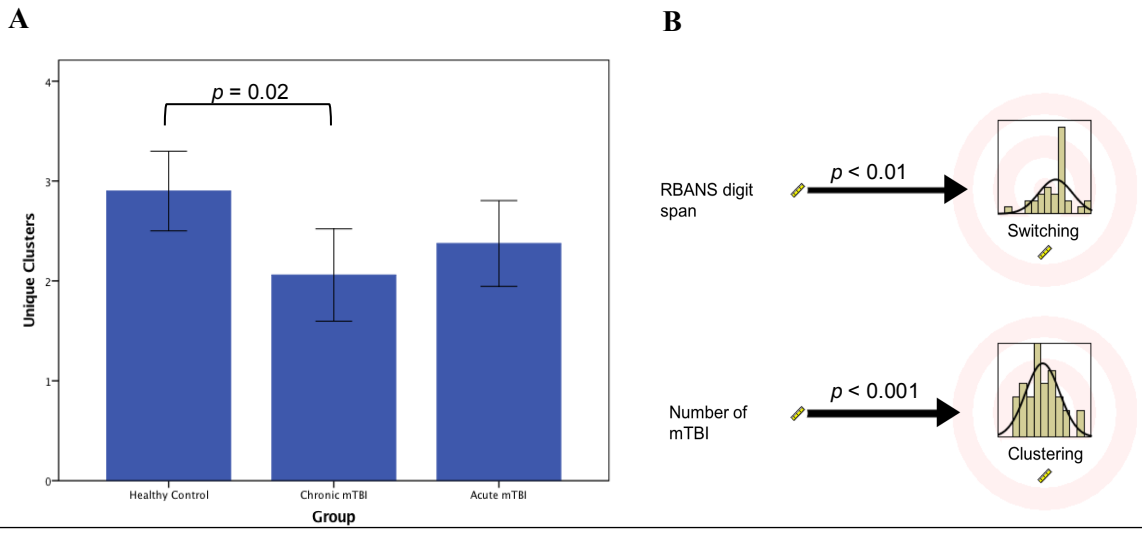


Figure 8. Number of unique cluster type generated on verbal fluency task for healthy control, chronic mTBI (6-12months post-injury), and acute mTBI (2-4weeks post-injury) (A). Significant positive predictors of switching and clustering ability for the mTBI groups (B).

Summary: Findings from preliminary analyses suggest individuals with mTBI exhibit an overreliance on a single clustering strategy to maintain sufficient verbal fluency performance. The association between mTBIs and clustering suggests that those with mTBI may struggle to access lexical-semantic knowledge within categories, resulting in more frequent category switches. Our preliminary further suggest the use of effective retrieval strategies by those with mTBI.

Major Task 7: Extensive Data Analysis – Pending

- Extensive data analysis will be conducted upon completion of data collection.

Major Task 8: Manuscript Preparation and Submission for Publication – Ongoing

- Manuscript preparation is ongoing for the preliminary findings regarding learning and memory in acute and chronic stages of mTBI recovery.

What opportunities for training and professional development have the project provided?

While the primary goal of this project is not to provide training and professional development, many such experiences have occurred for our team members. The present project has supported:

1 member of our lab presented research findings and attended lectures at the Anxiety and Depression Association of America, Washington DC, April 5-8, 2018.

1 member of our lab presented research findings and attended lectures at the Big Sky Athletic Training and Sports Medicine Conference, Big Sky, MT, February 4-7, 2018.

2 members of our lab presented research findings and attended lectures at International Neuropsychological Society, Washington, DC, February 14-17, 2018.

1 member of our lab attended a grant writing workshop for early-career researchers at the 16th Annual Lessons for Success, Rockville, MD, April 23-25, 2018.

1 member of our lab presented research findings and attended lectures at the Society for Biological Psychiatry, New York, NY, May 10-12, 2018.

1 member of our lab presented research findings and attended lectures at the Annual Meeting of The Associated Professional Sleep Societies, Baltimore, MD, June 3-6, 2018.

1 member of our lab presented research findings and attended lectures at the Organization for Human Brain Mapping, Singapore, Malaysia, June, 17-21, 2018

2 members of our lab presented research findings and attended lectures at the Military Health Systems Research Symposium, Orlando, FL, August 20-23, 2018.

Multiple members of our lab have attended regular training in MRI analysis methods and safety as part of an ongoing training series offered at the University of Arizona.

All members of our lab receive regular one-on-one instruction and supervision in the administration and scoring of neuro-psychological assessments, psycho-diagnostic testing, electrode placement, and patient interviewing to ensure best data collection practices.

5 college undergraduate students obtained training in research methods during a summer training program in our lab this year, 4 who were sponsored by the University of Arizona and the other by the National Institutes of Health MARC Undergraduate Student Training in Academic Research (U-STAR) Award.

1 undergraduate student was supervised for her Senior Honors Thesis in our lab this year.

1 graduate student was supervised for his Master's Thesis in our lab this year.

Over 10 members of our lab have undergone regular in-house training in the use of various brain-imaging software, including SPM12, Matlab, FSL, Freesurfer, TracVis, and MRIcron.

How were the results disseminated to communities of interest?

Results were disseminated to communities of interest through presentations at research meetings, journal articles, community forums and tabling events, and poster presentations. In particular, we

have given poster presentations on data from this study at the UofA Summer Symposium, the International Neuropsychological Society Annual Meeting, the Society of Biological Psychiatry meeting, the SLEEP meeting, the American Speech-Language Hearing Association (ASHA) meeting, and the Military Health Systems Research Symposium in recent years. The poster presentation at the UofA Summer Symposium allowed results to be disseminated to the broader community about recent findings in changes in semantic and serial cognitive abilities in the mTBI population between acute and chronic phases. Several peer-reviewed publications have recently led to widespread dissemination of the findings to the larger scientific community.

What do you plan to do during the next reporting period to accomplish the goals and objectives?

We plan to expand upon our existing recruitment efforts, utilizing market research on methods that we know are effective and increase the use of paid advertisements on the radio, in movie theaters, through community events, collaboration with emergency care and medical specialists and increasing our online presence. We hope to establish closer contacts with military populations in Arizona in order to expand recruitment to more relevant populations.

4. IMPACT:

What was the impact on the development of the principal discipline(s) of the project?

We expect that disseminated findings through publications and presentations have begun to significantly change our understanding of mTBI and the dynamic changes it may introduce to cortical morphology, structural integrity, and functional connectivity, as well as deficits in emotional regulation and cognitive processing over the time course of recovery. Through our research, there is growing awareness that mTBI results in *dynamic* deficits that change over the course of time following the injury.

What was the impact on other disciplines?

A subset of abstracts from our preliminary findings over the past year were submitted for presentation at American Speech-Language Hearing Association (ASHA). Our results on reduced information processing speed as a dynamic deficit across recovery stages received notoriety from the ASHA review board, expanding the impact of research to clinicians and researchers in the field of Speech, Language, and Hearing Sciences.

What was the impact on technology transfer?

Nothing to report.

What was the impact on society beyond science and technology?

This investigation has begun to identify structural and function biomarkers of mTBI and the significant relationship to emotional, cognitive, and behavioral outcomes following mTBI. Moving forward, these findings have the potential to complement and possibly replace relatively unreliable clinical markers of mTBI. We expect that findings from this study will facilitate the diagnosis of mTBI and help to identify individuals with mTBI who might be at risk for prolonged recovery and persistent symptoms and reduce the persistence of cognitive deficits, increased aggression and negative social and behavioral side effects.

5. CHANGES/PROBLEM:

Changes in approach and reasons for change
On July 12th, 2018, a minor change was made to remove handedness from the list of exclusionary criteria. The protocol now allows for the recruitment, and subsequent enrollment of left-handed participants. This change is minor and presents no risk to participants, but may increase the rate of recruitment for the study and allow the findings to generalize to a larger group of individuals with mTBI.

Actual or anticipated problems or delays and actions or plans to resolve them
No problems are anticipated at this time.

Changes that had a significant impact on expenditures
Nothing to report.

Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents
Nothing to report.

6. PRODUCTS:
Publications, conference papers, and presentations

Journal publications.

Bajaj, S., Dailey, N.S., Rosso, I., Rauch, S., & Killgore, W.D.S. (2018). Time-dependent differences in cortical measures and their associations with behavioral measures following mild traumatic brain injury. *Human Brain Mapping.* PMID:29359498

Dailey, N.S., Smith, R., Vanuk, J.R., Raikes, A.C. & Killgore, W.D.S. (in press, 2018). Resting-State Functional Connectivity as a Biomarker of Aggression in Mild Traumatic Brain Injury. *NeuroReport*, DOI: 10.1097/WNR.0000000000001127

Dailey, N.S., Smith, R., Bajaj, S., Alkozei, A., Gottschlich, M.K., Raikes, A.C., Satterfield, B.C., & Killgore, W. D. S. (2018). White matter integrity is associated with elevated aggression in mild traumatic brain injury: A DTI study. *Frontiers in Behavioral Neuroscience,* 12, DOI: 10.3389/fnbeh.2018.00118

Raikes, A.C., Bajaj, S., Dailey, N.S., Smith, R., Alkozei, A., Satterfield. B.C., & Killgore, W.D.S. (2018). Diffusion Tensor Imaging (DTI) Correlates of Self-Reported Sleep Quality and Depression Following Mild Traumatic Brain Injury. *Frontiers in Neurotrauma,* 9, DOI: 10.3389/fneur.2018.00468

Books or other non-periodical, one-time publications

Klimova, A, Singh, P, & Killgore WDS. White matter abnormalities in MS: Advances in diffusion tensor imaging/tractography. In Watson, RR & Killgore, WD (Eds), Nutrition and Lifestyle in Neurological Autoimmune Diseases (2017), pp. 21-28.

Other publications, conference papers, and presentations.

2017

Dailey, N.S., Bajaj, S., Alkozei, A., & Killgore, W.D.S. (2017, November). *Neural Correlates of Aggression during Chronic and Post-Acute Stages of Recover from Mild Traumatic Brain Injury.* Poster presentation at Junior Investigator Poster Forum, College of Medicine, University of Arizona.

Raikes, A. C., Dailey, N. S., Bajaj, S., & Killgore, W. D. S. (2017, November). *White Matter Structure Changes Associated with Depressive Symptoms Following Recent Mild Traumatic Brain Injury*. Poster submitted for presentation at the Anxiety and Depression Association of America, Washington DC.

Singh, A., Thurston, M.D., Gottschlich, M.K., Miller, M.A., & Killgore, W.D.S. (2017, November). *Trait Anxiety Predicts Hostile Tendencies in Post-Traumatic Brain Injury*. Poster submitted for presentation at the Anxiety and Depression Association of America, Washington, DC.

2018

Dailey, N.S., Bajaj, S., Alkozei, A., Smith, R., Knight, S.A., & Killgore, W.D.S. (2018, February). *Neural Correlates of Aggression in the Chronic and Post-acute States of Recovery from Mild Traumatic Brain Injury: A DTI Study*. Poster presented at International Neuropsychological Society, Washington, DC.

Dailey, N.S., Raikes, A.C., Smith, R., Alkozei, A., & Killgore, W.D.S. (2018, February). *The Executive Control Network after mild traumatic brain injury: Associations between functional connectivity and aggression*. Abstract presented at Big Sky Athletic Training Sports Medicine Conference, Big Sky, MT.

Dailey, N.S., Smith, R., Satterfield, B.C., Raikes, A.C., & Killgore, W.D. S. (2018, April). *Verbal Fluency following Mild Traumatic Brain Injury: The Strength of Switching.* Abstract accepted for talk at the American Speech-Language Hearing Association Conference, Boston, MA.

Dailey, N.S., Smith, R., Raikes, A.C., Alkozei, A., & Killgore, W.D.S. (2018, May). *Reduced Functional Connectivity in the Executive Control Network Following Mild Traumatic Brain Injury: Implications for Emotional Regulation.* Poster presented at the Society for Biological Psychiatry, New York, NY.

Dailey, N.S., Bajaj, S., Smith, R., Raikes, A. C., Alkozei, A., & Killgore, W. D. S. (2018, June). *Functional Connectivity in the Executive Control Network following Mild Traumatic Brain Injury*. Poster presented at the Organization for Human Brain Mapping Annual Meeting, Singapore, Malaysia.

Dailey, N.S., Meinhausen, C., & Killgore, W.D.S. (2018, August). *Self-Initiated Recall Strategies in Mild Traumatic Brain Injury: Identifying the Neural Correlates*. Abstract accepted to the 47th annual meeting of the International Neuropsychological Society, New York, NY.

Esbit, S., Dailey, N.S., & Killgore, W.D.S. (2018, August). *Making a List and Checking It Twice: Episodic Verbal Recall in Mild Traumatic Brain Injury.* Abstract

accepted to the 47th annual meeting of the International Neuropsychological Society, New York, NY.

Forebeck, B., Dailey, N.S., Esbit, S., & Killgore, W.D.S. (2018, April). *Reduced Information Processing Speed: A Dynamic Deficit in Mild Traumatic Brain Injury.* Abstract accepted for presentation at the American Speech-Language Hearing Association Conference, Boston, MA.

Meinhausen, C., Dailey, N.S., & Killgore, W.D.S. (2018, August). *Identifying Memory Retrieval Strategies during the Acute and Chronic Stages following a Mild Traumatic Brain Injury, using the CVLT-II.* Abstract accepted to the 47th annual meeting of the International Neuropsychological Society, New York, NY.

Raikes, A. C., Bajaj, S., Dailey, N. S., Smith, R., Alkozei, A., Satterfield, B. C., & Killgore, W. D. S. (2018, February). *White Matter Correlates of Self-Reported Sleep Quality after a Mild Traumatic Brain Injury: A DTI Study*. Poster presented at the Big Sky Athletic Training and Sports Medicine Conference, Big Sky, MT.

Raikes, A. C., Satterfield, B. C., Dailey, N. S., Bajaj, S., & Killgore, W. D. S. (2018, February). *Self-Reported Sleep Quality is Related to Cerebellar Grey Matter Volume After Mild Traumatic Brain Injury*. Poster presented at the Big Sky Athletic Training and Sports Medicine Conference, Big Sky, MT.

Raikes, A.C. & Killgore, W.D.S. (2018, February). *Increased Cerebellar Grey Matter in the Presence of Decreased Subjective Sleep Quality Following Mild Traumatic Brain Injury*. Poster presented at International Neuropsychological Society, Washington, DC.

Raikes, A.C., Satterfield, B.S., Knight, S.A., & Killgore, W.D.S. (2018, February). *Grey Matter Volumetric Differences with Increasing Numbers of Previous Mild Traumatic Brain Injuries: A Voxel-Based Morphometric Study*. Poster presented at International Neuropsychological Society, Washington, DC.

Raikes, A. C., Bajaj, S., Dailey, N. S., Smith, R., Alkozei, A., Satterfield, B. C., & Killgore, W. D. S. (2018, May). *Self-Reported Sleep Quality is Associated with Reductions in White-Matter Integrity Following Recent Mild Traumatic Brain Injury*. Poster presented at the 32nd Annual Meeting of the Associated Professional Sleep Societies, Baltimore, MD.

Raikes, A. C., Satterfield, B. C., Dailey, N. S., Bajaj, S., & Killgore, W. D. S. (2018, May). *Subjectively Poor Sleep Quality is Associated with Increased Cerebellar Grey Matter Volume Following Mild Traumatic Brain Injury*. Poster presented at the 32nd Annual Meeting of the Associated Professional Sleep Societies, Baltimore, MD.

Raikes, A. C., Bajaj, S., Dailey, N. S., Smith, R., Alkozei, A., Satterfield, B. C., & Killgore, W. D. S. (2018, June). *Post-mTBI White Matter Correlates of Self-Reported Sleep Quality: A DTI Study*. Poster presented at the Organization for Human Brain Mapping 2018 Annual Meeting, Singapore.

Website(s) or other Internet site(s)

Nothing to report

Technologies or techniques

Nothing to report.

Inventions, patent applications, and/or licenses

Nothing to report.

Other Products

Nothing to report.

7. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

What individuals have worked on the project?

Name: William D. “Scott” Killgore, Ph.D.
Project Role: PI
Nearest person month worked: 2
Contribution to Project: Dr. Killgore oversees all aspects of project progress and orchestrates data analysis and publication efforts.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Anna Alkozei, Ph.D.
Project Role: Postdoctoral Fellow
Nearest person month worked: 2
Contribution to Project: Dr. Alkozei performs data analysis and processing for the project.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Ryan Smith, Ph.D.
Project Role: Postdoctoral Fellow
Nearest person month worked: 2
Contribution to Project: Dr. Smith performs data analysis and processing for the project.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Natalie Dailey, Ph.D., CCC-SLP
Project Role: Postdoctoral Fellow
Nearest person month worked: 4
Contribution to Project: Dr. Dailey performs data analysis and processing for the project.
Funding support: USAMRAA W81XWH-14-1-0570

USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Sahil Bajaj, Ph.D.
Project Role: Postdoctoral Fellow
Nearest person month worked: 4
Contribution to Project: Dr. Bajaj performs data analysis and processing for the project.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Sara Knight
Project Role: Lab Manager
Nearest person month worked: 1
Contribution to Project: Ms. Knight oversaw the administrative needs of the study and study staff, and provided regulatory support and periodic quality control checks.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Matthew Allbright
Project Role: Research Technician
Nearest person month worked: 2
Contribution to Project: Mr. Allbright oversees the technical aspects of the project and assists in database export, storage, and management.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Garrett Baker
Project Role: Research Assistant
Nearest person month worked: 1
Contribution to Project: Mr. Baker assisted on the technical aspects of the project and assisted in database export, storage, and management.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Sarah (Markowski) Berryhill
Project Role: Research Technician
Nearest person month worked: 1
Contribution to Project: Mrs. Berryhill provided support with data collection and recruitment activities.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Skye Challener
Project Role: Research Technician
Nearest person month worked: 1
Contribution to Project: Ms. Challener provided support with data collection and recruitment activities.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Brittany Forbeck
Project Role: Research Technician
Nearest person month worked: 3
Contribution to Project: Ms. Forbeck provides support with data collection and recruitment activities and manages the day-to-day needs of the project.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Melissa Gottschlich
Project Role: ResearchTechnician
Nearest person month worked: 3
Contribution to Project: Ms. Gottschlich oversaw project needs and managed day-to-day aspects of project operations.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Jacqueline Marquez
Project Role: Research Technician
Nearest person month worked: 1
Contribution to Project: Ms. Marquez provided support with data collection and recruitment activities.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Michael Miller
Project Role: Research Specialist, Interim Lab Manager
Nearest person month worked: 3
Contribution to Project: Mr. Miller oversees the administrative needs of the study and study staff, in addition to providing regulatory and scientific support and performing periodic quality control checks.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Anna Sanova
Project Role: Research Technician
Nearest person month worked: 2
Contribution to Project: Ms. Sanova provided support with data collection and recruitment activities.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Anmol Singh
Project Role: Research Technician
Nearest person month worked: 1
Contribution to Project: Mr. Singh provided support with data collection and recruitment activities.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Michael Strong
Project Role: Research Technician
Nearest person month worked: 2
Contribution to Project: Mr. Strong provides support with data collection recruitment activities and manages the day-to-day needs of the project.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Matthew Thurston
Project Role: Research Technician
Nearest person month worked: 1
Contribution to Project: Mr. Thurston provided support with data collection and recruitment activities.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Name: Wing Ka Angela Yung
Project Role: Research Technician
Nearest person month worked: 1
Contribution to Project: Ms. Yung provided support with data collection and recruitment activities.
Funding support: USAMRAA W81XWH-14-1-0570
USAMRAA W81XWH-14-1-0571 USAMRAA W81XWH-16-1-0062
USAMRAA W81XWH-12-1-0386

Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

Our longstanding lab manager, Ms. Sara Knight, transferred from the lab to a research administration role in March of 2018. Mr. Miller assumed the role of interim laboratory manager while a search was performed for a suitable replacement for Ms. Knight.

What other organizations were involved as partners?
Nothing to Report.

8. SPECIAL REPORTING REQUIREMENTS

Please see updated Quad Chart attached in Appendix.

CONCLUSION

The study continues to progress as planned. Recruitment continues to be slower than we would like, but the study is progressing forward at an adequate pace. Preliminary findings suggest that the data collection methods and procedures are effective and that valid data is continuing to be acquired. We have begun to submit manuscripts for publication based on our preliminary findings. We believe that we will soon have a large enough sample to begin more extensive data analyses.

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Lange, R.T., Brickell, T.A., French, L.M., Merritt, V.C., Bhagwat, A., Pancholi, S., & Iverson, G.L. (2012). Neuropsychological outcome from uncomplicated mild, complicated mild, and moderate traumatic brain injury in US military personnel. *Archives of clinical neuropsychology : the official journal of the National Academy of Neuropsychologists, 27*(5), 480-494.

Lange, R.T., Brickell, T.A., Ivins, B., Vanderploeg, R.D., & French, L.M. (2013). Variable, not always persistent, postconcussion symptoms after mild TBI in U.S. military service members: a five-year cross-sectional outcome study. *Journal of neurotrauma, 30*(11), 958-969.

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Morey, R.A., Haswell, C.C., Selgrade, E.S., Massoglia, D., Liu, C., Weiner, J., . . . McCarthy, G. (2012). Effects of chronic mild traumatic brain injury on white matter integrity in Iraq and Afghanistan war veterans. *Human brain mapping*.

Spitz, G., Maller, J.J., O'Sullivan, R., & Ponsford, J.L. (2013). White matter integrity following traumatic brain injury: the association with severity of injury and cognitive functioning. *Brain topography, 26*(4), 648-660.

Yeh, P.H., Wang, B., Oakes, T.R., French, L.M., Pan, H., Graner, J., . . . Riedy, G. (2013). Postconcussional disorder and PTSD symptoms of military-related traumatic brain injury associated with compromised neurocircuitry. *Human brain mapping*.

APPENDICES
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William D. “Scott” Killgore, Ph.D. Curriculum Vitae……. 267 - 354

A Model for Predicting Cognitive and Emotional Health from Structural and Functional Neurocircuitry Following Traumatic Brain Injury

Study Tasks and Assessments

Day of Scan Questionnaire

Epworth Sleepiness Scale (ESS)

OSU TBI Interview

Glasgow Outcome Scale – Extended (GOS-E)

MINI International Psychiatric Interview (MINI)

California Verbal Learning Test (CVLT)

Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)

Delis-Kaplan Executive Function System (D-KEFS)

Go/No Go

Brief Visual Memory Test-Revised (BVMT-R)

Buss Perry Aggression Questionnaire (BPAQ)

Psychomotor Vigilance Test (PVT)

Pittsburgh Sleep Quality Index (PSQI)

State Trait Anxiety Inventory (STAI)

Automated Neuropsychological Assessment Metrics (ANAM)

Beck Depression Inventory (BDI-II)

Wechsler Abbreviated Scale of Intelligence (WASI II)

Connor- Davidson Resilience Scale (CD-RISC)

Craig Handicap Assessment and Reporting Technique Short Form (CHART-SF)

Personality Assessment Inventory (PAI)

Alcohol Use Disorder Identification Test (AUDIT)

Rivermead Post Concussion Symptoms Questionnaire (RPCSQ)

Snaith Hamilton Pleasure Scale (SHAPS)

Satisfaction With Life Scale (SWLS)

Edinburgh Handedness Survey (EHS)

Marijuana Use Questionnaire (MUSE)

Woodcock Johnson Sentence Reading Fluency (WJ IV)

A Model for Predicting Cognitive and Emotional Health from Structural and Functional Neurocircuitry following Traumatic Brain Injury

PT110814

W81XWH-12-1-0386

PI: William D. Killgore, Ph.D. **Org:** University of Arizona **Award Amount:** $2,272,098

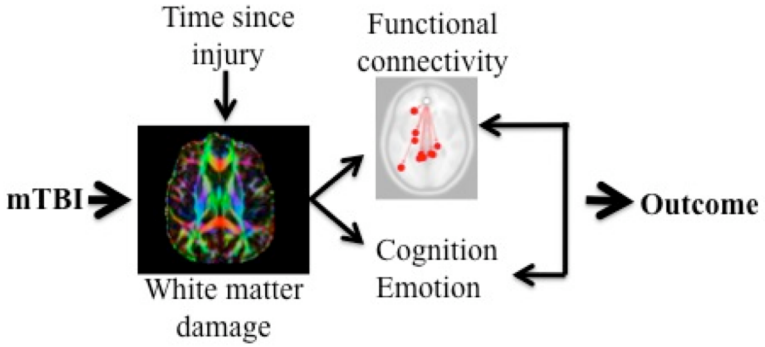
Study/Product Aim(s)

- Demonstrate the extent to which structural white matter damage explains abnormalities in cognition and emotion at different recovery stages following mild traumatic brain injury (TBI).
- Demonstrate the extent to which structural white matter damage explains abnormalities in functional connectivity at different recovery stages following mild TBI.
- Determine whether white matter disintegrity could serve as an objective marker for mild TBI.

Approach

Cross-sectional study involves comprehensive neuropsychiatric and neuropsychological assessment of 30 healthy controls and 150 individuals with mild TBI, of which 30 each will be assessed at 2 weeks, 1 month, 3 months, 6 months, and 12 month post-TBI. All participants undergo diffusion-weighted imaging, resting-state functional connectivity imaging, and neurocognitive assessment.

The study investigates whether and how white matter damage at 5 different natural recovery stages contributes to functional connectivity, cognition and emotion.



Accomplishments: Study is well underway after transferring from McLean Hospital to University of Arizona in 2014. 31 participants were collected at McLean, and 72 have been collected at University of Arizona. Data collection is now 57% complete.

Timeline and Cost

Activities CY	13	14	15	16	17	18	19
Study preparations							
Data collection							
Lab Relocation/Grant Move							
Data quality check							
Data analysis/dissemination							
Estimated Budget ($2,272K)	**$188K**	**$195K**	**$420K**	**$420K**	**$420K**	**$420K**	**$209K**

Updated: 1 OCT 2018

Goals/Milestones

CY14 Goal – Close study to enrolment and move lab to U of Arizona

☑ Completed move successfully. Funding transferred successfully

CY15 Goals – Complete preparations & launch study at UA

☑ Preparations, training, and MRI protocols successfully completed

☑ Study re-initiated in Arizona successfully!

☑ Preliminary findings published; several presentations submitted

CY16-18 Goal – Data collection, quality checks

☑ 70 Participants completed since relocation to UA; 103 participants have completed in total (57%). 4 month delay due to scanner relocation.

☐ Collect data from approximately 60 subjects per CY

CY19 Goal – Data analysis and dissemination

☐ Conduct final data analyses and prepare data for publication

Comments/Challenges/Issues/Concerns

- Study delayed due to uncontrollable circumstances (scanner moved to new building—resulted in 4-month delay in data collection.

Budget Expenditure to Date

Cumulative Expenditure: $1,938,703

AGE _____ years

HEIGHT _____ ft/inches

WEIGHT _____ lbs

SEX ☐ **MALE** ☐ **FEMALE**

For females only:

When was the start of your last menstrual period?

Be as precise as possible.

Date of period:_____

or about _____days ago.

RIGHT or LEFT-HANDED?

☐ **RIGHT**

☐ **LEFT**

☐ **BOTH/NEITHER**

Do you have any problems with reading? ☐ **NO** ☐ **YES**

EDUCATION: What is the highest grade or level of school you have completed or the highest degree you have obtained? *Please choose one:*

☐ 9th Grade
☐ 10th Grade
☐ 11th Grade
☐ 12th Grade, no diploma
☐ High school graduate
☐ GED or equivalent
☐ Some college, no degree
☐ Associate degree: occupational, technical, or vocational program
☐ Associate degree: academic program
☐ Bachelor's degree (e.g., BA, AB, BS, BBA)
☐ Master's degree (e.g., MA, MS, MEng, MEd, MBA)
☐ Professional school degree (e.g., MD, DDS, DVM, JD)
☐ Doctoral degree (e.g., PhD, EdD)
☐ Unknown

RACE: With what ethnicity do you identify?

☐ White
☐ Hispanic/Latino
☐ Black/African American
☐ Native American/ American Indian
☐ Asian/Pacific Islander
☐ Other

Are you currently doing shift work (e.g., working early morning, evening, or night shifts?

☐ **NO** ☐ **YES**

Do you engage in regular exercise?

☐ **NO** ☐ **YES**

Which sport? _____

How many days per week? _____

How many minutes per exercise session (on average)? _____

CAFFEINE USE

Did you have any caffeine containing products today?

☐ **NO** ☐ **YES** How much? _____

On average, how many cups (=8oz) of caffeinated coffee do you drink per day? _____

On average, how many cups (=8oz) of caffeinated tea do you drink per day? _____

On average, how many cans of caffeinated soda do you drink per day? _____

On average, how many caffeinated sports drinks do you drink per day? _____ (brand)

Do you use any other caffeinated products (e.g. Vivarin)?

☐ **NO** ☐ **YES** Brand? _____

How much? _____

How often? _____

NICOTINE AND OTHER SUBSTANCE USE

Do you currently smoke cigarettes?

☐ **NO** ☐ **YES**

How many? _____ daily / weekly / monthly / yearly (*circle one*)

For how long? _____ years _____ months

Have you tried to quit? ☐ **NO** ☐ **YES**

How many times? _____

Have you ever smoked cigarettes in the past?

☐ **NO** ☐ **YES**

How many? _____ daily / weekly / monthly / yearly (*circle one*)

For how long? _____ years _____ months

When did you quit? _____ (approximate date)

Do you currently smoke large cigars?

☐ **NO** ☐ **YES**

How many? _____ daily / weekly / monthly/ yearly (*circle one*)

For how long? _____ years _____ months

Have you tried to quit? ☐ **NO** ☐ **YES**

How many times? _____

Have you ever smoked large cigars in the past?

☐ **NO** ☐ **YES**

How many? _____ daily / weekly / monthly / yearly (*circle one*)

For how long? _____ years _____ months

When did you quit? _____ (approximate date)

Do you currently smoke small cigars?

☐ **NO** ☐ **YES**

How many? _____ daily / weekly / monthly/ yearly (*circle one*)

For how long? _____ years _____ months

Have you tried to quit? ☐ **NO** ☐ **YES**

How many times? _____

Have you ever smoked small cigars in the past?

☐ **NO** ☐ **YES**

How many? _____ daily / weekly / monthly / yearly (*circle one*)

For how long? _____ years _____ months

When did you quit? _____ (approximate date)

Do you currently smoke cigarillos?

☐ **NO** ☐ **YES**

How many? _____ daily / weekly / monthly/ yearly (*circle one*)

For how long? _____ years _____ months

Have you tried to quit? ☐ **NO** ☐ **YES**

How many times? _____

Have you ever smoked cigarillos in the past?

☐ **NO** ☐ **YES**

How many? _____ daily / weekly / monthly / yearly (*circle one*)

For how long? _____ years _____ months

When did you quit? _____ (approximate date)

Do you currently use smokeless tobacco, such as dip or chew?

☐ **NO** ☐ **YES**

About how much/ many? _____daily / weekly / monthly / yearly (*circle one*)

For how long? _____ years _____ months

Have you tried to quit? ☐ **NO**☐ **YES**

How many times? _____

Have you ever used smokeless tobacco in the past?

☐ **NO** ☐ **YES**

About how much/ many? _____ daily / weekly / monthly / yearly (*circle one*)

For how long? _____ years _____ months

When did you quit? _____ (approximate date)

Do you currently use any other nicotine-containing products?

☐ **NO** ☐ **YES**

Which kind? _____

For how long? _____ years _____ months

How often? _____daily/ weekly/ monthly/ yearly *(circle one)*

Have you tried to quit? ☐ **NO** ☐ **YES**

How many times? _____

Have you ever used any other kind of nicotine containing products?

☐ **NO** ☐ **YES**

Which kind? _____

For how long? _____ years _____ months

How often? _____daily/ weekly/ monthly/ yearly *(circle one)*

Have you tried to quit? ☐ **NO** ☐ **YES**

How many times? _____

Are you currently taking diet pills?

☐ **NO** ☐ **YES**

What brand? _____

For how long? _____ years _____ months _____ days

How much? _____

How often? _____ daily / weekly / monthly / yearly (*circle one*)

Are you currently taking any medications, vitamins, or supplements?

☐ **NO** ☐ **YES**

Please list:

Name: _____ Dosage: _____

Name: _____ Dosage: _____

Name: _____ Dosage: _____

Name: _____ Dosage: _____

Have you ever used any street drugs?

☐ **NO** ☐ **YES**

What? _____

How much? _____

How often? _____daily/ weekly/ monthly/ yearly *(circle one)*

In the past year, did you use any other street drugs?

☐ **NO**☐ **YES**

What? _____

How much? _____

How often? _____daily/ weekly/ monthly/ yearly *(circle one)*

Do you currently use any other street drugs?

☐ **NO** ☐ **YES**

What? _____

How much? _____

How often? _____daily/ weekly/ monthly/ yearly *(circle one)*

Do you drink alcohol?

☐ **NO** ☐ **YES**

How many times per month? _____

Using the below chart, what is the average number of drinks you consume on these occasions? _____

Using the chart, what is the largest number of drinks you consume? _____

One drink equals:

12 fl oz of **regular beer**	=	8-9 fl oz of **malt liquor** (shown in a 12-oz glass)	=	5 fl oz of **table wine**	=	3-4 oz of **fortified wine** (such as sherry or port; 3.5 oz shown)	=	2-3 oz of **cordial, liqueur, or aperitif** (2.5 oz shown)	=	1.5 oz of **brandy** (a single jigger or shot)	=	1.5 fl oz shot of **80-proof spirits** ("hard liquor")
about 5% alcohol		about 7% alcohol		about 12% alcohol		about 17% alcohol		about 24% alcohol		about 40% alcohol		about 40% alcohol

INFORMATION ON THE MOST RECENT DOCUMENTED INJURY

Injury date and time: __ __ _ /__ __/ __ __ **__ __: __ __**(24 hour clock)
(day /month/ year)

What happened? _____
_____
_____

Did you experience any symptoms or changes after the injury?

☐ **NO** ☐ **YES, IMMEDIATELY AFTER THE INJURY**
☐ **YES, NOT IMMEDIATELY AFTER THE INJURY**

Which symptoms or changes did you experience?

_____
_____
_____

At the time of the injury, were you under the influence of alcohol, medication or drugs at that time?

☐ **NO** ☐ **YES, ALCOHOL**
☐ **YES, MEDICATION** (which?) _____
☐ **YES, DRUGS** (which?) _____

Were medical services received after injury?

☐ **NO** ☐ **DO NOT KNOW** ☐ **YES**

Did you "see stars" during your last concussion?

☐ **NO** ☐ **DO NOT KNOW** ☐ **YES**

Did you experience loss of consciousness?

☐ **NO** ☐ **DO NOT KNOW** ☐ **YES**

Duration of loss of consciousness:

- ☐ <1 minute
- ☐ 1-29 minutes
- ☐ 30-59 minutes
- ☐ 1-24 hours
- ☐ 1-7 days
- ☐ > 7 days
- ☐ Unknown

How was the loss of consciousness verified?

☐ **Self-report** ☐ **Witness** ☐ **Medical chart**

Do you have a PERSONAL memory of the event/ incident itself?

☐ **YES, I FULLY REMEMBER** ☐ **YES, BUT THERE ARE GAPS IN MY MEMORY**

☐ **NO, I DO NOT REMEMBER AT ALL**

How much do you NOT remember after the injury?

- ☐ <1 minute
- ☐ 1-29 minutes
- ☐ 30-59 minutes
- ☐ 1-24 hours
- ☐ 1-7 days
- ☐ > 7 days
- ☐ Unknown

How was the memory loss verified?

☐ **Self-report** ☐ **Witness** ☐ **Medical chart**

After the injury, when did you feel back to yourself or 100%? Please state the approximate number of days. _____

How many separate injuries do you think have you sustained in total? _____

How many of these were documented by a health professional, athletic trainer, coach, etc.? _____

SLEEP HABITS

How much sleep did you get last night? _____ HRS

Before your injury, what time did you typically awaken on:

Weekdays (Mon-Fri)? _____ AM PM (midnight = 12 AM; noon = 12 PM)

Weekends (Sat-Sun)? _____ AM PM

Before your injury, how long did it typically take you to fall asleep at night?

Week nights (Sun-Thur) _____ MIN HRS (midnight = 12 AM; noon = 12 PM)

Weekends (Fri-Sat) _____ MIN HRS

Before your injury, at what time did you normally go to bed at night on:

Week nights (Sun-Thur)? _____ AM PM (midnight = 12 AM; noon = 12 PM)

Weekends (Fri-Sat)? _____ AM PM

Before the injury, did you experience sleep problems?

☐ **NO** ☐ **YES, I had trouble falling asleep.**

How often? _____ times per WEEK MONTH YEAR

☐ **YES, I had trouble staying asleep.**

How often? _____ times per WEEK MONTH YEAR

Since the injury, did you notice that your sleep became worse?

☐ **NO** ☐ **YES**

What sleep problems became more noticeable to you? (*check all that apply*)

☐ I get sleepier during the day.

☐ I get drowsier than I used to when trying to concentrate or work.

☐ I fall asleep when I should not.

☐ It is harder to stay alert during the day.

☐ It is harder to fall asleep at night.

How often? _____ times per WEEK MONTH YEAR *(circle one)*

☐ I fall asleep much later than I used to.

☐ I fall asleep much earlier than I used to.

☐ I sleep later in the morning than I used to.

☐ I have trouble staying asleep.

How often? _____ times per WEEK MONTH YEAR (circle one)

☐ I wake up much earlier in the morning than I used to.

☐ When I do sleep, it is fitful or less restful than it used to be.

☐ I wake up off and on throughout the night more than I used to.

☐ I have more nightmares than I used to.

Since your injury, how much do you typically sleep on weeknights (Sun-Thur)? _____ HRS

Since your injury, how much do you typically sleep on weekend nights (Fri-Sat)? _____ HRS

Since your injury, at what time do you normally go to bed at night on:

Week nights (Sun-Thur)? _____ AM PM (midnight = 12 AM; noon = 12 PM)

Weekends (Fri-Sat)? _____ AM PM

Since your injury, what time do you typically awaken on:

Weekdays (Mon-Fri)? _____ AM PM

Weekends (Sat-Sun)? _____ AM PM

Since your Injury, how long does it typically take you to fall asleep at night?

Week nights (Sun-Thur)? _____ MIN HRS

Weekends (Fri-Sat)? _____ MIN HRS

Since your injury,

at what time of day do you feel sleepiest? _____ AM PM

at what time of day do you feel most alert? _____ AM PM

how many hours do you need to sleep to feel your best? _____

if you get less than _____ hours of sleep, you notice impairment in your ability to function at work.

if you get more than _____ hours of sleep, you notice impairment in your ability to function at work.

Since your injury, do you take more than two daytime naps per month?

☐ **NO** ☐ **YES**

How many times per week do you nap? _____

At what time? ____:____ AM/PM to ____:____AM/PM

Do you consider yourself a light, normal, or heavy sleeper?

☐ **LIGHT** ☐ **NORMAL** ☐ **HEAVY**

Have you been told or do you think that you snore excessively?

☐ **NO** ☐ **YES**

Have you ever been diagnosed or treated for sleep apnea or sleep disordered breathing?

☐ **NO** ☐ **YES**

Is daytime sleepiness currently a problem for you?

☐ **NO** ☐ **YES**

Epworth Sleepiness Scale

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your **usual way of life in recent times**. Even if you have not done some of these things recently try to work out how they would have affected you. Use the following scale to choose the most appropriate number for each situation:

0 = would never doze
1 = slight chance of dozing
2 = moderate chance of dozing
3 = high chance of dozing

SITUATION	CHANCE OF DOZING			
Sitting and reading	**0**	**1**	**2**	**3**
Watching TV	**0**	**1**	**2**	**3**
Sitting, inactive in a public place (e.g. a theater or meeting)	**0**	**1**	**2**	**3**
As a passenger in a car for an hour without a break	**0**	**1**	**2**	**3**
Lying down to rest in the afternoon when circumstances permit	**0**	**1**	**2**	**3**
Sitting and talking to someone	**0**	**1**	**2**	**3**
Sitting quietly after a lunch without alcohol	**0**	**1**	**2**	**3**
In a car, while stopped for a few minutes in the traffic	**0**	**1**	**2**	**3**

Ohio State University TBI Identification Method Short Form*

I would like to ask you about injuries to your head or neck that you may have had at anytime in your life.
Interviewer instruction: Record cause and any details provided spontaneously in the box at the bottom of the page. DO NOT query further about LOC or other details at this stage.

1. Have you ever been hospitalized or treated in an emergency room following an injury to your head or neck? Think about any childhood injuries you remember or were told about.
   - ❑ Yes—Record cause(s) in table below
   - ❑ No
2. Have you ever injured your head or neck in a car accident or from some other moving vehicle accident (e.g. motorcycle, ATV)?
   - ❑ Yes—Record cause(s) in table below
   - ❑ No
3. Have you ever injured your head or neck in a fall or from being hit by something (e.g. falling from a bike, horse, or rollerblades, falling on ice, being hit by a rock)? Have you ever injured your head or neck playing sports or on the playground?
   - ❑ Yes—Record cause(s) in table below
   - ❑ No
4. Have you ever injured your head or neck in a fight, from being hit by someone, or from being shaken violently? Have you ever been shot in the head?
   - ❑ Yes—Record cause(s) in table below
   - ❑ No
5. Have you ever been nearby when an explosion or a blast occurred? If you served in the military, think about any combat- or training-related incidents.
   - ❑ Yes—Record cause(s) in table below
   - ❑ No
6. If all above are "no" then proceed to question 7. If answered "yes" to *any* of the questions above, ask the following for each injury: **Were you knocked or did you lose consciousness (LOC)? If yes, how long? If no, were you dazed or did you have a gap in your memory from the injury? How old were you? (*age is only needed if there was LOC)***

Cause	Loss of consciousness (LOC)/knocked out				Dazed/Memory Gap		Age
	No LOC	< 30 min	30 min-24 hrs	> 24 hrs.	Yes	No	

* adapted with permission from the Ohio State University TBI Identification Method (Corrigan, J.D., Bogner, J.A. (2007). Initial reliability and validity of the OSU TBI Identification Method. *J Head Trauma Rehabil, 22*(6):318-329,

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If more injuries with LOC: How many more?___ Longest knocked out?___ How many ≥ 30 mins.?___ Youngest age? ___

7. Have you ever lost consciousness from a drug overdose or being choked? ____# overdose ____# choked

SCORING

_____ **# TBI-LOC** (number of TBI's with loss of consciousness from #6a)
_____ **# TBI-LOC ≥ 30 (**number of TBI's with loss of consciousness ≥ 30 minutes from #6a)
_____ **age at first TBI-LOC** (youngest age from #6a)
_____ **TBI-LOC before age 15** (if youngest age from #7B < 15 then =1, if ≥ 15 then = 0)
_____ **Worst Injury** (1-5):
If responses to #1-5 are "no" classify as 1 "improbable TBI".
If in response to #6a and 6b reports never having LOC, being dazed or having memory lapses classify as 1 "improbable TBI".
If in response to #6b reports being dazed or having a memory lapse classify as 2 "possible TBI".
If in response to #6a loss of consciousness (LOC) does not exceed 30 minutes for any injury classify as 3 "mild TBI".
If in response to #6a LOC for any one injury is between 30 minutes and 24 hours classify as 4 "moderate TBI".
If in response to #6a LOC for any one injury exceeds 24 hours classify as 5 "severe TBI".
_____ **# anoxic injuries** (sum of incidents reported in #7)

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Subject ID: _____ Date: _____

Glasgow Outcome Scale – Extended

CONSCIOUSNESS			
1.	Is the subject able to obey simple commands, or say words?	NO	YES
INDEPENDENCE IN THE HOME			
2.a	Is assistance of another person at home essential every day for some activities of daily living?	NO	YES
	Notes.		
2.b	Do you need frequent help or someone to be around at home most of the time?	NO *(UPPER SD)*	YES *(LOWER SD)*
2.c	Was assistance at home essential before the injury?	NO	YES
	Notes.		
INDEPENDENCE OUTSIDE OF HOME			
3.a	Do you shop without assistance?	NO *(UPPER SD)*	YES
3.b	Did you need assistance before the injury?	NO	YES
	Notes.		
4.a	Do you travel without assistance?	NO *(UPPER SD)*	YES
4.b	Did you need assistance before the injury?	NO	YES
	Notes.		

Subject ID: _____ Date: _____

WORK				
5.a	Are you currently working to your previous capacity?	NO		YES
5.b	How restricted are you?	Reduced work capacity. (UPPER MD)		Able to work in sheltered workshop or non-competitive job, or unable to work (LOWER MD)
5.c	Have you been working or seeking employment before the injury?	NO		YES
	Notes.			
SOCIAL & LEISURE ACTIVITIES				
6.a	Are you able to resume regular social and leisure activities outside home?	NO		YES
6.b	What is the extent of the restriction?	Participate a bit less: at least half as often as before injury (LOWER GR)	Participate much less: less than half as often (UPPER MD)	Unable to participate: rarely, if ever (LOWER MD)
6.c	Did you engage in regular social and leisure activities before the injury?	NO		YES
	Notes.			
FAMILY & FRIENDSHIPS				
7.a	Have there been any psychological problems which have resulted in ongoing family disruption or disruption of friendship?	NO		YES

Subject ID: _____ Date: _____

7.b	What is the extent of disruption or strain?	Occasional: less than weekly	Frequent: once a week or more, but tolerable	Constant: daily and intolerable
7.c	Were there problems with family or friends before the injury?	NO	YES	
	Notes.			
RETURN TO NORMAL LIFE				
8.a	Are there any other current problems relating to the injury which affect daily life?	NO (UPPER GR)	YES (LOWER GR)	
8.b	Were similar problems present before injury?	NO	YES	
	Notes.			

SCORING		
1	Dead	
2	Vegetative State	VS
3	Lower Severe Disability	Lower SD
4	Upper Severe Disability	Upper SD
5	Lower Moderate Disability	Lower MD
6	Upper Moderate Disability	Upper MD
7	Lower Good Recovery	Lower GR
8	Upper Good Recovery	Upper GR

M.I.N.I.

MINI INTERNATIONAL NEUROPSYCHIATRIC INTERVIEW

English Version 6.0.0

DSM-IV

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DISCLAIMER

Our aim is to assist in the assessment and tracking of patients with greater efficiency and accuracy. Before action is taken on any data collected and processed by this program, it should be reviewed and interpreted by a licensed clinician.

This program is not designed or intended to be used in the place of a full medical and psychiatric evaluation by a qualified licensed physician – psychiatrist. It is intended only as a tool to facilitate accurate data collection and processing of symptoms elicited by trained personnel.

M.I.N.I. 6.0.0 (January 1, 2009)

			Patient Number:			
			Time Interview Began:			
Interviewer's Name:			***Time Interview Ended:***			
Date of Interview:			***Total Time:***			

	MODULES	TIME FRAME	MEETS CRITERIA	DSM-IV-TR	ICD-10	PRIMARY DIAGNOSIS
A	MAJOR DEPRESSIVE EPISODE	Current (2 weeks)	☐	296.20-296.26 Single	F32.x	☐
		Past	☐	296.20-296.26 Single	F32.x	☐
		Recurrent	☐	296.30-296.36 Recurrent	F33.x	☐
B	SUICIDALITY	Current (Past Month) ☐ Low ☐ Moderate ☐ High	☐			
C	MANIC EPISODE	Current	☐	296.00-296.06	F30.x-F31.9	☐
		Past	☐			
	HYPOMANIC EPISODE	Current	☐	296.80-296.89	F31.8-F31.9/F34.0	☐
		Past	☐			
	BIPOLAR I DISORDER	Current	☐	296.0x-296.6x	F30.x-F31.9	☐
		Past	☐	296.0x-296.6x	F30.x-F31.9	☐
	BIPOLAR II DISORDER	Current	☐	296.89	F31.8	☐
		Past	☐	296.89	F31.8	☐
	BIPOLAR DISORDER NOS	Current	☐	296.80	F31.9	☐
		Past	☐	296.80	F31.9	☐
D	PANIC DISORDER	Current (Past Month)	☐	300.01/300.21	F40.01-F41.0	☐
		Lifetime	☐			
E	AGORAPHOBIA	Current	☐	300.22	F40.00	☐
F	SOCIAL PHOBIA (Social Anxiety Disorder)	Current (Past Month)				
		Generalized	☐	300.23	F40.1	☐
		Non-Generalized	☐	300.23	F40.1	☐
G	OBSESSIVE-COMPULSIVE DISORDER	Current (Past Month)	☐	300.3	F42.8	☐
H	POSTTRAUMATIC STRESS DISORDER	Current (Past Month)	☐	309.81	F43.1	☐
I	ALCOHOL DEPENDENCE	Past 12 Months	☐	303.9	F10.2x	☐
	ALCOHOL ABUSE	Past 12 Months	☐	305.00	F10.1	☐
J	SUBSTANCE DEPENDENCE (Non-alcohol)	Past 12 Months	☐	304.00-.90/305.20-.90	F11.1-F19.1	☐
	SUBSTANCE ABUSE (Non-alcohol)	Past 12 Months	☐	304.00-.90/305.20-.90	F11.1-F19.1	☐
K	PSYCHOTIC DISORDERS	Lifetime	☐	295.10-295.90/297.1/	F20.xx-F29	☐
		Current	☐	297.3/293.81/293.82/ 293.89/298.8/298.9		
	MOOD DISORDER WITH	Lifetime	☐	296.24/296.34/296.44	F32.3/F33.3/	☐
	PSYCHOTIC FEATURES	Current	☐	296.24/296.34/296.44	F30.2/F31.2/F31.5 F31.8/F31.9/F39	☐
L	ANOREXIA NERVOSA	Current (Past 3 Months)	☐	307.1	F50.0	☐
M	BULIMIA NERVOSA	Current (Past 3 Months)	☐	307.51	F50.2	☐
	ANOREXIA NERVOSA, BINGE EATING/PURGING TYPE	Current	☐	307.1	F50.0	☐
N	GENERALIZED ANXIETY DISORDER	Current (Past 6 Months)	☐	300.02	F41.1	☐
O	MEDICAL, ORGANIC, DRUG CAUSE RULED OUT		☐ No	☐ Yes ☐Uncertain		
P	ANTISOCIAL PERSONALITY DISORDER	Lifetime	☐	301.7	F60.2	☐

IDENTIFY THE PRIMARY DIAGNOSIS BY CHECKING THE APPROPRIATE CHECK BOX.
(Which problem troubles you the most or dominates the others or came first in the natural history?)

The translation from DSM-IV-TR to ICD-10 coding is not always exact. For more information on this topic see Schulte-Markwort. Crosswalks ICD-10/DSM-IV-TR. Hogrefe & Huber Publishers 2006.

GENERAL INSTRUCTIONS

The M.I.N.I. was designed as a brief structured interview for the major Axis I psychiatric disorders in DSM-IV and ICD-10. Validation and reliability studies have been done comparing the M.I.N.I. to the SCID-P for DSM-III-R and the CIDI (a structured interview developed by the World Health Organization). The results of these studies show that the M.I.N.I. has similar reliability and validity properties, but can be administered in a much shorter period of time (mean 18.7 ± 11.6 minutes, median 15 minutes) than the above referenced instruments. It can be used by clinicians, after a brief training session. Lay interviewers require more extensive training.

INTERVIEW:

In order to keep the interview as brief as possible, inform the patient that you will conduct a clinical interview that is more structured than usual, with very precise questions about psychological problems which require a yes or no answer.

GENERAL FORMAT:

The M.I.N.I. is divided into **modules** identified by letters, each corresponding to a diagnostic category.

•At the beginning of each diagnostic module (except for psychotic disorders module), screening question(s) corresponding to the main criteria of the disorder are presented in a **gray box**.

•At the end of each module, diagnostic box(es) permit the clinician to indicate whether diagnostic criteria are met.

CONVENTIONS:

Sentences written in « normal font » should be read exactly as written to the patient in order to standardize the assessment of diagnostic criteria.

Sentences written in « CAPITALS » should not be read to the patient. They are instructions for the interviewer to assist in the scoring of the diagnostic algorithms.

Sentences written in « **bold** » indicate the time frame being investigated. The interviewer should read them as often as necessary. Only symptoms occurring during the time frame indicated should be considered in scoring the responses.

Answers with an arrow above them (➡) indicate that one of the criteria necessary for the diagnosis(es) is not met. In this case, the interviewer should go to the end of the module, circle « **NO** » in all the diagnostic boxes and move to the next module.

When terms are separated by a *slash (/)* the interviewer should read only those symptoms known to be present in the patient (for example, question G6).

Phrases in (parentheses) are clinical examples of the symptom. These may be read to the patient to clarify the question.

RATING INSTRUCTIONS:

All questions must be rated. The rating is done at the right of each question by circling either Yes or No. Clinical judgment by the rater should be used in coding the responses. Interviewers need to be sensitive to the diversity of cultural beliefs in their administration of questions and rating of responses. The rater should ask for examples when necessary, to ensure accurate coding. The patient should be encouraged to ask for clarification on any question that is not absolutely clear.

The clinician should be sure that each dimension of the question is taken into account by the patient (for example, time frame, frequency, severity, and/or alternatives).

Symptoms better accounted for by an organic cause or by the use of alcohol or drugs should not be coded positive in the M.I.N.I. The M.I.N.I. Plus has questions that investigate these issues.

For any questions, suggestions, need for a training session or information about updates of the M.I.N.I., please contact:

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A. MAJOR DEPRESSIVE EPISODE

(➡ MEANS : GO TO THE DIAGNOSTIC BOXES, CIRCLE **NO** IN ALL DIAGNOSTIC BOXES, AND MOVE TO THE NEXT MODULE)

A1	a	Were you ever depressed or down, most of the day, nearly every day, for two weeks?	NO	YES
		IF NO, CODE NO TO **A1b**: IF **YES** ASK:		
	b	For the past two weeks, were you depressed or down, most of the day, nearly every day?	NO	YES
A2	a	Were you ever much less interested in most things or much less able to enjoy the things you used to enjoy most of the time, for two weeks?	NO	YES
		IF NO, CODE NO TO **A2b**: IF **YES** ASK:		
	b	In the past two weeks, were you much less interested in most things or much less able to enjoy the things you used to enjoy, most of the time?	NO	YES
		➡ IS **A1a** OR **A2a** CODED **YES**?	NO	YES

A3 IF **A1b** OR **A2b** = **YES**: EXPLORE THE **CURRENT** AND THE MOST SYMPTOMATIC **PAST** EPISODE, OTHERWISE
IF **A1b** AND **A2b** = **NO**: EXPLORE ONLY THE MOST SYMPTOMATIC **PAST** EPISODE

Over that two week period, when you felt depressed or uninterested:

		Past 2 Weeks		Past Episode	
a	Was your appetite decreased or increased nearly every day? Did your weight decrease or increase without trying intentionally (i.e., by ±5% of body weight or ±8 lbs. or ±3.5 kgs., for a 160 lb./70 kg. person in a month)? IF **YES** TO EITHER, CODE **YES**.	NO	YES	NO	YES
b	Did you have trouble sleeping nearly every night (difficulty falling asleep, waking up in the middle of the night, early morning wakening or sleeping excessively)?	NO	YES	NO	YES
c	Did you talk or move more slowly than normal or were you fidgety, restless or having trouble sitting still almost every day?	NO	YES	NO	YES
d	Did you feel tired or without energy almost every day?	NO	YES	NO	YES
e	Did you feel worthless or guilty almost every day?	NO	YES	NO	YES
	IF **YES**, ASK FOR EXAMPLES. THE EXAMPLES ARE CONSISTENT WITH A DELUSIONAL IDEA. Current Episode ❒ No ❒ Yes; Past Episode ❒ No ❒ Yes				
f	Did you have difficulty concentrating or making decisions almost every day?	NO	YES	NO	YES
g	Did you repeatedly consider hurting yourself, feel suicidal, or wish that you were dead? Did you attempt suicide or plan a suicide? IF **YES TO EITHER, CODE YES.**	NO	YES	NO	YES
A4	Did these symptoms cause significant problems at home, at work, socially, at school or in some other important way?	NO	YES	NO	YES

A5 In between 2 episodes of depression, did you ever have an interval of at least 2 months, without any significant depression or any significant loss of interest? NO YES

ARE **5** OR MORE ANSWERS (**A1-A3**) CODED **YES** AND IS **A4** CODED YES FOR THAT TIME FRAME?

SPECIFY IF THE EPISODE IS CURRENT AND / OR PAST.

IF **A5** IS CODED **YES,** CODE **YES** FOR RECURRENT.

NO	**YES**
MAJOR DEPRESSIVE EPISODE	
CURRENT	❒
PAST	❒
RECURRENT	❒

A6 a How many episodes of depression did you have in your lifetime? _____

Between each episode there must be at least 2 months without any significant depression.

B. SUICIDALITY

				Points
	In the past month did you:			
B1	Suffer any accident? IF NO TO B1, SKIP TO B2; IF YES, ASK B1a:	NO	YES	0
B1a	Plan or intend to hurt yourself in that accident either actively or passively (e.g. not avoiding a risk)? IF NO TO B1a, SKIP TO B2: IF YES, ASK B1b:	NO	YES	0
B1b	Intend to die as a result of this accident?	NO	YES	0
B2	Feel hopeless?	NO	YES	1
B3	Think that you would be better off dead or wish you were dead?	NO	YES	1
B4	Want to harm yourself or to hurt or to injure yourself or have mental images of harming yourself?	NO	YES	2
B5	Think about suicide? IF NO TO B5, SKIP TO B7. OTHERWISE ASK:	NO	YES	6

Frequency		Intensity	
Occasionally	❒	Mild	❒
Often	❒	Moderate	❒
Very often	❒	Severe	❒

	Can you state that you will not act on these impulses during this treatment program?	NO	YES	
B6	Feel unable to control these impulses?	NO	YES	8
B7	Have a suicide plan?	NO	YES	8
B8	Take any active steps to prepare to injure yourself or to prepare for a suicide attempt in which you expected or intended to die?	NO	YES	9
B9	Deliberately injure yourself without intending to kill yourself?	NO	YES	4
B10	Attempt suicide? IF NO SKIP TO B11: Hope to be rescued / survive ❒ Expected / intended to die ❒	NO	YES	9
	In your lifetime:			
B11	Did you ever make a suicide attempt?	NO	YES	4

IS AT LEAST **1** OF THE ABOVE (EXCEPT B1) CODED **YES**?

IF YES, ADD THE TOTAL POINTS FOR THE ANSWERS (B1-B11) CHECKED 'YES' AND SPECIFY THE SUICIDALITY SCORE AS INDICATED IN THE DIAGNOSTIC BOX:

MAKE ANY ADDITIONAL COMMENTS ABOUT YOUR ASSESSMENT OF THIS PATIENT'S CURRENT AND NEAR FUTURE SUICIDALITY IN THE SPACE BELOW:

NO **YES**

SUICIDALITY CURRENT

1-8 points	Low	❒
9-16 points	Moderate	❒
≥ 17 points	High	❒

C. MANIC AND HYPOMANIC EPISODES

(➡ MEANS : GO TO THE DIAGNOSTIC BOXES, CIRCLE NO IN MANIC AND HYPOMANIC DIAGNOSTIC BOXES, AND MOVE TO NEXT MODULE)

Do you have any family history of manic depressive illness or bipolar disorder, or any family member who had mood swings treated with a medication like lithium, sodium valproate (Depakote) or lamotrigine (Lamictal)? NO YES

THIS QUESTION IS NOT A CRITERION FOR BIPOLAR DISORDER, BUT IS ASKED TO INCREASE THE CLINICIAN'S VIGILANCE ABOUT THE RISK FOR BIPOLAR DISORDER .

IF YES, PLEASE SPECIFY WHO:_____

C1 a Have you **ever** had a period of time when you were feeling 'up' or 'high' or 'hyper' or so full of energy or full of yourself that you got into trouble, - or that other people thought you were not your usual self? (Do not consider times when you were intoxicated on drugs or alcohol.) NO YES

IF PATIENT IS PUZZLED OR UNCLEAR ABOUT WHAT YOU MEAN BY 'UP' OR 'HIGH' OR 'HYPER', CLARIFY AS FOLLOWS: By 'up' or 'high' or 'hyper' I mean: having elated mood; increased energy; needing less sleep; having rapid thoughts; being full of ideas; having an increase in productivity, motivation, creativity, or impulsive behavior; phoning or working excessively or spending more money.

IF NO, CODE NO TO **C1b**: IF **YES** ASK:

b Are you currently feeling 'up' or 'high' or 'hyper' or full of energy? NO YES

C2 a Have you **ever** been persistently irritable, for several days, so that you had arguments or verbal or physical fights, or shouted at people outside your family? Have you or others noticed that you have been more irritable or over reacted, compared to other people, even in situations that you felt were justified? NO YES

IF NO, CODE NO TO **C2b**: IF **YES** ASK:

b Are you currently feeling persistently irritable? NO YES

➡

IS **C1a** OR **C2a** CODED **YES**? NO YES

C3 IF **C1b** OR **C2b** = **YES**: EXPLORE THE **CURRENT** AND THE MOST SYMPTOMATIC **PAST** EPISODE, OTHERWISE
IF **C1b** AND **C2b** = **NO**: EXPLORE ONLY THE MOST SYMPTOMATIC **PAST** EPISODE

During the times when you felt high, full of energy, or irritable did you:

		Current Episode		Past Episode	
a	Feel that you could do things others couldn't do, or that you were an especially important person? IF **YES**, ASK FOR EXAMPLES. THE EXAMPLES ARE CONSISTENT WITH A DELUSIONAL IDEA. Current Episode ❒ No ❒ Yes Past Episode ❒ No ❒ Yes	NO	YES	NO	YES
b	Need less sleep (for example, feel rested after only a few hours sleep)?	NO	YES	NO	YES
c	Talk too much without stopping, or so fast that people had difficulty understanding?	NO	YES	NO	YES
d	Have racing thoughts?	NO	YES	NO	YES

		Current Episode		Past Episode	
e	Become easily distracted so that any little interruption could distract you?	NO	YES	NO	YES
f	Have a significant increase in your activity or drive, at work, at school, socially or sexually or did you become physically or mentally restless?	NO	YES	NO	YES
g	Want so much to engage in pleasurable activities that you ignored the risks or consequences (for example, spending sprees, reckless driving, or sexual indiscretions)?	NO	YES	NO	YES

C3 SUMMARY: WHEN RATING CURRENT EPISODE: NO YES NO YES

IF C1b IS NO, ARE 4 OR MORE C3 ANSWERS CODED YES?
IF C1b IS YES, ARE 3 OR MORE C3 ANSWERS CODED YES?

WHEN RATING PAST EPISODE:
IF C1a IS NO, ARE 4 OR MORE C3 ANSWERS CODED YES?
IF C1a IS YES, ARE 3 OR MORE C3 ANSWERS CODED YES?

CODE YES ONLY IF THE ABOVE 3 OR 4 SYMPTOMS OCCURRED DURING THE SAME TIME PERIOD.

RULE: ELATION/EXPANSIVENESS REQUIRES ONLY THREE C3 SYMPTOMS, WHILE IRRITABLE MOOD ALONE REQUIRES 4 OF THE C3 SYMPTOMS.

C4	What is the longest time these symptoms lasted?				
	a) 3 days or less		❒		❒
	b) 4 to 6 days		❒		❒
	c) 7 days or more		❒		❒
C5	Were you hospitalized for these problems?	NO	YES	NO	YES

IF YES, STOP HERE AND CIRCLE YES IN MANIC EPISODE FOR THAT TIME FRAME.

C6	Did these symptoms cause significant problems at home, at work, socially in your relationships with others, at school or in some other important way?	NO	YES	NO	YES

ARE **C3** SUMMARY AND **C5** AND **C6** CODED **YES** AND EITHER **C4a or b or c** CODED **YES**?

OR

ARE **C3** SUMMARY AND **C4c** AND **C6** CODED **YES** AND IS **C5** CODED **NO**?

SPECIFY IF THE EPISODE IS CURRENT AND / OR PAST.

NO **YES**

MANIC EPISODE

CURRENT ❒
PAST ❒

ARE **C3** SUMMARY **AND C5** AND **C6** CODED **NO** AND EITHER **C4b** OR **C4c** CODED **YES**?

OR

ARE **C3** SUMMARY AND **C4b** AND **C6** CODED **YES** AND IS **C5** CODED **NO?**

SPECIFY IF THE EPISODE IS CURRENT AND / OR PAST.

NO **YES**

HYPOMANIC EPISODE

CURRENT ❒
PAST ❒

ARE **C3** SUMMARY AND **C4a** CODED **YES** AND IS **C5** CODED **NO**? **NO** **YES**

HYPOMANIC SYMPTOMS

SPECIFY IF THE EPISODE IS CURRENT AND / OR PAST.

CURRENT ❒
PAST ❒

C7 a) IF MANIC EPISODE IS POSITIVE FOR EITHER CURRENT OR PAST ASK:
Did you have 2 or more manic episodes (**C4c**) in your lifetime (including the current episode if present)? NO YES

b) IF HYPOMANIC EPISODE IS POSITIVE FOR EITHER CURRENT OR PAST ASK:
Did you have 2 or more hypomanic EPISODES (**C4b**) in your lifetime (including the current episode)? NO YES

c) IF PAST "HYPOMANIC SYMPTOMS" IS CODED POSITIVE ASK:
Did you have 2 or more episodes of hypomanic SYMPTOMS (**C4a**) in your lifetime
(including the current episode if present)? NO YES

D. PANIC DISORDER

(➡ MEANS : CIRCLE NO IN D5, D6 AND D7 AND SKIP TO E1)

D1	a	Have you, on more than one occasion, had spells or attacks when you **suddenly** felt anxious, frightened, uncomfortable or uneasy, even in situations where most people would not feel that way?	➡ NO	YES
	b	Did the spells surge to a peak within 10 minutes of starting?	➡ NO	YES
D2		At any time in the past, did any of those spells or attacks come on unexpectedly or occur in an unpredictable or unprovoked manner?	➡ NO	YES
D3		Have you ever had one such attack followed by a month or more of persistent concern about having another attack, or worries about the consequences of the attack - or did you make a significant change in your behavior because of the attacks (e.g., shopping only with a companion, not wanting to leave your house, visiting the emergency room repeatedly, or seeing your doctor more frequently because of the symptoms)?	NO	YES
D4		**During the worst attack that you can remember:**		
	a	Did you have skipping, racing or pounding of your heart?	NO	YES
	b	Did you have sweating or clammy hands?	NO	YES
	c	Were you trembling or shaking?	NO	YES
	d	Did you have shortness of breath or difficulty breathing?	NO	YES
	e	Did you have a choking sensation or a lump in your throat?	NO	YES
	f	Did you have chest pain, pressure or discomfort?	NO	YES
	g	Did you have nausea, stomach problems or sudden diarrhea?	NO	YES
	h	Did you feel dizzy, unsteady, lightheaded or faint?	NO	YES
	i	Did things around you feel strange, unreal, detached or unfamiliar, or did you feel outside of or detached from part or all of your body?	NO	YES
	j	Did you fear that you were losing control or going crazy?	NO	YES
	k	Did you fear that you were dying?	NO	YES
	l	Did you have tingling or numbness in parts of your body?	NO	YES
	m	Did you have hot flushes or chills?	NO	YES
D5		ARE BOTH **D3,** AND **4** OR MORE **D4** ANSWERS, CODED **YES**? IF YES TO D5, SKIP TO D7.	NO	YES *PANIC DISORDER LIFETIME*
D6		IF **D5** = **NO,** ARE ANY D4 ANSWERS CODED **YES**? THEN SKIP TO **E1.**	NO	YES *LIMITED SYMPTOM ATTACKS LIFETIME*

D7 In the past month, did you have such attacks repeatedly (2 or more), and did you have persistent concern about having another attack, or worry about the consequences of the attacks, or did you change your behavior in any way because of the attacks? NO YES

PANIC DISORDER CURRENT

E. AGORAPHOBIA

E1 Do you feel anxious or uneasy in places or situations where help might not be available or escape might be difficult, like being in a crowd, standing in a line (queue), when you are alone away from home or alone at home, or when crossing a bridge, or traveling in a bus, train or car or where you might have a panic attack or the panic-like symptoms we just spoke about? NO YES

IF **E1** = **NO**, CIRCLE **NO** IN **E2**.

E2 Do you fear these situations so much that you avoid them, or suffer through them, or need a companion to face them? NO YES

AGORAPHOBIA CURRENT

IS **E2** (CURRENT AGORAPHOBIA) CODED **YES**

and

IS **D7** (CURRENT PANIC DISORDER) CODED **YES**?

NO YES

PANIC DISORDER with Agoraphobia CURRENT

IS **E2** (CURRENT AGORAPHOBIA) CODED **NO**

and

IS **D7** (CURRENT PANIC DISORDER) CODED **YES**?

NO YES

PANIC DISORDER without Agoraphobia CURRENT

IS **E2** (CURRENT AGORAPHOBIA) CODED **YES**

and

IS **D5** (PANIC DISORDER LIFETIME) CODED **NO**?

NO YES

AGORAPHOBIA, CURRENT without history of Panic Disorder

F. SOCIAL PHOBIA (Social Anxiety Disorder)

(➡ MEANS : GO TO THE DIAGNOSTIC BOX, CIRCLE NO AND MOVE TO THE NEXT MODULE)

F1	In the past month, did you have persistent fear and significant anxiety at being watched, being the focus of attention, or of being humiliated or embarrassed? This includes things like speaking in public, eating in public or with others, writing while someone watches, or being in social situations.	➡ NO	YES
F2	Is this social fear excessive or unreasonable and does it almost always make you anxious?	➡ NO	YES
F3	Do you fear these social situations so much that you avoid them or suffer through them most of the time?	➡ NO	YES
F4	Do these social fears disrupt your normal work, school or social functioning or cause you significant distress?		

SUBTYPES

Do you fear and avoid 4 or more social situations?

If YES Generalized social phobia (social anxiety disorder)

If NO Non-generalized social phobia (social anxiety disorder)

EXAMPLES OF SUCH SOCIAL SITUATIONS TYPICALLY INCLUDE

- INITIATING OR MAINTAINING A CONVERSATION,
- PARTICIPATING IN SMALL GROUPS,
- DATING,
- SPEAKING TO AUTHORITY FIGURES,
- ATTENDING PARTIES,
- PUBLIC SPEAKING,
- EATING IN FRONT OF OTHERS,
- URINATING IN A PUBLIC WASHROOM, ETC.

NOTE TO INTERVIEWER: PLEASE ASSESS WHETHER THE SUBJECT'S FEARS ARE RESTRICTED TO NON-GENERALIZED ("ONLY 1 OR SEVERAL") SOCIAL SITUATIONS OR EXTEND TO GENERALIZED ("MOST") SOCIAL SITUATIONS. "MOST" SOCIAL SITUATIONS IS USUALLY OPERATIONALIZED TO MEAN 4 OR MORE SOCIAL SITUATIONS, ALTHOUGH THE DSM-IV DOES NOT EXPLICITLY STATE THIS.

NO **YES**

SOCIAL PHOBIA
(Social Anxiety Disorder)
CURRENT

GENERALIZED ❒

NON-GENERALIZED ❒

G. OBSESSIVE-COMPULSIVE DISORDER

(➡ MEANS: GO TO THE DIAGNOSTIC BOX, CIRCLE NO AND MOVE TO THE NEXT MODULE)

G1 In the past month, have you been bothered by recurrent thoughts, impulses, or images that were unwanted, distasteful, inappropriate, intrusive, or distressing? - (For example, the idea that you were dirty, contaminated or had germs, **or** fear of contaminating others, **or** fear you would act on some impulse, **or** fear or superstitions that you would be responsible for things going wrong, **or** obsessions with sexual thoughts, images or impulses, **or** hoarding, collecting, **or** religious obsessions.)

(DO NOT INCLUDE SIMPLY EXCESSIVE WORRIES ABOUT REAL LIFE PROBLEMS. DO NOT INCLUDE OBSESSIONS DIRECTLY RELATED TO EATING DISORDERS, SEXUAL DEVIATIONS, PATHOLOGICAL GAMBLING, OR ALCOHOL OR DRUG ABUSE BECAUSE THE PATIENT MAY DERIVE PLEASURE FROM THE ACTIVITY AND MAY WANT TO RESIST IT ONLY BECAUSE OF ITS NEGATIVE CONSEQUENCES.)

NO YES
↓
SKIP TO **G4**

G2 Did they keep coming back into your mind even when you tried to ignore or get rid of them?

NO YES
↓
SKIP TO **G4**

G3 Do you think that these obsessions are the product of your own mind and that they are not imposed from the outside?

NO YES
obsessions

G4 In the past month, did you do something repeatedly without being able to resist doing it, like washing or cleaning excessively, counting or checking things over and over, or repeating, collecting, arranging things, or other superstitious rituals?

NO YES
compulsions

➡

IS **G3** OR **G4** CODED **YES**?

NO YES

➡

G5 At any point, did you recognize that either these obsessive thoughts or these compulsive behaviors were excessive or unreasonable?

NO YES

G6 In the past month, did these obsessive thoughts and/or compulsive behaviors significantly interfere with your normal routine, your work or school, your usual social activities, or relationships, or did they take more than one hour a day?

NO **YES**

O.C.D. CURRENT

H. POSTTRAUMATIC STRESS DISORDER

(➡ MEANS : GO TO THE DIAGNOSTIC BOX, CIRCLE NO, AND MOVE TO THE NEXT MODULE)

H1	Have you ever experienced or witnessed or had to deal with an extremely traumatic event that included actual or threatened death or serious injury to you or someone else? EXAMPLES OF TRAUMATIC EVENTS INCLUDE: SERIOUS ACCIDENTS, SEXUAL OR PHYSICAL ASSAULT, A TERRORIST ATTACK, BEING HELD HOSTAGE, KIDNAPPING, FIRE, DISCOVERING A BODY, WAR, OR NATURAL DISASTER, WITNESSING THE VIOLENT OR SUDDEN DEATH OF SOMEONE CLOSE TO YOU, OR A LIFE THREATENING ILLNESS.	➡ NO	YES
H2	Did you respond with intense fear, helplessness or horror?	➡ NO	YES
H3	During the past month, have you re-experienced the event in a distressing way (such as in dreams, intense recollections, flashbacks or physical reactions) or did you have intense distress when you were reminded about the event or exposed to a similar event?	➡ NO	YES

H4	**In the past month:**			
	a	Have you avoided thinking about or talking about the event ?	NO	YES
	b	Have you avoided activities, places or people that remind you of the event?	NO	YES
	c	Have you had trouble recalling some important part of what happened?	NO	YES
	d	Have you become much less interested in hobbies or social activities?	NO	YES
	e	Have you felt detached or estranged from others?	NO	YES
	f	Have you noticed that your feelings are numbed?	NO	YES
	g	Have you felt that your life will be shortened or that you will die sooner than other people?	NO	YES
		ARE **3** OR MORE **H4** ANSWERS CODED **YES**?	➡ NO	YES
H5	**In the past month:**			
	a	Have you had difficulty sleeping?	NO	YES
	b	Were you especially irritable or did you have outbursts of anger?	NO	YES
	c	Have you had difficulty concentrating?	NO	YES
	d	Were you nervous or constantly on your guard?	NO	YES
	e	Were you easily startled?	NO	YES
		ARE **2** OR MORE **H5** ANSWERS CODED **YES**?	➡ NO	YES

H6	During the past month, have these problems significantly interfered with your work, school or social activities, or caused significant distress?	**NO** **YES** ***POSTTRAUMATIC STRESS DISORDER CURRENT***

I. ALCOHOL DEPENDENCE / ABUSE

(➡ MEANS: GO TO DIAGNOSTIC BOXES, CIRCLE NO IN BOTH AND MOVE TO THE NEXT MODULE)

		➡	
I1	**In the past 12 months**, have you had 3 or more alcoholic drinks, - within a 3 hour period, - on 3 or more occasions?	NO	YES

I2 **In the past 12 months**:

a	Did you need to drink a lot more in order to get the same effect that you got when you first started drinking or did you get much less effect with continued use of the same amount?	NO	YES
b	When you cut down on drinking did your hands shake, did you sweat or feel agitated? Did you drink to avoid these symptoms (for example, "the shakes", sweating or agitation) or to avoid being hungover? IF **YES** TO ANY, CODE **YES**.	NO	YES
c	During the times when you drank alcohol, did you end up drinking more than you planned when you started?	NO	YES
d	Have you tried to reduce or stop drinking alcohol but failed?	NO	YES
e	On the days that you drank, did you spend substantial time in obtaining alcohol, drinking, or in recovering from the effects of alcohol?	NO	YES
f	Did you spend less time working, enjoying hobbies, or being with others because of your drinking?	NO	YES
g	If your drinking caused you health or mental problems, did you still keep on drinking?	NO	YES

ARE **3** OR MORE **I2** ANSWERS CODED **YES**?

***** IF YES, SKIP I3 QUESTIONS AND GO TO NEXT MODULE. "DEPENDENCE PREEMPTS ABUSE" IN DSM IV TR.

NO	YES*
ALCOHOL DEPENDENCE **CURRENT**	

I3 **In the past 12 months:**

a	Have you been intoxicated, high, or hungover more than once when you had other responsibilities at school, at work, or at home? Did this cause any problems? (CODE **YES** ONLY IF THIS CAUSED PROBLEMS.)	NO	YES
b	Were you intoxicated more than once in any situation where you were physically at risk, for example, driving a car, riding a motorbike, using machinery, boating, etc.?	NO	YES
c	Did you have legal problems more than once because of your drinking, for example, an arrest or disorderly conduct?	NO	YES
d	If your drinking caused problems with your family or other people, did you still keep on drinking?	NO	YES

ARE **1** OR MORE **I3** ANSWERS CODED **YES**?

NO	YES
	ALCOHOL ABUSE **CURRENT**

J. SUBSTANCE DEPENDENCE / ABUSE (NON-ALCOHOL)

(➡ MEANS : GO TO THE DIAGNOSTIC BOXES, CIRCLE NO IN ALL DIAGNOSTIC BOXES, AND MOVE TO THE NEXT MODULE)

Now I am going to show you / read to you a list of street drugs or medicines.

			➡	
J1	a	**In the past 12 months**, did you take any of these drugs more than once, to get high, to feel elated, to get "a buzz" or to change your mood?	NO	YES

CIRCLE EACH DRUG TAKEN:

Stimulants: amphetamines, "speed", crystal meth, "crank", "rush", Dexedrine, Ritalin, diet pills.

Cocaine: snorting, IV, freebase, crack, "speedball".

Narcotics: heroin, morphine, Dilaudid, opium, Demerol, methadone, Darvon, codeine, Percodan, Vicoden, OxyContin.

Hallucinogens: LSD ("acid"), mescaline, peyote, psilocybin, STP, "mushrooms", "ecstasy", MDA, MDMA.

Phencyclidine: PCP ("Angel Dust", "PeaCe Pill", "Tranq", "Hog"), or ketamine ("special K").

Inhalants: "glue", ethyl chloride, "rush", nitrous oxide ("laughing gas"), amyl or butyl nitrate ("poppers").

Cannabis: marijuana, hashish ("hash"), THC, "pot", "grass", "weed", "reefer".

Tranquilizers: Quaalude, Seconal ("reds"), Valium, Xanax, Librium, Ativan, Dalmane, Halcion, barbiturates, Miltown, GHB, Roofinol, "Roofies".

Miscellaneous: steroids, nonprescription sleep or diet pills. Cough Medicine? Any others?

SPECIFY THE MOST USED DRUG(S): _____

WHICH DRUG(S) CAUSE THE BIGGEST PROBLEMS?: _____

FIRST EXPLORE THE DRUG CAUSING THE BIGGEST PROBLEMS AND MOST LIKELY TO MEET DEPENDENCE / ABUSE CRITERIA.

IF MEETS CRITERIA FOR ABUSE OR DEPENDENCE, SKIP TO THE NEXT MODULE. OTHERWISE, EXPLORE THE NEXT MOST PROBLEMATIC DRUG.

J2 **Considering your use of (NAME THE DRUG / DRUG CLASS SELECTED), in the past 12 months:**

a	Have you found that you needed to use much more (NAME OF DRUG / DRUG CLASS SELECTED) to get the same effect that you did when you first started taking it?	NO	YES
b	When you reduced or stopped using (NAME OF DRUG / DRUG CLASS SELECTED), did you have withdrawal symptoms (aches, shaking, fever, weakness, diarrhea, nausea, sweating, heart pounding, difficulty sleeping, or feeling agitated, anxious, irritable, or depressed)? Did you use any drug(s) to keep yourself from getting sick (withdrawal symptoms) or so that you would feel better?	NO	YES
	IF **YES** TO EITHER, CODE **YES**.		
c	Have you often found that when you used (NAME OF DRUG / DRUG CLASS SELECTED), you ended up taking more than you thought you would?	NO	YES
d	Have you tried to reduce or stop taking (NAME OF DRUG / DRUG CLASS SELECTED) but failed?	NO	YES
e	On the days that you used (NAME OF DRUG / DRUG CLASS SELECTED), did you spend substantial time (>2 HOURS), obtaining, using or in recovering from the drug, or thinking about the drug?	NO	YES
f	Did you spend less time working, enjoying hobbies, or being with family or friends because of your drug use?	NO	YES
g	If (NAME OF DRUG / DRUG CLASS SELECTED) caused you health or mental problems, did you still keep on using it?	NO	YES

ARE **3** OR MORE **J2** ANSWERS CODED **YES**?

SPECIFY DRUG(S): _____

***** IF YES, SKIP J3 QUESTIONS, MOVE TO NEXT DISORDER.
"DEPENDENCE PREEMPTS ABUSE" IN DSM IV TR.

NO **YES ***

SUBSTANCE DEPENDENCE
CURRENT

Considering your use of (NAME THE DRUG CLASS SELECTED), in the past 12 months:

J3 a Have you been intoxicated, high, or hungover from (NAME OF DRUG / DRUG CLASS SELECTED) more than once, when you had other responsibilities at school, at work, or at home? Did this cause any problem? NO YES

(CODE **YES** ONLY IF THIS CAUSED PROBLEMS.)

b Have you been high or intoxicated from (NAME OF DRUG / DRUG CLASS SELECTED) more than once in any situation where you were physically at risk (for example, driving a car, riding a motorbike, using machinery, boating, etc.)? NO YES

c Did you have legal problems more than once because of your drug use, for example, an arrest or disorderly conduct? NO YES

d If (NAME OF DRUG / DRUG CLASS SELECTED) caused problems with your family or other people, did you still keep on using it? NO YES

ARE **1** OR MORE **J3** ANSWERS CODED **YES**?

SPECIFY DRUG(S): _____

NO **YES**

SUBSTANCE ABUSE
CURRENT

K. PSYCHOTIC DISORDERS AND MOOD DISORDER WITH PSYCHOTIC FEATURES

ASK FOR AN EXAMPLE OF EACH QUESTION ANSWERED POSITIVELY. CODE **YES** ONLY IF THE EXAMPLES CLEARLY SHOW A DISTORTION OF THOUGHT OR OF PERCEPTION OR IF THEY ARE NOT CULTURALLY APPROPRIATE. BEFORE CODING, INVESTIGATE WHETHER DELUSIONS QUALIFY AS "BIZARRE".

DELUSIONS ARE "BIZARRE" IF: CLEARLY IMPLAUSIBLE, ABSURD, NOT UNDERSTANDABLE, AND CANNOT DERIVE FROM ORDINARY LIFE EXPERIENCE.
HALLUCINATIONS ARE SCORED "BIZARRE" IF: A VOICE COMMENTS ON THE PERSON'S THOUGHTS OR BEHAVIOR, OR WHEN TWO OR MORE VOICES ARE CONVERSING WITH EACH OTHER.
THE PURPOSE OF THIS MODULE IS TO EXCLUDE PATIENTS WITH PSYCHOTIC DISORDERS. THIS MODULE NEEDS EXPERIENCE.

		Now I am going to ask you about unusual experiences that some people have.			BIZARRE
K1	a	Have you ever believed that people were spying on you, or that someone was plotting against you, or trying to hurt you? **NOTE**: ASK FOR EXAMPLES TO RULE OUT ACTUAL STALKING.	NO	YES	YES
	b	**IF YES OR YES BIZARRE:** do you currently believe these things?	NO	YES	YES →**K6**
K2	a	Have you ever believed that someone was reading your mind or could hear your thoughts, or that you could actually read someone's mind or hear what another person was thinking?	NO	YES	YES
	b	**IF YES OR YES BIZARRE:** do you currently believe these things?	NO	YES	YES →**K6**
K3	a	Have you ever believed that someone or some force outside of yourself put thoughts in your mind that were not your own, or made you act in a way that was not your usual self? Have you ever felt that you were possessed? CLINICIAN: ASK FOR EXAMPLES AND DISCOUNT ANY THAT ARE NOT PSYCHOTIC.	NO	YES	YES
	b	**IF YES OR YES BIZARRE:** do you currently believe these things?	NO	YES	YES →**K6**
K4	a	Have you ever believed that you were being sent special messages through the TV, radio, newspapers, books or magazines or that a person you did not personally know was particularly interested in you?	NO	YES	YES
	b	**IF YES OR YES BIZARRE:** do you currently believe these things?	NO	YES	YES →**K6**
K5	a	Have your relatives or friends ever considered any of your beliefs odd or unusual? INTERVIEWER**:** ASK FOR EXAMPLES. ONLY CODE **YES** IF THE EXAMPLES ARE **CLEARLY** DELUSIONAL IDEAS NOT EXPLORED IN QUESTIONS K1 TO K4, FOR EXAMPLE, SOMATIC OR RELIGIOUS DELUSIONS OR DELUSIONS OF GRANDIOSITY, JEALOUSY, GUILT, RUIN OR DESTITUTION, ETC.	NO	YES	YES
	b	**IF YES OR YES BIZARRE:** do they currently consider your beliefs strange?	NO	YES	YES
K6	a	Have you ever heard things other people couldn't hear, such as voices?	NO	YES	
		IF YES TO VOICE HALLUCINATION: Was the voice commenting on your thoughts or behavior or did you hear two or more voices talking to each other?	NO		YES
	b	**IF YES OR YES BIZARRE TO K6a:** have you heard sounds / voices in the past month?	NO	YES	
		IF YES TO VOICE HALLUCINATION: Was the voice commenting on your thoughts or behavior or did you hear two or more voices talking to each other?	NO		YES →**K8b**

K7 a Have you ever had visions when you were awake or have you ever seen things other people couldn't see? NO YES

CLINICIAN: CHECK TO SEE IF THESE ARE CULTURALLY INAPPROPRIATE.

b **IF YES:** have you seen these things in the past month? NO YES

CLINICIAN'S JUDGMENT

K8 b IS THE PATIENT CURRENTLY EXHIBITING INCOHERENCE, DISORGANIZED SPEECH, OR MARKED LOOSENING OF ASSOCIATIONS? NO YES

K9 b IS THE PATIENT CURRENTLY EXHIBITING DISORGANIZED OR CATATONIC BEHAVIOR? NO YES

K10 b ARE NEGATIVE SYMPTOMS OF SCHIZOPHRENIA, E.G. SIGNIFICANT AFFECTIVE FLATTENING, POVERTY OF SPEECH (ALOGIA) OR AN INABILITY TO INITIATE OR PERSIST IN GOAL-DIRECTED ACTIVITIES (AVOLITION), PROMINENT DURING THE INTERVIEW? NO YES

K11 a ARE 1 OR MORE « a » QUESTIONS FROM K1a TO K7a CODED **YES OR YES BIZARRE** AND IS EITHER:

MAJOR DEPRESSIVE EPISODE, (CURRENT, RECURRENT OR PAST)
OR
MANIC OR HYPOMANIC EPISODE, (CURRENT OR PAST) CODED **YES**? NO YES
↳ **K13**

IF NO TO K11 a, CIRCLE NO IN BOTH 'MOOD DISORDER WITH PSYCHOTIC FEATURES' DIAGNOSTIC BOXES AND MOVE TO K13.

b You told me earlier that you had period(s) when you felt (depressed/high/persistently irritable).

Were the beliefs and experiences you just described (SYMPTOMS CODED **YES** FROM **K1**a TO **K7**a) restricted exclusively to times when you were feeling depressed/high/irritable?

IF THE PATIENT EVER HAD A PERIOD OF AT LEAST 2 WEEKS OF HAVING THESE BELIEFS OR EXPERIENCES (PSYCHOTIC SYMPTOMS) WHEN THEY WERE NOT DEPRESSED/HIGH/IRRITABLE, CODE NO TO THIS DISORDER.

IF THE ANSWER IS NO TO THIS DISORDER, ALSO CIRCLE NO TO K12 AND MOVE TO K13

NO **YES**

MOOD DISORDER WITH *PSYCHOTIC FEATURES*

LIFETIME

K12 a ARE 1 OR MORE « b » QUESTIONS FROM K1b TO K7b CODED **YES OR YES BIZARRE** AND IS EITHER:

MAJOR DEPRESSIVE EPISODE, (CURRENT)
OR
MANIC OR HYPOMANIC EPISODE, (CURRENT) CODED **YES**?

IF THE ANSWER IS YES TO THIS DISORDER (LIFETIME OR CURRENT), CIRCLE NO TO K13 AND K14 AND MOVE TO THE NEXT MODULE.

NO **YES**

MOOD DISORDER WITH *PSYCHOTIC FEATURES*

CURRENT

K13 ARE 1 OR MORE « b » QUESTIONS FROM K1b TO K6b, CODED **YES BIZARRE**?

OR

ARE 2 OR MORE « b » QUESTIONS FROM K1b TO K10b, CODED **YES** (RATHER THAN **YES BIZARRE**)?

AND DID AT LEAST TWO OF THE PSYCHOTIC SYMPTOMS OCCUR DURING THE SAME 1 MONTH PERIOD?

NO **YES**

PSYCHOTIC DISORDER
CURRENT

K14 IS **K13** CODED **YES**

OR

ARE 1 OR MORE « a » QUESTIONS FROM K1a TO K6a, CODED **YES BIZARRE**?

OR

ARE 2 OR MORE « a » QUESTIONS FROM K1a TO K7a, CODED **YES** (RATHER THAN **YES BIZARRE**)

AND DID AT LEAST TWO OF THE PSYCHOTIC SYMPTOMS OCCUR DURING THE SAME 1 MONTH PERIOD?

NO **YES**

PSYCHOTIC DISORDER
LIFETIME

L. ANOREXIA NERVOSA

(➡ MEANS : GO TO THE DIAGNOSTIC BOX, CIRCLE NO, AND MOVE TO THE NEXT MODULE)

L1	a	How tall are you?	❑ ft ❑❑ in. ❑❑❑ cm.
	b.	What was your lowest weight in the past 3 months?	❑❑❑ lbs. ❑❑❑ kgs.
	c	IS PATIENT'S WEIGHT EQUAL TO OR BELOW THE THRESHOLD CORRESPONDING TO HIS / HER HEIGHT? (SEE TABLE BELOW)	➡ NO YES

In the past 3 months:

L2		In spite of this low weight, have you tried not to gain weight?	➡ NO YES
L3		Have you intensely feared gaining weight or becoming fat, even though you were underweight?	➡ NO YES
L4	a	Have you considered yourself too big / fat or that part of your body was too big / fat?	NO YES
	b	Has your body weight or shape greatly influenced how you felt about yourself?	NO YES
	c	Have you thought that your current low body weight was normal or excessive?	NO YES
L5		ARE 1 OR MORE ITEMS FROM **L4** CODED **YES**?	➡ NO YES
L6		FOR WOMEN ONLY: During the last 3 months, did you miss all your menstrual periods when they were expected to occur (when you were not pregnant)?	➡ NO YES

FOR WOMEN: ARE **L5 AND L6** CODED **YES**?

FOR MEN: IS **L5** CODED **YES**?

NO YES

ANOREXIA NERVOSA
CURRENT

HEIGHT / WEIGHT TABLE CORRESPONDING TO A BMI THRESHOLD OF 17.5 KG/M^2

Height/Weight														
ft/in	4'9	4'10	4'11	5'0	5'1	5'2	5'3	5'4	5'5	5'6	5'7	5'8	5'9	5'10
lbs.	81	84	87	89	92	96	99	102	105	108	112	115	118	122
cm	145	147	150	152	155	158	160	163	165	168	170	173	175	178
kgs	37	38	39	41	42	43	45	46	48	49	51	52	54	55

Height/Weight					
ft/in	5'11	6'0	6'1	6'2	6'3
lbs.	125	129	132	136	140
cm	180	183	185	188	191
kgs	57	59	60	62	64

The weight thresholds above are calculated using a body mass index (BMI) equal to or below 17.5 kg/m^2 for the patient's height. This is the threshold guideline below which a person is deemed underweight by the DSM-IV and the ICD-10 Diagnostic Criteria for Research for Anorexia Nervosa.

M. BULIMIA NERVOSA

(➡ MEANS : GO TO THE DIAGNOSTIC BOXES, CIRCLE NO IN ALL DIAGNOSTIC BOXES, AND MOVE TO THE NEXT MODULE)

M1	In the past three months, did you have eating binges or times when you ate a very large amount of food within a 2-hour period?	➡ NO	YES
M2	In the last 3 months, did you have eating binges as often as twice a week?	➡ NO	YES
M3	During these binges, did you feel that your eating was out of control?	➡ NO	YES
M4	Did you do anything to compensate for, or to prevent a weight gain from these binges, like vomiting, fasting, exercising or taking laxatives, enemas, diuretics (fluid pills), or other medications?	➡ NO	YES
M5	Does your body weight or shape greatly influence how you feel about yourself?	➡ NO	YES
M6	DO THE PATIENT'S SYMPTOMS MEET CRITERIA FOR ANOREXIA NERVOSA?	NO	YES ↓ Skip to M8
M7	Do these binges occur only when you are under (____lbs./kgs.)? INTERVIEWER: WRITE IN THE ABOVE PARENTHESIS THE THRESHOLD WEIGHT FOR THIS PATIENT'S HEIGHT FROM THE HEIGHT / WEIGHT TABLE IN THE ANOREXIA NERVOSA MODULE.	NO	YES

M8 IS **M5** CODED **YES** AND IS EITHER **M6** OR **M7** CODED **NO**?

NO **YES**

BULIMIA NERVOSA
CURRENT

IS **M7** CODED **YES**?

NO **YES**

ANOREXIA NERVOSA
Binge Eating/Purging Type
CURRENT

N. GENERALIZED ANXIETY DISORDER

(➡ MEANS : GO TO THE DIAGNOSTIC BOX, CIRCLE NO, AND MOVE TO THE NEXT MODULE)

N1	a	Were you excessively anxious or worried about several routine things, over the past 6 months? IN ENGLISH, IF THE PATIENT IS UNCLEAR ABOUT WHAT YOU MEAN, PROBE BY ASKING (Do others think that you are a "worry wart") AND GET EXAMPLES.	➡ NO	YES
	b	Are these anxieties and worries present most days?	➡ NO	YES
		ARE THE PATIENT'S ANXIETY AND WORRIES RESTRICTED EXCLUSIVELY TO, OR BETTER EXPLAINED BY, ANY DISORDER PRIOR TO THIS POINT?	NO	➡ YES
N2		Do you find it difficult to control the worries?	➡ NO	YES
N3		FOR THE FOLLOWING, CODE **NO** IF THE SYMPTOMS ARE CONFINED TO FEATURES OF ANY DISORDER EXPLORED PRIOR TO THIS POINT**.**		
		When you were anxious over the past 6 months, did you, most of the time:		
	a	Feel restless, keyed up or on edge?	NO	YES
	b	Have muscle tension?	NO	YES
	c	Feel tired, weak or exhausted easily?	NO	YES
	d	Have difficulty concentrating or find your mind going blank?	NO	YES
	e	Feel irritable?	NO	YES
	f	Have difficulty sleeping (difficulty falling asleep, waking up in the middle of the night, early morning wakening or sleeping excessively)?	NO	YES
		ARE **3** OR MORE **N3** ANSWERS CODED **YES?**	➡ NO	YES
N4		Do these anxieties and worries disrupt your normal work, school or social functioning or cause you significant distress?	**NO**	**YES**

GENERALIZED ANXIETY DISORDER
CURRENT

O. RULE OUT MEDICAL, ORGANIC OR DRUG CAUSES FOR ALL DISORDERS

IF THE PATIENT CODES POSITIVE FOR ANY CURRENT DISORDER ASK:

Just before these symptoms began:

O1a	Were you taking any drugs or medicines?	❒ No	❒ Yes	❒ Uncertain
O1b	Did you have any medical illness?	❒ No	❒ Yes	❒ Uncertain

IN THE CLINICIAN'S JUDGMENT: ARE EITHER OF THESE LIKELY TO BE DIRECT CAUSES OF THE PATIENT'S DISORDER?
IF NECESSARY ASK ADDITIONAL OPEN-ENDED QUESTIONS.

O2	**SUMMARY**: HAS AN ORGANIC CAUSE BEEN RULED OUT?	❒ No	❒ Yes	❒ Uncertain

P. ANTISOCIAL PERSONALITY DISORDER

(➡ MEANS : GO TO THE DIAGNOSTIC BOX AND CIRCLE NO)

P1 **Before you were 15 years old, did you:**

a	repeatedly skip school or run away from home overnight?	NO	YES
b	repeatedly lie, cheat, "con" others, or steal?	NO	YES
c	start fights or bully, threaten, or intimidate others?	NO	YES
d	deliberately destroy things or start fires?	NO	YES
e	deliberately hurt animals or people?	NO	YES
f	force someone to have sex with you?	NO	YES
		➡	
	ARE **2** OR MORE **P1** ANSWERS CODED **YES**?	NO	YES

DO NOT CODE **YES** TO THE BEHAVIORS BELOW IF THEY ARE EXCLUSIVELY POLITICALLY OR RELIGIOUSLY MOTIVATED**.**

P2 **Since you were 15 years old, have you:**

a	repeatedly behaved in a way that others would consider irresponsible, like failing to pay for things you owed, deliberately being impulsive or deliberately not working to support yourself?	NO	YES
b	done things that are illegal even if you didn't get caught (for example, destroying property, shoplifting, stealing, selling drugs, or committing a felony)?	NO	YES
c	been in physical fights repeatedly (including physical fights with your spouse or children)?	NO	YES
d	often lied or "conned" other people to get money or pleasure, or lied just for fun?	NO	YES
e	exposed others to danger without caring?	NO	YES
f	felt no guilt after hurting, mistreating, lying to, or stealing from others, or after damaging property?	NO	YES

ARE **3** OR MORE **P2** QUESTIONS CODED **YES**?

NO **YES**

ANTISOCIAL PERSONALITY DISORDER
LIFETIME

THIS CONCLUDES THE INTERVIEW

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A validation study of this instrument was made possible, in part, by grants from SmithKline Beecham and the European Commission.
The authors are grateful to Dr. Pauline Powers for her advice on the modules on Anorexia Nervosa and Bulimia.

MOOD DISORDERS: DIAGNOSTIC ALGORITHM

Consult Modules:

A	Major Depressive Episode
C	(Hypo) manic Episode
K	Psychotic Disorders

MODULE K:

1a	IS **K11b** CODED YES?	NO	YES
1b	IS **K12a** CODED YES?	NO	YES

MODULES A and C:		Current	Past
2 a	CIRCLE YES IF A DELUSIONAL IDEA IS IDENTIFIED IN **A3e**?	YES	YES
b	CIRCLE YES IF A DELUSIONAL IDEA IS IDENTIFIED IN **C3a**?	YES	YES

c Is a Major Depressive Episode coded YES (current or past)?
and
is Manic Episode coded NO (current and past)?
and
is Hypomanic Episode coded NO (current and past)?
and
is **"**Hypomanic Symptoms" coded NO (current and past)?

Specify:

- If the depressive episode is **current** or **past** or both
- **With Psychotic Features** Current: If 1b or 2a (current) = YES
  With Psychotic Features Past: If 1a or 2a (past) = YES

MAJOR DEPRESSIVE DISORDER

	current	past
MDD	❑	❑

With Psychotic Features

Current	❑
Past	❑

d Is a Manic Episode coded YES (current or past)?

Specify:

- If the Bipolar I Disorder is **current** or **past** or both
- With **Single Manic Episode**: If Manic episode (current or past) = YES
  and MDE (current and past) = NO
- **With Psychotic Features** Current: If 1b or 2a (current) or 2b (current) = YES
  With Psychotic Features Past: If 1a or 2a (past) or 2b (past) = YES
- If the **most recent episode** is manic, depressed,
  mixed or hypomanic or unspecified (all mutually exclusive)
- **Unspecified** if the Past Manic Episode is coded YES AND
  Current (C3 Summary AND C4a AND C6 AND O2) are coded YES

BIPOLAR I DISORDER

	current	past
Bipolar I Disorder	❑	❑
Single Manic Episode	❑	❑

With Psychotic Features

Current	❑
Past	❑

Most Recent Episode

Manic	❑
Depressed	❑
Mixed	❑
Hypomanic	❑
Unspecified	❑

e Is Major Depressive Episode coded YES (current or past)?
and
Is Hypomanic Episode coded YES (current or past)?
and
Is Manic Episode coded NO (current and past)?

Specify:

- If the Bipolar Disorder is **current** or **past** or both
- If the most recent mood episode is **hypomanic** or **depressed** (mutually exclusive)

BIPOLAR II DISORDER

	current	past
Bipolar II Disorder	❑	❑

Most Recent Episode

Hypomanic	❑
Depressed	❑

f Is MDE coded NO (current and past)
and
Is Manic Episode coded NO (current and past)?
and is either:

1) C7b coded YES for the appropriate time frame?

or

2) C3 Summary coded YES for the appropriate time frame?
and
C4a coded YES for the appropriate time frame?
and
C7c coded YES for the appropriate time frame?

Specify if the Bipolar Disorder NOS is **current** or **past** or both

BIPOLAR DISORDER NOS

	current	past
Bipolar Disorder NOS	❑	❑

M.I.N.I. PLUS

The shaded modules below are additional modules available in the MINI PLUS beyond what is available in the standard MINI. The un-shaded modules below are in the standard MINI.

These MINI PLUS modules can be inserted into or used in place of the standard MINI modules, as dictated by the specific needs of any study.

	MODULES	TIME FRAME
A	MAJOR DEPRESSIVE EPISODE	Current (2 weeks) Past Recurrent
	MOOD DISORDER DUE TO A GENERAL MEDICAL CONDITION	Current Past
	SUBSTANCE INDUCED MOOD DISORDER	Current Past
	MDE WITH MELANCHOLIC FEATURES	Current (2 weeks)
	MDE WITH ATYPICAL FEATURES	Current (2 weeks)
	MDE WITH CATATONIC FEATURES	Current (2 weeks)
B	DYSTHYMIA	Current (Past 2 years) Past
C	SUICIDALITY	Current (Past Month) Risk: ❑ Low ❑ Medium ❑ High
D	MANIC EPISODE	Current Past
	HYPOMANIC EPISODE	Current Past
	BIPOLAR I DISORDER	Current Past
	BIPOLAR II DISORDER	Current Past
	BIPOLAR DISORDER NOS	Current Past
	MANIC EPISODE DUE TO A GENERAL MEDICAL CONDITION	Current Past
	HYPOMANIC EPISODE DUE TO A GENERAL MEDICAL CONDITION	Current Past
	SUBSTANCE INDUCED MANIC EPISODE	Current Past
	SUBSTANCE INDUCED HYPOMANIC EPISODE	Current Past
E	PANIC DISORDER	Current (Past Month) Lifetime
	ANXIETY DISORDER WITH PANIC ATTACKS DUE TO A GENERAL MEDICAL CONDITION	Current
	SUBSTANCE INDUCED ANXIETY DISORDER WITH PANIC ATTACKS	Current
F	AGORAPHOBIA	Current
G	SOCIAL PHOBIA (Social Anxiety Disorder)	Current (Past Month)
H	SPECIFIC PHOBIA	Current
I	OBSESSIVE-COMPULSIVE DISORDER	Current (Past Month)
	OCD DUE TO A GENERAL MEDICAL CONDITION	Current
	SUBSTANCE INDUCED OCD	Current
J	POSTTRAUMATIC STRESS DISORDER	Current (Past Month)
K	ALCOHOL DEPENDENCE	Past 12 Months
	ALCOHOL DEPENDENCE	Lifetime
	ALCOHOL ABUSE	Past 12 Months
	ALCOHOL ABUSE	Lifetime
L	SUBSTANCE DEPENDENCE (Non-alcohol)	Past 12 Months
	SUBSTANCE DEPENDENCE (Non-alcohol)	Lifetime
	SUBSTANCE ABUSE (Non-alcohol)	Past 12 Months

M	PSYCHOTIC DISORDERS	Lifetime
		Current
	MOOD DISORDER WITH PSYCHOTIC FEATURES	Current
	SCHIZOPHRENIA	Current
		Lifetime
	SCHIZOAFFECTIVE DISORDER	Current
		Lifetime
	SCHIZOPHRENIFORM DISORDER	Current
		Lifetime
	BRIEF PSYCHOTIC DISORDER	Current
		Lifetime
	DELUSIONAL DISORDER	Current
		Lifetime
	PSYCHOTIC DISORDER DUE TO A GENERAL MEDICAL CONDITION	Current
		Lifetime
	SUBSTANCE INDUCED PSYCHOTIC DISORDER	Current
		Lifetime
	PSYCHOTIC DISORDER NOS	Current
		Lifetime
	MOOD DISORDER WITH PSYCHOTIC FEATURES	Lifetime
	MOOD DISORDER NOS	Lifetime
	MAJOR DEPRESSIVE DISORDER WITH PSYCHOTIC FEATURES	Current
		Past
	BIPOLAR I DISORDER WITH PSYCHOTIC FEATURES	Current
		Past
N	ANOREXIA NERVOSA	Current (Past 3 Months)
O	BULIMIA NERVOSA	Current (Past 3 Months)
	BULIMIA NERVOSA PURGING TYPE	Current
	BULIMIA NERVOSA NONPURGING TYPE	Current
	ANOREXIA NERVOSA, BINGE EATING/PURGING TYPE	Current
	ANOREXIA NERVOSA, RESTRICTING TYPE	Current
P	GENERALIZED ANXIETY DISORDER	Current (Past 6 Months)
	GENERALIZED ANXIETY DISORDER DUE TO A GENERAL MEDICAL CONDITION	Current
	SUBSTANCE INDUCED GAD	Current
Q	ANTISOCIAL PERSONALITY DISORDER	Lifetime
R	SOMATIZATION DISORDER	Lifetime
		Current
S	HYPOCHONDRIASIS	Current
T	BODY DYSMORPHIC DISORDER	Current
U	PAIN DISORDER	Current
V	CONDUCT DISORDER	Past 12 Months
W	ATTENTION DEFICIT/HYPERACTIVITY DISORDER (Children/Adolescents)	Past 6 Months
	ATTENTION DEFICIT/HYPERACTIVITY DISORDER (Adults)	Lifetime
		Current
X	ADJUSTMENT DISORDERS	Current
Y	PREMENSTRUAL DYSPHORIC DISORDER	Current
Z	MIXED ANXIETY-DEPRESSIVE DISORDER	Current

CVLT-II
California Verbal Learning Test®
Second Edition • Adult Version

California Verbal Learning Test–Second Edition

Dean C. Delis Joel H. Kramer Edith Kaplan Beth A. Ober

Standard Form

ID#: _____ Examiner: _____

	Year	Month	Day
Date Tested			
Age at Testing			

Sex: ☐ F ☐ M Race/Ethnicity: _____ Education (years): _____

Handedness: ☐ R ☐ L ☐ Ambidextrous Hearing adequate? ☐ Y ☐ N Hearing aid? ☐ Y ☐ N

First language: _____ Preferred language: _____ Effort appear adequate? ☐ Y ☐ ? ☐ N

Affect and mood: _____ Physical appearance: _____

Other behaviors: _____

Major complaints: _____

Diagnostic history: _____

_____

Current medications: _____

	Raw Score	Standard Score		Raw Score	Standard Score
Trial 1 Free Recall **Correct**			Long-Delay Free Recall **Correct**		
Trial 2 Free Recall **Correct**			Long-Delay Cued Recall **Correct**		
Trial 3 Free Recall **Correct**			Free-Recall **Intrusions** (Immediate & Delayed, All Types)		
Trial 4 Free Recall **Correct**			Cued-Recall **Intrusions** (All Types)		
Trial 5 Free Recall **Correct**			Total **Intrusions** (All Recall Trials, All Types)		
Trials 1–5 Free Recall Total **Correct**		(*T* score)	Total **Repetitions** (All Recall Trials)		
List B Free Recall **Correct**			Long-Delay Yes/No Recognition **Hits**		
Short-Delay Free Recall **Correct**			Long-Delay Yes/No Recognition **False-Positives**		
Short-Delay Cued Recall **Correct**			Long-Delay Forced-Choice Recognition **Accuracy** (# hits _____ /16) × 100	%	

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Product Number 0154035742

List A Immediate Free Recall Trial 1

I'm going to read a list of words to you. Listen carefully, because when I'm through, I want you to tell me as many of the words as you can. You can say them in any order, just say as many of them as you can. Are you ready?

Read List A at an even pace, taking slightly longer than one second per word, so the entire list takes 18 to 20 seconds. Then say: **Go ahead.**

Trial 2

I'm going to read the same list again. Like before, tell me as many of the words as you can, in any order. Be sure to also say words from the list that you told me the first time.

Trials 3 and 4

I'm going to read the same list again. Like before, tell me as many of the words as you can, in any order, including words from the list you've said before.

Trial 5

I'm going to read the same list one more time. Like before, tell me as many of the words as you can, in any order, including words from the list you've said before.

Record all responses verbatim, in the order recalled. Prompt only once (e.g., Anything else?) at the end of each free and cued recall trial (i.e., after 15 seconds with no response or when the examinee says he/she cannot remember more words).

List A
truck
spinach
giraffe
bookcase
onion
motorcycle
cabinet
zebra
subway
lamp
celery
cow
desk
boat
squirrel
cabbage

	Trial 1	Resp Type	Trial 2	Resp Type	Trial 3	Resp Type	Trial 4	Resp Type	Trial 5	Resp Type
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
Total Correct	C		C		C		C		C	
Total Repetitions	R		R		R		R		R	
Total Intrusions	I		I		I		I		I	

List B Immediate Free Recall

Now I'm going to read a second list of words to you. When I'm through, I want you to tell me as many words from this second list as you can, in any order. Don't tell me words from the first list, just this second list.

Read List B at an even pace, taking slightly longer than one second per word, so the entire list takes 18 to 20 seconds. Then say: **Go ahead.**

List A Short-Delay Free Recall

Now I want you to tell me all the words you can from the *first* list, the one I read to you several times. Don't tell me words from the second list, just the first list. Go ahead.

List A Short-Delay Cued Recall

Tell me all the words from the first list that are furniture.
Tell me all the words from the first list that are vegetables.
Tell me all the words from the first list that are ways of traveling.
Tell me all the words from the first list that are animals.

Record all responses verbatim, in the order recalled. Prompt only once (e.g., Anything else?) at the end of each free and cued recall trial (i.e., after 15 seconds with no response or when the examinee says he/she cannot remember more words).

List B

violin
cucumber
elephant
closet
turnip
guitar
basement
sheep
clarinet
garage
corn
rabbit
patio
saxophone
tiger
radishes

Trial B

		Resp Type
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Total Correct C ☐
Total Repetitions R ☐
Total Intrusions I ☐

List A

		Resp Type
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Total Correct C ☐
Total Repetitions R ☐
Total Intrusions I ☐

Furniture

		Resp Type
1		
2		
3		
4		
5		
6		
7		
8		

Vegetables

		Resp Type
1		
2		
3		
4		
5		
6		
7		
8		

Ways of Traveling

		Resp Type
1		
2		
3		
4		
5		
6		
7		
8		

Animals

		Resp Type
1		
2		
3		
4		
5		
6		
7		
8		

Total Correct C ☐
Total Repetitions R ☐
Total Intrusions I ☐

*There should be approximately a **20-minute delay** between the completion of Short-Delay Cued Recall and the start of Long-Delay Free Recall. Do not inform the examinee that there will be later CVLT–II trials.*

List A Long-Delay Free Recall

I read two different lists of words to you earlier: a first list that I read to you several times, and a second list that I read to you once. Tell me all the words you can that were from the *first* list. Don't tell me words from the second list, just the first list. Go ahead.

List A

		Resp Type
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Total Correct C ☐

Total Repetitions R ☐

Total Intrusions I ☐

List A Long-Delay Cued Recall

Tell me all the words from the first list that are furniture.
Tell me all the words from the first list that are vegetables.
Tell me all the words from the first list that are ways of traveling.
Tell me all the words from the first list that are animals.

	Furniture	Resp Type	Vegetables	Resp Type	Ways of Traveling	Resp Type	Animals	Resp Type
1								
2								
3								
4								
5								
6								
7								
8								

Total Correct C ☐ Total Repetitions R ☐ Total Intrusions I ☐

List A Long-Delay Yes/No Recognition

Now I'm going to read more words to you. After I read each one, say "Yes" if that word was from the first list, or say "No" if it was not from the first list.

If the examinee responds "I don't know" during Yes/No Recognition, say, "Tell me whether you think _____ was on the first list."

	Response	Item Type		Response	Item Type		Response	Item Type		Response	Item Type
wallet	Y N	UN	violin	Y N	BN	dog	Y N	PR	turnip	Y N	BS
boat	**Y** N	T	**cow**	**Y** N	T	**bookcase**	**Y** N	T	**cabinet**	**Y** N	T
saxophone	Y N	BN	fork	Y N	UN	matches	Y N	UN	**onion**	**Y** N	T
cucumber	Y N	BS	bus	Y N	PR	**spinach**	**Y** N	T	lion	Y N	PR
giraffe	**Y** N	T	**celery**	**Y** N	T	clarinet	Y N	BN	camera	Y N	UN
carrot	Y N	PR	**lamp**	**Y** N	T	**truck**	**Y** N	T	guitar	Y N	BN
patio	Y N	BN	radishes	Y N	BS	rabbit	Y N	BS	**subway**	**Y** N	T
cabbage	**Y** N	T	table	Y N	PR	chair	Y N	PR	tiger	Y N	BS
desk	**Y** N	T	rose	Y N	UN	corn	Y N	BS	coffee	Y N	UN
bracelet	Y N	UN	**motorcycle**	**Y** N	T	seashell	Y N	UN	**zebra**	**Y** N	T
car	Y N	PR	sheep	Y N	BS	garage	Y N	BN	lettuce	Y N	PR
elephant	Y N	BS	basement	Y N	BN	**squirrel**	**Y** N	T	closet	Y N	BN

T = Target
Distractor Types: BS = List B Shared; BN = List B Non-Shared; PR = Prototypical; UN = Unrelated

Total Hits ☐

Total False-Positives ☐

*There should be approximately a **10-minute delay** between the completion of Yes/No Recognition and the start of Forced-Choice Recognition. Do not inform the examinee that there will be a later CVLT–II trial.*

List A Long-Delay Forced-Choice Recognition (Optional)

Earlier, I read some lists of words to you, remember? Now I am going to read some words two at a time. After I read both words, say which of the words was from the *first* list, the one I read to you several times. It may be difficult to remember which one to pick, but even if it's hard for you, just try your best. Ready?

Was *boat* or *flag* on the first list?

Was ____ or ____ on the first list?

Circle the examinee's responses.

If the examinee says "I don't know," say, "I know it may be difficult, but just take your best guess."

			Score (1 or 0)	Dist. type
boat	or	flag		C
cake	or	**desk**		C
majority	or	**cow**		A
celery	or	aspirin		C
bookcase	or	silence		A
blender	or	**truck**		C
onion	or	logic		A
baseball	or	**zebra**		C
instruction	or	**cabinet**		A
squirrel	or	direction		A
blanket	or	**cabbage**		C
subway	or	technique		A
height	or	**spinach**		A
giraffe	or	towel		C
subject	or	**motorcycle**		A
lamp	or	sprinkler		C

Distractor types: C = concrete; A = abstract Total Hits ____

Total Accuracy: (_____ /16) × 100 = _____ %

Notes: _____

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Portions of this work were published in previous editions.

Printed in the United States of America.

24 A B C D E

RBANS™

Repeatable Battery for the Assessment of Neuropsychological Status

Christopher Randolph

Record Form A

Subject#_____ Age____ Sex____ Education Level _____

Examiner_____ Date of Testing_____ Ethnicity_____

Observations: _____

_____

_____

	Immediate Memory	Visuospatial/ Constructional	Language	Attention	Delayed Memory	Total Scale
Index Score						
Confidence Interval ____%						
Percentile						

Index Score	Percentile Rank	Total Scale Index Score
160	>99.9	160
155	>99.9	155
150	>99.9	150
145	99.9	145
140	99.6	140
135	99	135
130	98	130
125	95	125
120	91	120
115	84	115
110	75	110
105	63	105
100	50	100
95	37	95
90	25	90
85	16	85
80	9	80
75	5	75
70	2	70
65	1	65
60	0.4	60
55	0.1	55
50	<0.1	50
45	<0.1	45
40	<0.1	40

ISBN 015-4166-03-0

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1 List Learning

Trial 1

Say *I am going to read you a list of words. I want you to listen carefully and, when I finish, repeat back as many words as you can. You don't have to say them in the same order that I do—just repeat back as many words as you can remember, in any order. Okay?*

Trials 2–4

Say *I am going to read the list again. When I finish, repeat back as many words as you can, even if you have already said them before. Okay?*

Record responses in order.

Scoring: 1 point for each word correctly recalled on each trial.

List	Trial 1	Trial 2	Trial 3	Trial 4
Market				
Package				
Elbow				
Apple				
Story				
Carpet				
Bubble				
Highway				
Saddle				
Powder				

Number Correct		+		+		+		=	
	Total Trial 1		Total Trial 2		Total Trial 3		Total Trial 4		Total Score Range=0–40

2 Story Memory

Trial 1

Say ***I am going to read you a short story. I'd like you to listen carefully and, when I finish, repeat back as much of the story as you can remember. Try and use the same wording, if you can. Okay?***

Read the story below, then say ***Now repeat back as much of that story as you can.***

Trial 2

Say ***I am going to read that same story again. When I finish, I want you to again repeat back as much of the story as you can remember. Try to repeat it as exactly as you can.***

Read the story below, then say ***Now repeat back as much of that story as you can.***

Scoring: 1 point for *verbatim* recall of bold, italic words or alternatives, shown below in color within parentheses. Record intrusions or variations in the Responses column.

Story	Responses	Trial 1 Score (0 or 1)	Trial 2 Score (0 or 1)	Item Score (0–2)
1. On ***Tuesday,***				
2. ***May***				
3. ***Fourth,***				
4. in ***Cleveland,*** Ohio,				
5. a ***3 alarm***				
6. ***fire*** broke out.				
7. ***Two***				
8. ***hotels***				
9. and a ***restaurant***				
10. were ***destroyed***				
11. before the ***firefighters (firemen)***				
12. were able to ***extinguish it (put it out).***				
			Total Score (Trial 1 + Trial 2) Range=0–24	

3 Figure Copy

Time Limit: 4 minutes

Fold this page back and present the Figure Copy Drawing Page along with the stimulus. Ask the examinee to make an exact copy of the figure. Tell the examinee that he or she is being timed, but that the score is based *only* on the exactness of his or her copy.

Scoring: 1 point for correctness and completeness (drawing), and 1 point for proper placement. See Appendix 1 in Stimulus Booklet A for complete scoring criteria and scoring examples.

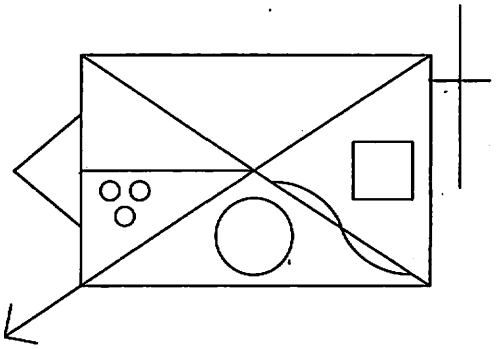

Figure Copy Criteria

(Fold back for use.)

Item	Drawing (0 or 1)	Placement (0 or 1)	Score (0, 1, or 2)	Scoring Criteria
1. rectangle				**Drawing:** lines are unbroken and straight; angles 90 degrees; top/bottom lines 25% longer than sides **Placement:** not rotated more than 15 degrees
2. diagonal cross				**Drawing:** lines are unbroken and straight and should approximately bisect each other **Placement:** ends of lines should meet corners of the rectangle without significant overlap or measurable distance between the ends of the lines and the corners
3. horizontal line				**Drawing:** line is unbroken and straight; should not exceed 1/2 the length of the rectangle **Placement:** should bisect left side of the rectangle at approximately a right angle and intersect the diagonal cross
4. circle				**Drawing:** round, unbroken and closed; diameter should be approximately 1/4–1/3 height of rectangle **Placement:** placed in appropriate segment; not touching any other part of figure
5. 3 small circles				**Drawing:** round, unbroken and closed; equal size; triangular arrangement; not touching each other **Placement:** in appropriate segment; not touching figure; triangle formed not rotated more than 15 degrees
6. square				**Drawing:** must be closed; 90 degree angles; lines straight and unbroken; height is 1/4–1/3 height of rectangle **Placement:** in appropriate segment; not touching any other part of figure; not rotated more than 15 degrees
7. curving line				**Drawing:** 2 curved segments are approximately equal in length and symmetrical; correct direction of curves **Placement:** ends of line touch diagonal; do not touch corner of rectangle or intersection of diagonal lines
8. outside cross				**Drawing:** vertical line of the outside cross is parallel to side of rectangle; >1/2 the height of rectangle; horizontal line crosses vertical at 90 degree angle and is between 20–50% of length of vertical line **Placement:** horizontal line of outside cross touches rectangle higher than 2/3 the height of rectangle, but below top; does not penetrate the rectangle
9. triangle				**Drawing:** angle formed by 2 sides of triangle is between 60–100 degrees; sides are straight, unbroken and meet in a point; distance on vertical side of rectangle subsumed by triangle is approximately 50% of the height of vertical side **Placement:** roughly centered on the left vertical side of the rectangle
10. arrow				**Drawing:** straight and unbroken; lines forming arrow are approximately equal in length and not more than 1/3 length of staff **Placement:** must protrude from appropriate corner of rectangle such that staff appears to be continuation of diagonal cross
		Total Score Range=0–20		

Figure Copy Drawing Page

(Fold back for use.)

4 Line Orientation

Time Limit: 20 seconds/item

Present the sample item, and say ***These two lines down here*** (indicate) ***match two of the lines on top. Can you tell me the numbers, or point to the lines that they match?*** Correct any errors and make sure the examinee understands the task. Continue with Items 1–10.

Scoring: 1 point for each line correctly identified.

Item	Responses	Correct Responses	Score (0, 1, or 2)
Sample		1, 7	
1.		10, 12	
2.		4, 11	
3.		6, 9	
4.		8, 13	
5.		2, 4	

Item	Responses	Correct Responses	Score (0, 1, or 2)
6.		1, 6	
7.		3, 10	
8.		5, 8	
9.		1, 3	
10.		11, 13	
		Total Score Range=0–20	

5 Picture Naming

Time Limit: 20 seconds/item

Ask the examinee to name each picture. Give the semantic cue only if the picture is obviously misperceived.

Scoring: 1 point for each item that is correctly named spontaneously or following semantic cue.

Item	Semantic Cue	Responses	Score (0 or 1)
1. chair	a piece of furniture		
2. pencil	used for writing		
3. well	you get water from it		
4. giraffe	an animal		
5. sailboat	used on the water (if "boat," query "what kind")		
6. cannon	a weapon, used in war		
7. pliers	a tool		
8. trumpet	a musical instrument ("cornet" okay)		
9. clothespin	used to hold laundry on a line		
10. kite	it's flown in the air		
		Total Score Range=0–10	

6 Semantic Fluency

Time Limit: 60 seconds

Say ***Now I'd like you to tell me the names of all of the different kinds of fruits and vegetables that you can think of. I'll give you one minute to come up with as many as you can. Ready?***

Scoring: 1 point for each correct response.

1. _____	11. _____	21. _____	31. _____
2. _____	12. _____	22. _____	32. _____
3. _____	13. _____	23. _____	33. _____
4. _____	14. _____	24. _____	34. _____
5. _____	15. _____	25. _____	35. _____
6. _____	16. _____	26. _____	36. _____
7. _____	17. _____	27. _____	37. _____
8. _____	18. _____	28. _____	38. _____
9. _____	19. _____	29. _____	39. _____
10. _____	20. _____	30. _____	40. _____

Total Score
Range=0–40 ☐

7 Digit Span

Say ***I am going to say some numbers, and I want you to repeat them after me. Okay?***
Read the numbers at the rate of 1 per second. Only read the second string in each set if the first string was failed. Discontinue after failure of both strings in any set.

Scoring: 2 points for the first string correct, 1 point for the second string correct, and 0 points for both strings failed.

Item First String	String Score (0 or 2)	Second String	String Score (0 or 1)	Item Score (0–2)
1. 4—9		5—3		
2. 8—3—5		2—4—1		
3. 7—2—4—6		1—6—3—8		
4. 5—3—9—2—4		3—8—4—9—1		
5. 6—4—2—9—3—5		9—1—5—3—7—6		
6. 2—8—5—1—9—3—7		5—3—1—7—4—9—2		
7. 8—3—7—9—5—2—4—1		9—5—1—4—2—7—3—8		
8. 1—5—9—2—3—8—7—4—6		5—1—9—7—6—2—3—6—5		

Total Score
Range=0–16 ☐

8 Coding

Time Limit: 90 seconds

Say ***Look at these boxes*** (indicate key). ***For each one of these marks there is a number that goes with it. Down here there are marks, but no numbers. I want you to fill in the number that goes with each mark.***

Demonstrate the first three. Say ***Now I would like you to fill in the rest of these boxes up to the double lines*** (indicate) ***for practice.*** Correct any errors as they are made. Make sure that the examinee understands the task and has correctly completed the sample items before you begin timing.

Say ***Now I would like you to continue to fill in the numbers that match the marks. Go as quickly as you can without skipping any. When you reach the end of the line, go on to the next one. Ready? Go ahead.***

Redirect the examinee to the task if he or she becomes distracted. If the examinee is unable to comprehend the task, the subtest score is 0.

Scoring: 1 point for each item correctly coded within 90 seconds (*do not* score the sample items).

Note: Familiarize yourself with these instructions before administering this subtest.

Total Score Range=0–89	

9 List Recall

Say ***Do you remember the list of words that I read to you in the beginning? Tell me as many of those words as you can remember now.***

Scoring: 1 point for each word correctly recalled.

List (Do not read.)	Response	Score (0 or 1)
Market		
Package		
Elbow		
Apple		
Story		
Carpet		
Bubble		
Highway		
Saddle		
Powder		
	Total Score Range=0–10	

10 List Recognition

Say ***I'm going to read you some words. Some of these words were on that list, and some of them weren't. I want you to tell me which words were on the list.*** For each word, ask ***Was_____ on the list?***

Scoring: 1 point for each word correctly identified. Circle the letter corresponding to examinee's response (y = yes, n = no); bold, capitalized (**Y, N**) letter indicates correct response.

List	Circle One	List	Circle One	List	Circle One	List	Circle One
1. **Apple**	**Y** n	6. sailor	y **N**	11. **Bubble**	**Y** n	16. **Saddle**	**Y** n
2. honey	y **N**	7. velvet	y **N**	12. prairie	y **N**	17. **Powder**	**Y** n
3. **Market**	**Y** n	8. **Carpet**	**Y** n	13. **Highway**	**Y** n	18. angel	y **N**
4. **Story**	**Y** n	9. valley	y **N**	14. oyster	y **N**	19. **Package**	**Y** n
5. fabric	y **N**	10. **Elbow**	**Y** n	15. student	y **N**	20. meadow	y **N**
						Total Score Range=0–20	

11 Story Recall

Say: ***Do you remember that story about a fire that I read to you earlier? Tell me as many details from the story as you can remember now.***

Scoring: 1 point for each verbatim recall of bold, italic words or alternatives, shown below in color within parentheses. Record intrusions or variations in the Responses column.

Story (Do not read.)	Responses	Item Score (0 or 1)
1. On ***Tuesday,***		
2. ***May***		
3. ***Fourth,***		
4. in ***Cleveland,*** Ohio,		
5. a ***3 alarm***		
6. ***fire*** broke out.		
7. ***Two***		
8. ***hotels***		
9. and a ***restaurant***		
10. were ***destroyed***		
11. before the ***firefighters (firemen)***		
12. were able to ***extinguish it (put it out).***		
	Total Score Range=0–12	

12 Figure Recall

Say ***Do you remember that figure that I had you copy? I want you to draw as much of it as you can remember now. If you remember a part, but you're not sure where it goes, put it anywhere. Try to draw as much of it as you can.***

Now, present the Figure Recall Drawing Page.

Scoring: 1 point for correctness and completeness (drawing), and 1 point for proper placement. See Appendix 1 in Stimulus Booklet.A for complete scoring criteria and scoring examples.

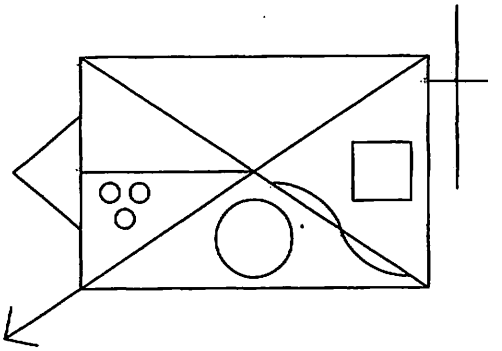

Figure Recall Criteria

(Fold back for use.)

Item	Drawing (0 or 1)	Placement (0 or 1)	Score (0, 1, or 2)	Scoring Criteria
1. rectangle				**Drawing:** lines are unbroken and straight; angles 90 degrees; top/bottom lines 25% longer than sides **Placement:** not rotated more than 15 degrees
2. diagonal cross				**Drawing:** lines are unbroken and straight and should approximately bisect each other **Placement:** ends of lines should meet corners of the rectangle without significant overlap or measurable distance between the ends of the lines and the corners
3. horizontal line				**Drawing:** line is unbroken and straight; should not exceed 1/2 the length of the rectangle **Placement:** should bisect left side of the rectangle at approximately a right angle and intersect the diagonal cross
4. circle				**Drawing:** round, unbroken and closed; diameter should be approximately 1/4–1/3 height of rectangle **Placement:** placed in appropriate segment; not touching any other part of figure
5. 3 small circles				**Drawing:** round, unbroken and closed; equal size; triangular arrangement; not touching each other **Placement:** in appropriate segment; not touching figure; triangle formed not rotated more than 15 degrees
6. square				**Drawing:** must be closed; 90 degree angles; lines straight and unbroken; height is 1/4–1/3 height of rectangle **Placement:** in appropriate segment; not touching any other part of figure; not rotated more than 15 degrees
7. curving line				**Drawing:** 2 curved segments are approximately equal in length and symmetrical; correct direction of curves **Placement:** ends of line touch diagonal; do not touch corner of rectangle or intersection of diagonal lines
8. outside cross				**Drawing:** vertical line of the outside cross is parallel to side of rectangle; >1/2 the height of rectangle; horizontal line crosses vertical at 90 degree angle and is between 20–50% of length of vertical line **Placement:** horizontal line of outside cross touches rectangle higher than 2/3 the height of rectangle, but below top; does not penetrate the rectangle
9. triangle				**Drawing:** angle formed by 2 sides of triangle is between 60–100 degrees; sides are straight, unbroken and meet in a point; distance on vertical side of rectangle subsumed by triangle is approximately 50% of the height of vertical side **Placement:** roughly centered on the left vertical side of the rectangle
10. arrow				**Drawing:** straight and unbroken; lines forming arrow are approximately equal in length and not more than 1/3 length of staff **Placement:** must protrude from appropriate corner of rectangle such that staff appears to be continuation of diagonal cross
		Total Score Range=0–20		

Figure Recall Drawing Page

(Fold back for use.)

DELIS • KAPLAN
D-KEFS™
Executive Function System™

Delis–Kaplan Executive Function System

Dean C. Delis Edith Kaplan Joel H. Kramer

Standard Record Form

ID: _____ Examiner: _____

Sex: ❑ F ❑ M Handedness: ❑ R ❑ L ❑ Ambidextrous

Highest Level of Education (years): _____

Current Grade (if applicable): _____

School (if applicable): _____

	Year	Month	Day
Date Tested			
Age at Testing			

Referral Source/Reason for Referral/Presenting Complaints: _____

Attitude Toward Testing: _____

Affect and Mood: _____

Unusual Behaviors and Comments: _____

Physical Appearance: _____

Visual/Auditory/Motor Problems: _____

Language Background: _____

Diagnostic History: _____

Current Medications: _____

PEARSON

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PsychCorp

Product Number 0154091154

D-KEFS Trail Making Test: Summary of Scores

Primary Measures: Completion Times

Condition 1: Visual Scanning	Condition 2: Number Sequencing	Condition 3: Letter Sequencing	Condition 4: Number–Letter Switching	Condition 5: Motor Speed
Raw Score → **Scaled Score**	Raw Score → **Scaled Score**	Raw Score → **Scaled Score**	Raw Score → **Scaled Score**	Raw Score → **Scaled Score**

Primary Combined Measure: Completion Times

	Number Sequencing		Letter Sequencing				Composite Scaled Score
Combined Number Sequencing + Letter Sequencing	**Scaled Score**	+	**Scaled Score**	=	**Sum of Scaled Scores**	→	

Primary Contrast Measures: Completion Times

	Switching: Scaled Score		Scaled Score		Scaled Score Difference		Contrast Scaled Score*
			Visual Scanning				
Number–Letter Switching vs. Visual Scanning*		–		=		→	
			Number Sequencing				
Number–Letter Switching vs. Number Sequencing*		–		=		→	
			Letter Sequencing				
Number–Letter Switching vs. Letter Sequencing*		–		=		→	
			Number Sequencing + Letter Sequencing				
Number–Letter Switching vs. Combined Number Sequencing + Letter Sequencing*		–	Composite	=		→	
			Motor Speed				
Number–Letter Switching vs. Motor Speed*		–		=		→	

* A low or high contrast scaled score may reflect different cognitive problems; see examiner's manual.

Optional Measures: Error Analysis

	Condition 1: Visual Scanning	Condition 2: Number Sequencing	Condition 3: Letter Sequencing	Condition 4: Number–Letter Switching	Condition 5: Motor Speed
Omission Errors	Raw Score; **Cumulative Percentile Rank**				
Sequencing Errors		Raw Score; **Cumulative Percentile Rank**	Raw Score; **Cumulative Percentile Rank**	Raw Score; **Cumulative Percentile Rank**	
Commission Errors	Raw Score; **Cumulative Percentile Rank**				
Set-Loss Errors		Raw Score; **Cumulative Percentile Rank**	Raw Score; **Cumulative Percentile Rank**	Raw Score; **Cumulative Percentile Rank**	
Time-Discontinue Errors		Raw Score; **Cumulative Percentile Rank**	Raw Score; **Cumulative Percentile Rank**	Raw Score; **Cumulative Percentile Rank**	Raw Score; **Cumulative Percentile Rank**

Condition 4: All Error Types — Total Raw Score; **Scaled Score**

Note: Cumulative percentile ranks for the D–KEFS were scaled to reflect the percentage of the normative sample that obtained raw scores equal to or worse than the raw score obtained by the examinee.

D-KEFS Verbal Fluency Test

Condition 1: Letter Fluency

	F	A	S	
First Interval: 1–15 Seconds	1"–15" ☐	1"–15" ☐	1"–15" ☐	1"–15" **F** + **A** + **S** Correct Responses ☐
Second Interval: 16–30 Seconds	16"–30" ☐	16"–30" ☐	16"–30" ☐	16"–30" **F** + **A** + **S** Correct Responses ☐
Third Interval: 31–45 Seconds	31"–45" ☐	31"–45" ☐	31"–45" ☐	31"–45" **F** + **A** + **S** Correct Responses ☐
Fourth Interval: 46–60 Seconds	46"–60" ☐	46"–60" ☐	46"–60" ☐	46"–60" **F** + **A** + **S** Correct Responses ☐
	F Total Correct Responses ☐	**A** Total Correct Responses ☐	**S** Total Correct Responses ☐	1"–60" ☐ Letter Fluency: Total Correct Raw Score
	Total Set-Loss Errors ☐	Total Set-Loss Errors ☐	Total Set-Loss Errors ☐	
	Total Repetition Errors ☐	Total Repetition Errors ☐	Total Repetition Errors ☐	

Letter Fluency: Total Responses* (Correct + Incorrect) ☐

* *Note*: Some repetition errors are coded also as set-loss errors; each double-coded error counts as only one response for the total responses measure.

D-KEFS Verbal Fluency Test *(continued)*

Condition 2: Category Fluency

	Animals	Boys' Names	
First Interval: 1–15 Seconds	1"–15" ☐	1"–15" ☐	1"–15" **Animals** + **Boys' Names** Correct Responses ☐
Second Interval: 16–30 Seconds	16"–30" ☐	16"–30" ☐	16"–30" **Animals** + **Boys' Names** Correct Responses ☐
Third Interval: 31–45 Seconds	31"–45" ☐	31"–45" ☐	31"–45" **Animals** + **Boys' Names** Correct Responses ☐
Fourth Interval: 46–60 Seconds	46"–60" ☐	46"–60" ☐	46"–60" **Animals** + **Boys' Names** Correct Responses ☐

Animals Total Correct Responses ☐		**Boys' Names** Total Correct Responses ☐	1"–60" ☐ Category Fluency: Total Correct Raw Score
Total Set-Loss Errors ☐		Total Set-Loss Errors ☐	
Total Repetition Errors ☐		Total Repetition Errors ☐	

Category Fluency: Total Responses (Correct + Incorrect)* ☐

* *Note*: Some repetition errors are coded also as set-loss errors; each double-coded error counts as only one response for the total responses measure.

D-KEFS Verbal Fluency Test *(continued)*

Condition 3: Category Switching

Fruits / Furniture

First Interval: 1–15 Seconds		1"–15" **Fruits** + **Furniture** Correct Responses* ☐
Second Interval: 16–30 Seconds		16"–30" **Fruits** + **Furniture** Correct Responses* ☐
Third Interval: 31–45 Seconds		31"–45" **Fruits** + **Furniture** Correct Responses* ☐
Fourth Interval: 46–60 Seconds		46"–60" **Fruits** + **Furniture** Correct Responses* ☐

☐ Category Switching: Total Switching Accuracy

☐ **Fruits** Total Correct Responses* + ☐ **Furniture** Total Correct Responses* = ☐ 1"–60" Raw Score — Category Switching: Total Correct Responses*

* Correct responses are summed independent of switching accuracy.

☐ Total Set-Loss Errors

☐ Total Repetition Errors

Category Switching: Total Responses (Correct + Incorrect)** ☐

** *Note*: Some repetition errors are coded also as set-loss errors; each double-coded error counts as only one response for the total responses measure.

D-KEFS Verbal Fluency Test: Summary of Scores

Primary Measures

Condition 1: Letter Fluency Total Correct	Condition 2: Category Fluency Total Correct	Condition 3: Category Switching Total Correct Responses	Condition 3: Category Switching Total Switching Accuracy
Raw Score → Scaled Score	Raw Score → Scaled Score	Raw Score → Scaled Score	Raw Score → Scaled Score

Primary Contrast Measures

Letter Fluency vs. Category Fluency*

Letter Fluency: Total Correct (Scaled Score) − Category Fluency: Total Correct (Scaled Score) = Scaled-Score Difference → Contrast Scaled Score*

Category Switching vs. Category Fluency*

Category Switching: Total Correct Responses (Scaled Score) − Category Fluency: Total Correct (Scaled Score) = Scaled-Score Difference → Contrast Scaled Score*

* A low or high contrast scaled score may reflect different cognitive problems; see examiner's manual.

Optional Measures: Conditions 1–3 Combined

	Condition 1: Letter Fluency Raw Score		Condition 2: Category Fluency Raw Score		Condition 3: Category Switching Raw Score		Total Raw Score	Scaled Score
First Interval (1"–15"): Total Correct		+		+		=		
Second Interval (16"–30"): Total Correct		+		+		=		
Third Interval (31"–45"): Total Correct		+		+		=		
Fourth Interval (46"–60"): Total Correct		+		+		=		
Set-Loss Errors		+		+		=		
Repetition Errors		+		+		=		
Total Responses (Correct + Incorrect)*		+		+		=		

* *Note*: Some repetition errors are coded also as set-loss errors; each double-coded error counts as only one response for the total responses measure.

Percent Set-Loss Errors

Total Set-Loss Errors (Raw Score) ÷ Total Responses* (Raw Score) × 100 = Percent Raw Score → Scaled Score

Percent Repetition Errors

Total Repetition Errors (Raw Score) ÷ Total Responses* (Raw Score) × 100 = Percent Raw Score → Scaled Score

Category Switching: Percent Switching Accuracy (Condition 3 Only)

[Total Switching Accuracy (Raw Score) + 1] ÷ [Total Responses Condition 3 Only* (Raw Score)] × 100 = Percent Raw Score → Scaled Score

* *Note*: Some repetition errors are coded also as set-loss errors; each double-coded error counts as only one response for the total responses measure.

D-KEFS Design Fluency Test: Summary of Scores

Primary Measures

Condition 1 Filled Dots: Total Correct		Condition 2 Empty Dots Only: Total Correct		Condition 3 Switching: Total Correct		Design Fluency Total Correct
Raw Score	+	Raw Score	+	Raw Score	=	Raw Score
↓		↓		↓		
Scaled Score	+	**Scaled Score**	+	**Scaled Score**	=	

Design Fluency: Total Correct

Sum of Scaled Scores → **Composite Scaled Score**

Primary Combined Measure: Filled Dots + Empty Dots

Combined Filled Dots + Empty Dots: Total Correct

Condition 1 Filled Dots		Condition 2 Empty Dots Only		Sum of Scaled Scores		Composite Scaled Score
Scaled Score	+	**Scaled Score**	=		→	

Primary Contrast Measure

Switching vs. Combined Filled Dots + Empty Dots*

Condition 3 Switching: Total Correct		Conditions 1 + 2 Combined		Scaled Score Difference		Contrast Scaled Score*
Scaled Score	−	**Composite Scaled Score**	=		→	

* A low or high contrast scaled score may reflect different cognitive problems; see examiner's manual.

Optional Measures

	Condition 1 Filled Dots		**Condition 2 Empty Dots Only**		**Condition 3 Switching**			
	Set-Loss Designs		Set-Loss Designs		Set-Loss Designs		Total Set-Loss Designs	**Total Set-Loss Designs**
Total Set-Loss Designs	Raw Score	+	Raw Score	+	Raw Score	=	Raw Score	→ **Scaled Score**
	Repeated Designs		Repeated Designs		Repeated Designs		Total Repeated Designs	**Total Repeated Designs**
Total Repeated Designs	Raw Score	+	Raw Score	+	Raw Score	=	Raw Score	→ **Scaled Score**
	Attempted Designs		Attempted Designs		Attempted Designs		Total Attempted Designs	**Total Attempted Designs***
Total Attempted Designs*	Raw Score	+	Raw Score	+	Raw Score	=	Raw Score	→ **Scaled Score**

* *Note*: Some repetition errors are coded also as set-loss errors; each double-coded error counts as only one response for the total attempted designs measure.

Percent Design Accuracy

[**Design Fluency: Total Correct** Raw Score ÷ **Total Attempted Designs*** Raw Score] × 100 = **Percent Raw Score** → **Scaled Score**

D-KEFS Color-Word Interference Test

Ages 8–89
Materials: Record Form, Stimulus Booklet (Flat Position), Stopwatch

Condition 1: Color Naming

Discontinue

Discontinue if the examinee has marked difficulty or makes four uncorrected errors on the practice lines. Otherwise, discontinue the scored task after 90 seconds.

Administration and Recording

Place the stimulus booklet flat on the table in a horizontal (landscape) position directly in front of the examinee so that the two practice lines of Condition 1 are positioned at the top of the page from the examinee's perspective. Say,

> **This page has patches of color on it. I'd like you to say the colors as quickly as you can without skipping any or making mistakes. When you finish this line** (sweep across the first practice line of five squares with your finger), **go on to this one** (point to the first square of the second row). **Now try these first two lines for practice.**

If the examinee is able to complete the two practice lines, say, **Good. Now, when I say begin, I want you to say the rest of the colors. Begin here** (point to the first square on the first line of 10 squares below the practice lines) **and say each color, one after the other, without skipping any. When you finish this line** (sweep across the first row with your finger), **go on to this one** (point to the first square of the second row). **Keep saying the colors until you reach the end of the last line** (point). **Say the colors as quickly as you can without making mistakes. Ready? Begin.**

Start timing. Follow the examinee's progress item by item. Record errors by writing the first letter of the incorrect color name beneath the correct response and record any nonsense words (e.g., "bleen") verbatim. Indicate self-corrections by drawing a slash mark through the letter or word. Record total completion time in seconds.

Allow the examinee to use a finger to maintain his or her place on the stimulus page. If the examinee skips a line accidentally, point out the error immediately and redirect the examinee to the correct line. Keep the stopwatch running while pointing out line-skipping errors.

If the examinee does not complete the task at the end of 90 seconds, say, **Stop.** Indicate the last item attempted and record 90 seconds as the total completion time. Items to which the examinee did not respond because the time limit was reached are not counted as errors. Turn the page in the stimulus booklet to Condition 2: Word Reading.

green red blue green blue

red blue green blue green

red blue red green red blue green blue red green

blue green red green red green blue red blue green

red green blue red green red green blue green red

blue red green blue red green blue red blue green

red blue red green blue green blue red blue green

Condition 1: Color Naming

Total Uncorrected Errors	Total Self-Corrected Errors	Total Time To Complete

D-KEFS Color-Word Interference Test *(continued)*

Condition 2: Word Reading

Discontinue

Discontinue if the examinee has marked difficulty or makes four uncorrected errors on the two practice lines. Otherwise, discontinue the scored task after 90 seconds.

Administration and Recording

Place the stimulus booklet flat on the table in a horizontal (landscape) position directly in front of the examinee, with the rows of words printed in black ink facing the examinee. Say,

> **Now look at this page with words printed on it. I'd like you to read the words aloud as quickly as you can without skipping any or making mistakes. When you finish this line** (sweep across the first practice line of five words with your finger)**, go on to this one** (point to the first word of the second row)**. Now try reading these first two lines for practice.**

If the examinee is able to complete the two practice lines, say,

> **Good. Now, when I say begin, I want you to read the rest of the words. Begin here** (point to the first word on the first line of 10 words below the practice lines) **and read each word, one after the other, without skipping any. Keep reading the words until you reach the end** (point to the last word on the last line). **Read the words as quickly as you can without making mistakes. Ready? Begin.**

Start timing. Follow the examinee's progress item by item. Record errors by writing the first letter of the incorrect word beneath the correct response and record any nonsense words (e.g., "bleen") verbatim. Indicate self-corrections by drawing a slash mark through the letter or word. Record total completion time in seconds.

Allow the examinee to use a finger to maintain his or her place on the stimulus page. If the examinee skips a line accidentally, point out the error immediately and redirect the examinee to the correct line. Keep the stopwatch running while pointing out line-skipping errors.

If the examinee does not complete the task at the end of 90 seconds, say, **Stop.** Indicate the last item attempted and record 90 seconds as the total completion time. Items to which the examinee did not respond because the time limit was reached are not counted as errors. Turn the page in the stimulus booklet to Condition 3: Inhibition.

red blue green red blue

green blue green red green

green	red	blue	green	blue	red	blue	green	blue	green
red	green	blue	green	blue	green	red	blue	red	green
red	green	blue	green	red	blue	green	red	blue	red
blue	green	red	blue	green	red	blue	green	blue	red
green	red	blue	red	blue	green	red	blue	red	green

Condition 2: Word Reading

Total Uncorrected Errors	Total Self-Corrected Errors	Total Time To Complete

Condition 3: Inhibition

Discontinue

Discontinue if the examinee has marked difficulty or requires four corrections on the two practice lines. Otherwise, discontinue the scored task after 180 seconds.

Administration and Recording

Place the stimulus booklet flat on the table in a horizontal (landscape) position directly in front of the examinee, with the rows of words printed in dissonant ink colors facing the examinee. Say,

> **Now look at this page. It's going to be a little harder than the other pages because the color names are printed in a different-colored ink. For example** (point to the first word on the first practice line of five words)**, do you see how the word *red* is printed in *green* ink here? This time, you are to name *the color of the ink* that the letters are printed in and *not read the word*. So, what would you say for this one?** (Point again to the first word on the first practice line and allow the examinee to respond. Correct any errors.) **Good. And this one?** (Point to the next two practice items. Correct any errors.) **Good. Now try these first two lines for practice.**

If the examinee has difficulty understanding the task, you may demonstrate it by naming the ink colors on the first practice line, then inviting the examinee to respond to the second line. If the examinee requires four corrections on the two practice lines, discontinue this condition and do not administer Condition 4: Inhibition/Switching.

If the examinee is able to complete the two practice lines, say,

> **Good. Now, when I say begin, I want you to do the same thing for the rest of them. Say the color of the ink the letters are printed in; do not read the words. Begin here** (point to the first word on the first line of 10 words below the practice lines) **and say each ink color, one after the other, without skipping any. Keep saying the ink colors until you reach the end** (point to the last word of the last line)**. Say the ink colors as quickly as you can without making mistakes. Ready? Begin.**

Start timing. Follow the examinee's progress item by item. The single letter (*r* for red, *b* for blue, *g* for green) printed in parentheses next to each correct response represents the error response if the examinee reads the word rather than naming the ink color. Record errors by circling the letter or by writing the initial letter of other incorrect colors beneath the correct response. Also record any nonsense words (e.g., "bleen") verbatim. Indicate self-corrections by drawing a slash through the letter or word. Record total completion time in seconds.

Allow the examinee to use a finger to maintain his or her place on the stimulus page. If the examinee skips a line accidentally, point out the error immediately and redirect the examinee to the correct line. Keep the stopwatch running while pointing out line-skipping errors.

If the examinee makes three consecutive errors of reading the words, prompt him or her to name the ink color. Provide this prompt only once during this condition and keep the stopwatch running.

If the examinee does not complete the task at the end of 180 seconds, say, **Stop.** Indicate the last item attempted and record 180 seconds as the total completion time. Items to which the examinee did not respond because the time limit was reached are not counted as errors. Turn the page in the stimulus booklet to Condition 4: Inhibition/Switching.

green(r) red(b) blue(g) green(b) red(g)

blue(r) red(b) green(r) red(g) green(r)

red(b) blue(g) red(b) green(r) red(b) blue(r) green(b) blue(r) red(b) green(r)

red(b) blue(g) green(b) blue(g) green(r) blue(g) red(b) green(r) red(b) blue(g)

green(r) blue(g) green(r) red(b) blue(g) green(r) red(g) blue(r) green(b) red(g)

green(b) blue(g) red(b) green(r) blue(g) red(b) green(r) blue(g) green(r) red(g)

blue(g) green(b) blue(r) red(b) blue(g) green(r) red(b) blue(g) green(r) red(b)

Condition 3: Inhibition

Total Uncorrected Errors	Total Self-Corrected Errors	Total Time To Complete

D-KEFS Color-Word Interference Test *(continued)*

Condition 4: Inhibition/Switching

Discontinue

Do not administer Condition 4 if the examinee had marked difficulty or did not finish before the time limit was reached on Condition 3: Inhibition. Discontinue if the examinee has marked difficulty or requires four corrections on the practice lines of Condiditon 4. Otherwise, discontinue the scored task after 180 seconds.

Administration and Recording

Place the stimulus booklet flat on the table in a horizontal (landscape) position directly in front of the examinee, with the rows of words printed in dissonant ink colors, half of which are contained in rectangles, facing the examinee. Say,

> **This is the fourth and last page. This time, for many of the words, you are to do the same thing you just did: Name the color of the ink and do not read the words. But if a word is inside a little box, you should read the word and not name the ink color.** (Point to the first three items in the first practice line of five words.) **For example, what would you say for these first three words?** (Allow the examinee to respond and provide corrections if necessary.) **Good. Now try these first two lines for practice.**

If the examinee has difficulty understanding the task, you may demonstrate it by responding to the items on the first practice line, then inviting the examinee to respond to the second line. If the examinee requires four corrections on the two practice lines, discontinue this condition. If the examinee is able to complete the practice lines, say,

> **Very good. Now, when I say begin, I want you to do the same thing for the rest of them. Say the color of the ink the letters are printed in or read the word if it is in a box. Begin here** (point to the first word on the first line of 10 words below the practice lines) **and keep going until you reach the end** (point to the last word of the last line). **Say the ink colors or words as quickly as you can without making mistakes. Ready? Begin.**

Start timing. Follow the examinee's progress item by item. The single letter (*r* for red, *b* for blue, *g* for green) printed in parentheses next to each correct response represents the error response if the examinee either (a) reads the word rather than naming the ink color for an item not contained in a rectangle or (b) names the ink color rather than reading the word for an item contained in a rectangle. Record errors by circling the letter or by writing the initial letter of other incorrect colors beneath the correct response. Also record any nonsense words (e.g., "bleen") verbatim. Indicate self-corrections by drawing a slash through the letter or word. Record total completion time in seconds.

Allow the examinee to use a finger to maintain his or her place on the stimulus page. If the examinee skips a line accidentally, point out the error immediately and redirect the examinee to the correct line. Keep the stopwatch running while pointing out line-skipping errors.

If the examinee makes three consecutive errors, prompt him or her either to name the ink color or to read the word in the rectangle. Provide this prompt only once during this condition and keep the stopwatch running.

If the examinee does not complete the task at the end of 180 seconds, say, **Stop.** Indicate the last item attempted and record 180 seconds as the total completion time. Items to which the examinee did not respond because the time limit was reached are not counted as errors.

			red(b)	blue(r)	green(r)	blue(r)	green(b)		
			blue(g)	red(g)	blue(g)	green(r)	blue(r)		
red(g)	blue(g)	red(g)	green(b)	red(b)	green(r)	blue(r)	green(r)	green(r)	blue(r)
red(b)	blue(r)	green(r)	red(g)	blue(g)	red(g)	green(b)	red(b)	green(r)	blue(r)
green(b)	blue(r)	green(r)	red(g)	blue(r)	green(r)	green(b)	red(b)	green(b)	red(b)
red(b)	green(b)	red(b)	green(b)	red(g)	blue(r)	green(r)	blue(r)	blue(g)	red(g)
green(r)	red(g)	blue(r)	red(b)	green(b)	red(b)	blue(r)	green(r)	blue(g)	red(g)

Condition 4: Inhibition/Switching

Total Uncorrected Errors	Total Self-Corrected Errors	Total Time To Complete

Color

D-KEFS Color-Word Interference Test: Summary of Scores

Primary Measures: Completion Times

Condition 1: Color Naming	Condition 2: Word Reading	Condition 3: Inhibition	Condition 4: Inhibition/Switching
Raw Score → **Scaled Score**	Raw Score → **Scaled Score**	Raw Score → **Scaled Score**	Raw Score → **Scaled Score**

Primary Combined Measure: Completion Times

	Condition 1: Color Naming		Condition 2: Word Reading		Sum of Scaled Scores		Composite Scaled Score
Combined Naming + Reading	Scaled Score	+	Scaled Score	=		→	

Primary Contrast Measures: Completion Times

	Scaled Score		Scaled Score		Scaled-Score Difference		Contrast Scaled Score*
Inhibition vs. Color Naming*	Inhibition	–	Color Naming	=		→	
Inhibition/Switching vs. Combined Naming + Reading*	Inhibition/Switching	–	Combined Naming + Reading (Composite)	=		→	
Inhibition/Switching vs. Inhibition*	Inhibition/Switching	–	Inhibition	=		→	

* A low or high contrast scaled score may reflect different cognitive problems; see examiner's manual.

Optional Contrast Measures: Completion Times

	Inhibition/Switching: Scaled Score		Scaled Score		Scaled-Score Difference		Contrast Scaled Score*
Inhibition/Switching vs. Color Naming*		–	Color Naming	=		→	
Inhibition/Switching vs. Word Reading*		–	Word Reading	=		→	

* A low or high contrast scaled score may reflect different cognitive problems; see examiner's manual.

Optional Measures: Error Analysis

	Condition 1: Color Naming	Condition 2: Word Reading	Condition 3: Inhibition	Condition 4: Inhibition/Switching
Corrected Errors	Raw Score	Raw Score	Raw Score, **Cumulative Percentile Rank**	Raw Score, **Cumulative Percentile Rank**
+				
Uncorrected Errors	Raw Score	Raw Score	Raw Score, **Cumulative Percentile Rank**	Raw Score, **Cumulative Percentile Rank**
↓				
Total Errors	Raw Score, **Cumulative Percentile Rank**	Raw Score, **Cumulative Percentile Rank**	Raw Score, **Scaled Score**	Raw Score, **Scaled Score**

Note: Cumulative percentile ranks for the D–KEFS were scaled to reflect the percentage of the normative sample that obtained raw scores equal to or worse than the raw score obtained by the examinee.

D-KEFS Sorting Test

Screening Pretest

Words Incorrectly Read: _____ Raw Score: _____

Words Not Understood: _____ Raw Score: _____

Condition 1–Free Sorting: Card Set 1

Discontinue administration of Card Set 1 after either (a) the examinee indicates that he or she cannot identify any more sorts, even after receiving the single prompt to keep trying; (b) 240 seconds (4 minutes) of cumulative ***sorting*** time have elapsed; or (c) the examinee has completed 10 attempted sorts.

First Sort

Description:

Sorting Time (Seconds) ☐

Sort:

Animals	Air	1 Syllable
Transportation	Land	2 Syllables

Verbal Sorts

Large	Curved	Uppercase	Blue	White
Small	Straight	Lowercase	Yellow	Red

Perceptual Sorts

For an ***incorrect*** sort, mark the cards of one group: Airplane Bus Car Duck Eagle Tiger

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Second Sort

Description:

Cumulative Sorting Time (Seconds) ☐

Sort:

Animals	Air	1 Syllable
Transportation	Land	2 Syllables

Verbal Sorts

Large	Curved	Uppercase	Blue	White
Small	Straight	Lowercase	Yellow	Red

Perceptual Sorts

For an ***incorrect*** sort, mark the cards of one group: Airplane Bus Car Duck Eagle Tiger

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Third Sort

Description:

Cumulative Sorting Time (Seconds) ☐

Sort:

Animals	Air	1 Syllable
Transportation	Land	2 Syllables

Verbal Sorts

Large	Curved	Uppercase	Blue	White
Small	Straight	Lowercase	Yellow	Red

Perceptual Sorts

For an ***incorrect*** sort, mark the cards of one group: Airplane Bus Car Duck Eagle Tiger

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Fourth Sort

Description:

Cumulative Sorting Time (Seconds)

Sort:

Verbal Sorts			Perceptual Sorts				
Animals / Transportation	Air / Land	1 Syllable / 2 Syllables	Large / Small	Curved / Straight	Uppercase / Lowercase	Blue / Yellow	White / Red

For an ***incorrect*** sort, mark the cards of one group: Airplane Bus Car Duck Eagle Tiger

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Fifth Sort

Description:

Cumulative Sorting Time (Seconds)

Sort:

Verbal Sorts			Perceptual Sorts				
Animals / Transportation	Air / Land	1 Syllable / 2 Syllables	Large / Small	Curved / Straight	Uppercase / Lowercase	Blue / Yellow	White / Red

For an ***incorrect*** sort, mark the cards of one group: Airplane Bus Car Duck Eagle Tiger

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Sixth Sort

Description:

Cumulative Sorting Time (Seconds)

Sort:

Verbal Sorts			Perceptual Sorts				
Animals / Transportation	Air / Land	1 Syllable / 2 Syllables	Large / Small	Curved / Straight	Uppercase / Lowercase	Blue / Yellow	White / Red

For an ***incorrect*** sort, mark the cards of one group: Airplane Bus Car Duck Eagle Tiger

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Seventh Sort

Description:

Cumulative Sorting Time (Seconds)

Sort:

Verbal Sorts			Perceptual Sorts				
Animals / Transportation	Air / Land	1 Syllable / 2 Syllables	Large / Small	Curved / Straight	Uppercase / Lowercase	Blue / Yellow	White / Red

For an ***incorrect*** sort, mark the cards of one group: Airplane Bus Car Duck Eagle Tiger

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Free Sorting: Card Set 1 *(continued)*

Eighth Sort

Description:

Cumulative Sorting Time (Seconds)

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Sort:

Animals Transportation	Air Land	1 Syllable 2 Syllables

Verbal Sorts

Large Small	Curved Straight	Uppercase Lowercase	Blue Yellow	White Red

Perceptual Sorts

For an ***incorrect*** sort, mark the cards of one group: Airplane Bus Car Duck Eagle Tiger

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Ninth Sort

Description:

Cumulative Sorting Time (Seconds)

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Sort:

Animals Transportation	Air Land	1 Syllable 2 Syllables

Verbal Sorts

Large Small	Curved Straight	Uppercase Lowercase	Blue Yellow	White Red

Perceptual Sorts

For an ***incorrect*** sort, mark the cards of one group: Airplane Bus Car Duck Eagle Tiger

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Tenth Sort

Description:

Cumulative Sorting Time (Seconds)

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Sort:

Animals Transportation	Air Land	1 Syllable 2 Syllables

Verbal Sorts

Large Small	Curved Straight	Uppercase Lowercase	Blue Yellow	White Red

Perceptual Sorts

For an ***incorrect*** sort, mark the cards of one group: Airplane Bus Car Duck Eagle Tiger

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Free Sorting: Card Set 1

Raw Score

Total Description Score

Number of Confirmed Correct Sorts

Condition 1–Free Sorting: Card Set 2

Discontinue administration of Card Set 2 after either (a) the examinee indicates that he or she cannot identify any more sorts, even after receiving the single prompt to keep trying; (b) 240 seconds (4 minutes) of cumulative ***sorting*** time have elapsed; or (c) the examinee has completed 10 attempted sorts.

First Sort

Description:

Sorting Time (Seconds) ☐

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Sort:

Verbal Sorts			Perceptual Sorts				
Clothing Body Parts	Head Feet	Plural Singular	Filled Triangles Empty Triangles	Cursive Printed	Slope Up Slope Down	Triangles Above Triangles Below	Diagonals Close Diagonals Apart

For an ***incorrect*** sort, mark the cards of one group: Ears Hat Mouth Shoe Socks Toes

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Second Sort

Description:

Cumulative Sorting Time (Seconds) ☐

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Sort:

Verbal Sorts			Perceptual Sorts				
Clothing Body Parts	Head Feet	Plural Singular	Filled Triangles Empty Triangles	Cursive Printed	Slope Up Slope Down	Triangles Above Triangles Below	Diagonals Close Diagonals Apart

For an ***incorrect*** sort, mark the cards of one group: Ears Hat Mouth Shoe Socks Toes

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Third Sort

Description:

Cumulative Sorting Time (Seconds) ☐

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Sort:

Verbal Sorts			Perceptual Sorts				
Clothing Body Parts	Head Feet	Plural Singular	Filled Triangles Empty Triangles	Cursive Printed	Slope Up Slope Down	Triangles Above Triangles Below	Diagonals Close Diagonals Apart

For an ***incorrect*** sort, mark the cards of one group: Ears Hat Mouth Shoe Socks Toes

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Free Sorting: Card Set 2 *(continued)*

Fourth Sort

Description:

Cumulative Sorting Time (Seconds)

Sort:

Verbal Sorts			Perceptual Sorts				
Clothing Body Parts	Head Feet	Plural Singular	Filled Triangles Empty Triangles	Cursive Printed	Slope Up Slope Down	Triangles Above Triangles Below	Diagonals Close Diagonals Apart

For an ***incorrect*** sort, mark the cards of one group: Ears Hat Mouth Shoe Socks Toes

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Fifth Sort

Description:

Cumulative Sorting Time (Seconds)

Sort:

Verbal Sorts			Perceptual Sorts				
Clothing Body Parts	Head Feet	Plural Singular	Filled Triangles Empty Triangles	Cursive Printed	Slope Up Slope Down	Triangles Above Triangles Below	Diagonals Close Diagonals Apart

For an ***incorrect*** sort, mark the cards of one group: Ears Hat Mouth Shoe Socks Toes

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Sixth Sort

Description:

Cumulative Sorting Time (Seconds)

Sort:

Verbal Sorts			Perceptual Sorts				
Clothing Body Parts	Head Feet	Plural Singular	Filled Triangles Empty Triangles	Cursive Printed	Slope Up Slope Down	Triangles Above Triangles Below	Diagonals Close Diagonals Apart

For an ***incorrect*** sort, mark the cards of one group: Ears Hat Mouth Shoe Socks Toes

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Seventh Sort

Description:

Cumulative Sorting Time (Seconds)

Sort:

Verbal Sorts			Perceptual Sorts				
Clothing Body Parts	Head Feet	Plural Singular	Filled Triangles Empty Triangles	Cursive Printed	Slope Up Slope Down	Triangles Above Triangles Below	Diagonals Close Diagonals Apart

For an ***incorrect*** sort, mark the cards of one group: Ears Hat Mouth Shoe Socks Toes

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Eighth Sort

Description:

Cumulative Sorting Time (Seconds) ☐

Sort:

Clothing Body Parts	Head Feet	Plural Singular	Filled Triangles Empty Triangles	Cursive Printed	Slope Up Slope Down	Triangles Above Triangles Below	Diagonals Close Diagonals Apart
Verbal Sorts			**Perceptual Sorts**				

For an ***incorrect*** sort, mark the cards of one group: Ears Hat Mouth Shoe Socks Toes

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Ninth Sort

Description:

Cumulative Sorting Time (Seconds) ☐

Sort:

Clothing Body Parts	Head Feet	Plural Singular	Filled Triangles Empty Triangles	Cursive Printed	Slope Up Slope Down	Triangles Above Triangles Below	Diagonals Close Diagonals Apart
Verbal Sorts			**Perceptual Sorts**				

For an ***incorrect*** sort, mark the cards of one group: Ears Hat Mouth Shoe Socks Toes

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Tenth Sort

Description:

Cumulative Sorting Time (Seconds) ☐

Sort:

Clothing Body Parts	Head Feet	Plural Singular	Filled Triangles Empty Triangles	Cursive Printed	Slope Up Slope Down	Triangles Above Triangles Below	Diagonals Close Diagonals Apart
Verbal Sorts			**Perceptual Sorts**				

For an ***incorrect*** sort, mark the cards of one group: Ears Hat Mouth Shoe Socks Toes

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

PRIMARY SORTING MEASURE	
Confirmed Correct Sort	Y
OPTIONAL SORTING MEASURES	
Repeated Sort	Y
Unconfirmed Target Sort	Y
Set-Loss Sort	Y
Nontarget Even Sort	Y
Sort Type	V P

Free Sorting: Card Set 2

Raw Score

Total Description Score ☐

Number of Confirmed Correct Sorts ☐

Condition 2–Sort Recognition: Card Set 1

Administer all eight target sorts to the examinee. Discontinue administration of ***each sort*** after either (a) the examinee provides a correct or incorrect description, (b) the examinee indicates that he or she cannot identify the sorting rules, or (c) 45 seconds have elapsed after the examiner made the sort and the examinee failed to initiate a description response.

First Sort — Perceptual Sort

RULE

Small Cards *(Bus Car Eagle)* | Large Cards *(Airplane Duck Tiger)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Second Sort — Verbal Sort

RULE

Animals *(Duck Eagle Tiger)* | Transportation *(Airplane Bus Car)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Third Sort — Perceptual Sort

RULE

Straight Outer Edges *(Airplane Bus Tiger)* | Curved Outer Edges *(Car Duck Eagle)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Fourth Sort — Verbal Sort

RULE

One-Syllable Words *(Bus Car Duck)* | Two-Syllable Words *(Airplane Eagle Tiger)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Fifth Sort — Perceptual Sort

RULE

Blue Cards *(Bus Duck Tiger)* | Yellow Cards *(Airplane Car Eagle)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Sort Recognition: Card Set 1 *(continued)*

Sixth Sort — Verbal Sort

RULE

Air	Land
(Airplane Duck Eagle)	*(Bus Car Tiger)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Seventh Sort — Perceptual Sort

RULE

Red Label	White Label
(Airplane Bus Duck)	*(Car Eagle Tiger)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Eighth Sort — Perceptual Sort

RULE

Uppercase Letters	Lowercase Letters
(Bus Duck Eagle)	*(Airplane Car Tiger)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Sort Recognition: Card Set 1

Raw Score

Total Description Score ☐

Condition 2–Sort Recognition: Card Set 2

Administer all eight target sorts to the examinee. Discontinue administration of ***each sort*** after either (a) the examinee provides a correct or incorrect description, (b) the examinee indicates that he or she cannot identify the sorting rules, or (c) 45 seconds have elapsed after the examiner made the sort and the examinee failed to initiate a description response.

First Sort — Perceptual Sort

RULE

Diagonals Close *(Ears Shoe Socks)* | Diagonals Apart *(Hat Mouth Toes)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Second Sort — Verbal Sort

RULE

Body Parts *(Ears Mouth Toes)* | Clothing *(Hat Shoe Socks)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Third Sort — Perceptual Sort

RULE

Triangles Above Word *(Ears Mouth Socks)* | Triangles Below Word *(Hat Shoe Toes)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Fourth Sort — Perceptual Sort

RULE

Cursive Letters *(Ears Hat Toes)* | Printed Letters *(Mouth Shoe Socks)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Fifth Sort — Verbal Sort

RULE

Plural Words *(Ears Socks Toes)* | Singular Words *(Mouth Shoe Hat)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Sixth Sort — Perceptual Sort

RULE

Diagonals Slope Up *(Ears Hat Shoe)*

Diagonals Slope Down *(Mouth Socks Toes)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Seventh Sort — Verbal Sort

RULE

Related to Head *(Ears Hat Mouth)*

Related to Feet *(Shoe Socks Toes)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Eighth Sort — Perceptual Sort

RULE

Filled Triangles *(Ears Mouth Shoe)*

Empty Triangles *(Hat Socks Toes)*

Description:

PRIMARY DESCRIPTION MEASURES	
1st Group Description Score	0 1 2
2nd Group Description Score	0 1 2
OPTIONAL DESCRIPTION MEASURES	
Incorrect Description	Y
Repeated Description	Y
No/Don't Know Response	Y
Noncredit Description	Y
Overly Abstract Description	Y
Description Type	V P

Sort Recognition: Card Set 2

Raw Score

Total Description Score ☐

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D-KEFS Sorting Test: Summary of Scores

Primary Measures

	Card Set 1	+	Card Set 2	=	Raw Score	Scaled Score
Condition 1: Free Sorting						
Confirmed Correct Sorts	_____ Raw Score	+	_____ Raw Score	=	☐ →	☐
Free Sorting Description Score	_____ Raw Score	+	_____ Raw Score	=	☐ →	☐
Condition 2: Sort Recognition						
Sort Recognition Description Score	_____ Raw Score	+	_____ Raw Score	=	☐ →	☐

Combined Conditions 1 + 2

	Condition 1: Free Sorting Description Score	+	Condition 2: Sort Recognition Description Score	=	Sum of Scaled Scores	Composite Scaled Score
Combined Description Score	☐ Scaled Score	+	☐ Scaled Score	=	☐ →	☐

Contrast Measure: Sort Recognition Versus Free Sorting Description Score

	Condition 2: Sort Recognition Description Score	−	Condition 1: Free Sorting Description Score	=	Scaled-Score Difference	Contrast Scaled Score*
	☐ Scaled Score	−	☐ Scaled Score	=	☐ →	☐

* A low or high contrast scaled score may reflect different cognitive problems; see examiner's manual.

Optional Measures

Screening Pretest

	Raw Score	Cumulative Percentile Rank
Word Reading Errors	☐ →	☐
Word Comprehension Errors	☐ →	☐

Condition 1: Free Sorting Sorting Measures (Optional)

Confirmed Correct Sorts: Card Set 1 — Raw Score ☐ → ☐ Scaled Score

Confirmed Correct Sorts: Card Set 2 — Raw Score ☐ → ☐ Scaled Score

	Card Set 1	+	Card Set 2	=	Total Raw Score	Scaled Score
Confirmed Correct Verbal Sorts	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐
Confirmed Correct Perceptual Sorts	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐
Confirmed/Unconfirmed Target Sorts	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐
Repeated Sorts	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐
Set-Loss Sorts	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐ Cumulative Percentile Rank
Nontarget Even Sorts	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐ Cumulative Percentile Rank
Attempted Sorts	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐

Percent Sorting Accuracy = [Confirmed Correct Sorts ☐ (Total Raw Score) ÷ Attempted Sorts ☐ (Total Raw Score)] × 100 = Percent Raw Score ☐ → ☐

Time-Per-Sort Ratio** = Cumulative Sorting Time Cards Sets 1 + 2 ☐ (Total Raw Score) ÷ Attempted Sorts ☐ (Total Raw Score) → Ratio Raw Score ☐ → ☐

Condition 1: Free Sorting Description Measures (Optional)

	Raw Score	Scaled Score
Free Sorting Description Score: Card Set 1	☐	→ ☐
Free Sorting Description Score: Card Set 2	☐	→ ☐

	Card Set 1	+	Card Set 2	=	Total Raw Score	
Free Sorting Incorrect Descriptions*	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐
Free Sorting Repeated Descriptions*	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐ Cumulative Percentile Rank

Percent Description Accuracy = [Free Sorting Description Score ☐ (Total Raw Score) ÷ [Attempted Sorts ☐ (Total Raw Score) × 4]] × 100 = Percent Raw Score ☐ → ☐

* No/Don't Know responses are not included in these measures.

** A low or high ratio scaled score may reflect different cognitive problems; see examiner's manual.

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Optional Measures *(continued)*

Condition 2: Sort Recognition Description Measures (Optional)

	Raw Score		Scaled Score
Sort Recognition Description Score: Card Set 1	☐	→	☐
Sort Recognition Description Score: Card Set 2	☐	→	☐

	Card Set 1	+	Card Set 2	=	Total Raw Score
Sort Recognition Incorrect Descriptions*	_____ Raw Score	+	_____ Raw Score	=	☐ → ☐
Sort Recognition Repeated Descriptions*	_____ Raw Score	+	_____ Raw Score	=	☐ → ☐ Cumulative Percentile Rank

Combined Conditions 1 + 2: Description Measures (Optional)

	Condition 1: Free Sorting Total	+	Condition 2: Sort Recognition Total	=	Combined Raw Score	Scaled Score
Combined Description Score: Verbal Rules	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐
Combined Description Score: Perceptual Rules	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐
Combined No/Don't Know Responses	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐
Combined Noncredit Descriptions	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐ Cumulative Percentile Rank
Combined Overly Abstract Descriptions	_____ Raw Score	+	_____ Raw Score	=	☐	→ ☐ Cumulative Percentile Rank

	Condition 1: Free Sorting Incorrect Descriptions	+	Condition 2: Sort Recognition Incorrect Descriptions	=	Sum of Scaled Scores	Composite Scaled Score
Combined Incorrect Descriptions*	☐ Scaled Score	+	☐ Scaled Score	=	☐	→ ☐

	Repeated Descriptions	+	Repeated Descriptions	=	Total Raw Score	
Combined Repeated Descriptions*	☐ Raw Score	+	☐ Raw Score	=	☐	→ ☐ Cumulative Percentile Rank

* No/Don't Know responses are not included in these measures

Note: Cumulative percentile ranks for the D–KEFS were scaled to reflect the percentage of the normative sample that obtained raw scores equal to or worse than the raw score obtained by the examinee.

D-KEFS Twenty Questions Test

Ages 8–89

Materials

Record Form

Stimulus Booklet (Flat Position)

Discontinue

Do not discontinue. Administer all four items to examinees in the order in which they appear here. Discontinue each item after the examinee either has identified the target object or has asked 20 yes/no questions without identifying the target object. Do not reveal the target object if the examinee has failed to identify it after asking 20 questions.

Administration and Recording

Position the stimulus booklet flat on the table in a horizontal (landscape) position directly in front of the examinee's midline, with the pictures facing the examinee.

Say,

> **Now we are going to do something where you ask *me* questions. I have picked *one* of these pictures, and I want you to figure out which one it is by asking me questions. You can only ask questions that I can answer yes or no. You can ask any question at all, as long as I can answer it yes or no. Try to guess the picture that I have picked with the fewest number of questions you can. I'm going to write down your questions so I can remember them. Go ahead and ask me the fewest number of yes/no questions you can to figure out which picture I have selected.**

Record verbatim each of the examinee's questions in the order that they are asked. Answer **Yes** if the examinee's question encompasses or identifies the target item or **No** if it does not. Circle *Y* (for yes) or *N* (for no) to indicate your answer to each of the examinee's questions.

Whether or not the examinee correctly identifies the target object for Item 1 after asking 20 yes/no questions or fewer, say,

> **Good. Let's try the next one. I've picked a new picture, and I want you to ask me the fewest number of yes/no questions you can to figure out which one it is. Go ahead.**

Repeat these administration and recording procedures for each of Items 2–4.

COMMON PROMPTS

- If an examinee's first question for an item refers only to one object (e.g.,"Is it the elephant?"), record and answer the question. Then say, **Remember, try to ask the fewest number of questions you can.** Provide this prompt only once for each item.
- When answering questions, respond only with yes or no as much as possible. In deciding how to answer, base your response on how most people would respond to the same question. If the question could possibly be answered either way, you may say, **Most people would say yes** or **Most people would say no.** If an answer is true or untrue for an item most of the time, you may say, **Usually yes** or **Usually no.**
- If you do not know the answer to an examinee's question, say, **That's an excellent question. I'm not sure I know the answer. Try another question.** Do not count this question as one of the 20 questions.
- If an examinee asks a compound question (e.g., "Is it red and a plant?"), record the response and say, **I can answer only one of those questions. Which one do you want me to answer?** If the examinee asks an either/or question (e.g., "Is it an animal or a fruit?"), ask him or her to rephrase it as a yes/no question. After these prompts, if the examinee provides a yes/no question that clarifies the compound or either/or question, consider both responses as representing one yes/no question.
- If you are unsure of how to answer a spatial question, say, **Show me the ones you mean.** Pointing to the target object is an acceptable correct response.
- Some common types of questions ("Is it living?" or "Is it dead?") can be difficult to answer yes or no for some target items. If the object is organic or natural, say, **Yes, it is or once was living.** If the object is inorganic or human-made, say, **No, it never was alive.**
- If the examinee's question is vague (e.g., "Is it big?"), say, **Could you make your question more specific?** Consider both the vague question and any additional specific question as representing only one question.
- If an examinee fails to identify the target object after 20 questions but wants to know which one it is, say, **I can't tell you, but try to guess the next one.**

SPECIAL CONSIDERATIONS

- If an examinee has difficulty perceiving an object on the stimulus page because of visual problems and asks for clarification (e.g., "Is that a fork?"), record and answer the question; however, do not score or count it as one of the 20 questions allowed for that item.
- An examinee may have difficulty remembering previously asked questions, your yes/no answers to those questions, or both, and request that the information be repeated. You may provide such information as often as it is requested.
- If an examinee points to the correct target object but misnames it, the response is still considered correct.

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D-KEFS Twenty Questions Test

Discontinue each item after the examinee asks 20 questions without identifying the target object.

Total Questions Asked (Circle One)	Item 1 (banana)	Examiner's Answer	Weighted Achievement Score (Circle One)
1		Y N	1
2		Y N	1
3		Y N	2
4		Y N	5
5		Y N	5
6		Y N	4
7		Y N	4
8		Y N	3
9		Y N	3
10		Y N	3
11		Y N	2
12		Y N	2
13		Y N	2
14		Y N	2
15		Y N	1
16		Y N	1
17		Y N	1
18		Y N	1
19		Y N	1
20		Y N	1
21	← Failed to guess in 20 questions →		0

Total Questions Asked (Circle One)	Item 2 (spoon)	Examiner's Answer	Weighted Achievement Score (Circle One)
1		Y N	1
2		Y N	1
3		Y N	2
4		Y N	5
5		Y N	5
6		Y N	4
7		Y N	4
8		Y N	3
9		Y N	3
10		Y N	3
11		Y N	2
12		Y N	2
13		Y N	2
14		Y N	2
15		Y N	1
16		Y N	1
17		Y N	1
18		Y N	1
19		Y N	1
20		Y N	1
21	← Failed to guess in 20 questions →		0

	Raw Score
Initial Abstraction Score*	
Optional Scores:	
# Spatial Questions	
# Repeated Questions	
# Set-Loss Questions	

Item 1: Total Questions Asked Max. = 21

Item 1: Weighted Achievement Score Max. = 5

	Raw Score
Initial Abstraction Score*	
Optional Scores:	
# Spatial Questions	
# Repeated Questions	
# Set-Loss Questions	

Item 2: Total Questions Asked Max. = 21

Item 2: Weighted Achievement Score Max. = 5

* Minimum number of objects eliminated by the first question asked regardless of the yes or no answer.

D-KEFS Twenty Questions Test *(continued)*

Discontinue each item after the examinee asks 20 questions without identifying the target object.

Total Questions Asked (Circle One)	**Item 3 (owl)**	Examiner's Answer	Weighted Achievement Score (Circle One)
1		Y N	1
2		Y N	1
3		Y N	2
4		Y N	5
5		Y N	5
6		Y N	4
7		Y N	4
8		Y N	3
9		Y N	3
10		Y N	3
11		Y N	2
12		Y N	2
13		Y N	2
14		Y N	2
15		Y N	1
16		Y N	1
17		Y N	1
18		Y N	1
19		Y N	1
20		Y N	1
21	← Failed to guess in 20 questions →		0

Total Questions Asked (Circle One)	**Item 4 (helicopter)**	Examiner's Answer	Weighted Achievement Score (Circle One)
1		Y N	1
2		Y N	1
3		Y N	2
4		Y N	5
5		Y N	5
6		Y N	4
7		Y N	4
8		Y N	3
9		Y N	3
10		Y N	3
11		Y N	2
12		Y N	2
13		Y N	2
14		Y N	2
15		Y N	1
16		Y N	1
17		Y N	1
18		Y N	1
19		Y N	1
20		Y N	1
21	← Failed to guess in 20 questions →		0

Item 3: Total Questions Asked Max. = 21	Item 3: Weighted Achievement Score Max. = 5	Item 4: Total Questions Asked Max. = 21	Item 4: Weighted Achievement Score Max. = 5

Raw Score		Raw Score	
Initial Abstraction Score*	_____	Initial Abstraction Score*	_____
Optional Scores:		**Optional Scores:**	
# Spatial Questions	_____	# Spatial Questions	_____
# Repeated Questions	_____	# Repeated Questions	_____
# Set-Loss Questions	_____	# Set-Loss Questions	_____

* Minimum number of objects eliminated by the first question asked regardless of the yes or no answer.

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D-KEFS Twenty Questions Test: Summary of Scores

Primary Measures

	Item 1 Raw Score		Item 2 Raw Score		Item 3 Raw Score		Item 4 Raw Score		Total Raw Score	Scaled Score
Initial Abstraction Score*		+		+		+		=		→
Total Questions Asked		+		+		+		=		→
Total Weighted Achievement Score		+		+		+		=		→

* Minimum number of objects eliminated by the first question asked regardless of the yes or no answer.

Optional Measures

	Item 1 Raw Score		Item 2 Raw Score		Item 3 Raw Score		Item 4 Raw Score		Total Raw Score	Cumulative Percentile Rank
Spatial Questions		+		+		+		=		→
Repeated Questions		+		+		+		=		→
Set-Loss Questions		+		+		+		=		→

Note: Cumulative percentile ranks for the D–KEFS were scaled to reflect the percentage of the normative sample that obtained raw scores equal to or worse than the raw score obtained by the examinee.

D-KEFS Word Context Test

Do not discontinue. Administer all items in the order presented here and in the stimulus booklet.

Practice Item: sev (apple)

Examinee's Responses:

1. _____
2. _____
3. _____
4. _____
5. _____

1. prifa (eat)

Examinee's Responses:

	Response Correct	1st Sentence Correct (Circle One)	1st Sentence Consecutively Correct (Circle One)
1. _____	Y N	5	5
2. _____	Y N	4	4
3. _____	Y N	3	3
4. _____	Y N	2	2
5. _____	Y N	1	1

Optional:
Repeated Incorrect
Raw Score
No/DK Responses
Raw Score
Correct-To-Incorrect
Raw Score

Incorrect responses on all sentences: 0

Incorrect response on Sentence 5: 0

2. enton (dance)

Examinee's Responses:

	Response Correct	1st Sentence Correct (Circle One)	1st Sentence Consecutively Correct (Circle One)
1. _____	Y N	5	5
2. _____	Y N	4	4
3. _____	Y N	3	3
4. _____	Y N	2	2
5. _____	Y N	1	1

Optional:
Repeated Incorrect
Raw Score
No/DK Responses
Raw Score
Correct-To-Incorrect
Raw Score

Incorrect responses on all sentences: 0

Incorrect response on Sentence 5: 0

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D-KEFS Word Context Test *(continued)*

3. delz (voice)

Examinee's Responses:

	Response Correct	1st Sentence Correct (Circle One)	1st Sentence Consecutively Correct (Circle One)
1. _____	Y N	5	5
2. _____	Y N	4	4
3. _____	Y N	3	3
4. _____	Y N	2	2
5. _____	Y N	1	1

Optional:
Repeated Incorrect: ____ Raw Score
No/DK Responses: ____ Raw Score
Correct-To-Incorrect: ____ Raw Score

Incorrect responses on all sentences: 0

Incorrect response on Sentence 5: 0

4. vern (horse)

Examinee's Responses:

	Response Correct	1st Sentence Correct (Circle One)	1st Sentence Consecutively Correct (Circle One)
1. _____	Y N	5	5
2. _____	Y N	4	4
3. _____	Y N	3	3
4. _____	Y N	2	2
5. _____	Y N	1	1

Optional:
Repeated Incorrect: ____ Raw Score
No/DK Responses: ____ Raw Score
Correct-To-Incorrect: ____ Raw Score

Incorrect responses on all sentences: 0

Incorrect response on Sentence 5: 0

5. nelzen (make)

Examinee's Responses:

	Response Correct	1st Sentence Correct (Circle One)	1st Sentence Consecutively Correct (Circle One)
1. _____	Y N	5	5
2. _____	Y N	4	4
3. _____	Y N	3	3
4. _____	Y N	2	2
5. _____	Y N	1	1

Optional:
Repeated Incorrect: ____ Raw Score
No/DK Responses: ____ Raw Score
Correct-To-Incorrect: ____ Raw Score

Incorrect responses on all sentences: 0

Incorrect response on Sentence 5: 0

6. gesh (fill)

Examinee's Responses:

	Response Correct	1st Sentence Correct (Circle One)	1st Sentence Consecutively Correct (Circle One)	Optional: # Repeated Incorrect
1. _____	Y N	5	5	Raw Score
2. _____	Y N	4	4	# No/DK Responses
3. _____	Y N	3	3	Raw Score
4. _____	Y N	2	2	# Correct-To-Incorrect
5. _____	Y N	1	1	Raw Score

Incorrect responses on all sentences: 0

Incorrect response on Sentence 5: 0

7. luri (motor, engine)

Examinee's Responses:

	Response Correct	1st Sentence Correct (Cricle One)	1st Sentence Consecutively Correct (Circle One)	Optional: # Repeated Incorrect
1. _____	Y N	5	5	Raw Score
2. _____	Y N	4	4	# No/DK Responses
3. _____	Y N	3	3	Raw Score
4. _____	Y N	2	2	# Correct-To-Incorrect
5. _____	Y N	1	1	Raw Score

Incorrect responses on all sentences: 0

Incorrect response on Sentence 5: 0

8. krame (tooth, teeth)

Examinee's Responses:

	Response Correct	1st Sentence Correct (Circle One)	1st Sentence Consecutively Correct (Circle One)	Optional: # Repeated Incorrect
1. _____	Y N	5	5	Raw Score
2. _____	Y N	4	4	# No/DK Responses
3. _____	Y N	3	3	Raw Score
4. _____	Y N	2	2	# Correct-To-Incorrect
5. _____	Y N	1	1	Raw Score

Incorrect responses on all sentences: 0

Incorrect response on Sentence 5: 0

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9. kapla (word)

Examinee's Responses:

1. _____
2. _____
3. _____
4. _____
5. _____

Response Correct	1st Sentence Correct (Circle One)	1st Sentence Consecutively Correct (Circle One)
Y N	5	5
Y N	4	4
Y N	3	3
Y N	2	2
Y N	1	1

Optional:
Repeated Incorrect ____ Raw Score
No/DK Responses ____ Raw Score
Correct-To-Incorrect ____ Raw Score

Incorrect responses on all sentences: 0

Incorrect response on Sentence 5: 0

10. grot (curtain)

Examinee's Responses:

1. _____
2. _____
3. _____
4. _____
5. _____

Response Correct	1st Sentence Correct (Circle One)	1st Sentence Consecutively Correct (Circle One)
Y N	5	5
Y N	4	4
Y N	3	3
Y N	2	2
Y N	1	1

Optional:
Repeated Incorrect ____ Raw Score
No/DK Responses ____ Raw Score
Correct-To-Incorrect ____ Raw Score

Incorrect responses on all sentences: 0

Incorrect response on Sentence 5: 0

D–KEFS Word Context Test: Summary of Scores

Primary Measure

Total Consecutively Correct

[ ] Raw Score → [ ] **Scaled Score**

Optional Measures

Consistently Correct Ratio

[Total Consecutively Correct Score [ ] Raw Score ÷ Total First Sentence Correct Score [ ] Raw Score] × 100 = Percent Raw Score [ ] → **Scaled Score** [ ]

Repeated Incorrect Responses

[ ] Total Raw Score → [ ] **Scaled Score**

No/Don't Know Responses

[ ] Total Raw Score → [ ] **Cumulative Percentile Rank**

Total Correct-To-Incorrect Errors

[ ] Total Raw → [ ] **Cumulative Percentile Rank**

Note: Cumulative percentile ranks for the D–KEFS were scaled to reflect the percentage of the normative sample that obtained raw scores equal to or worse than the raw score obtained by the examinee.

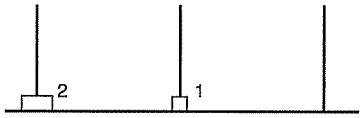
D-KEFS Tower Test

Discontinue after three consecutive item failures. Disk Labels: 1 = Smallest to 5 = Largest.

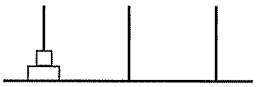
Item 1: Two Disks

Time Limit: 30"

Starting Position (Examiner's View)



Ending Position:



1st Move Time	Total # Moves (Min. = 1)	# Rule Violations	Item Completion Time
			Correct Tower Y N

Demonstrate 1-move solution if examinee fails to solve item in 1 move.

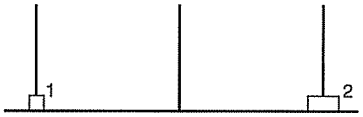
Achievement Score

	Correct Within Time Limit	
	>1 Moves	1 Move
Failed	1	2
0		

Item 2: Two Disks

Time Limit: 30"

Starting Position (Examiner's View)



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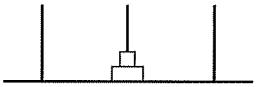


1st Move Time	Total # Moves (Min. = 2)	# Rule Violations	Item Completion Time
			Correct Tower Y N

Demonstrate 2-move solution if examinee fails to solve item in 2 moves.

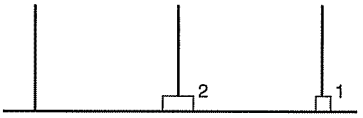
Achievement Score

	Correct Within Time Limit	
	>2 Moves	2 Moves
Failed	1	2
0		

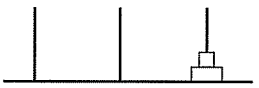
Item 3: Two Disks

Time Limit: 30"

Starting Position (Examiner's View)



Ending Position:



1st Move Time	Total # Moves (Min. = 3)	# Rule Violations	Item Completion Time
			Correct Tower Y N

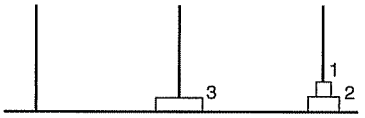
Achievement Score

	Correct Within Time Limit		
	>4 Moves	4 Moves	3 Moves
Failed	1	2	3
0			

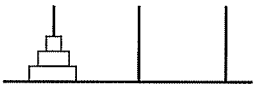
Item 4: Three Disks

Time Limit: 60"

Starting Position (Examiner's View)



Ending Position:



1st Move Time	Total # Moves (Min. = 4)	# Rule Violations	Item Completion Time
			Correct Tower Y N

Achievement Score

	Correct Within Time Limit		
	>5 Moves	5 Moves	4 Moves
Failed	1	2	3
0			

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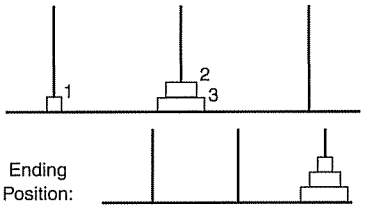
Item 5: Three Disks

Time Limit: 120"

Starting Position (Examiner's View)



Ending Position:

1st Move Time	Total # Moves (Min. = 7)	# Rule Violations	Item Completion Time
			Correct Tower Y N

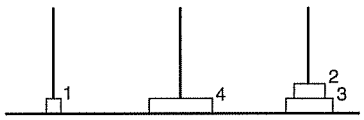
Achievement Score

Correct Within Time Limit				
Failed	>9 Moves	9 Moves	8 Moves	7 Moves
0	1	2	3	4

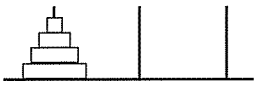
Item 6: Four Disks

Time Limit: 120"

Starting Position (Examiner's View)



Ending Position:



1st Move Time	Total # Moves (Min. = 9)	# Rule Violations	Item Completion Time
			Correct Tower Y N

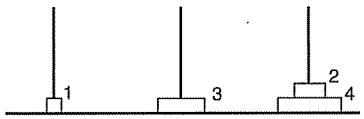
Achievement Score

Correct Within Time Limit				
Failed	>11 Moves	11 Moves	10 Moves	9 Moves
0	1	2	3	4

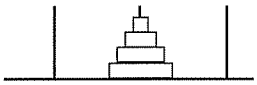
Item 7: Four Disks

Time Limit: 180"

Starting Position (Examiner's View)



Ending Position:



1st Move Time	Total # Moves (Min. = 13)	# Rule Violations	Item Completion Time
			Correct Tower Y N

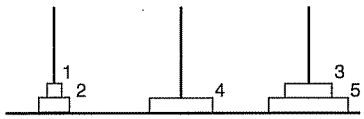
Achievement Score

Correct Within Time Limit				
Failed	>15 Moves	15 Moves	14 Moves	13 Moves
0	1	2	3	4

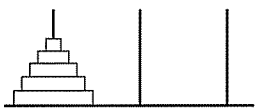
Item 8: Five Disks

Time Limit: 240"

Starting Position (Examiner's View)



Ending Position:



1st Move Time	Total # Moves (Min. = 20)	# Rule Violations	Item Completion Time
			Correct Tower Y N

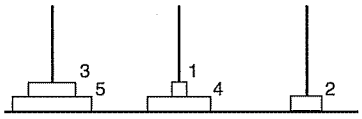
Achievement Score

Correct Within Time Limit				
Failed	>24 Moves	23–24 Moves	21–22 Moves	20 Moves
0	1	2	3	4

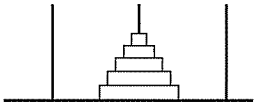
Item 9: Five Disks

Time Limit: 240"

Starting Position (Examiner's View)



Ending Position:



1st Move Time	Total # Moves (Min. = 26)	# Rule Violations	Item Completion Time
			Correct Tower Y N

Achievement Score

Correct Within Time Limit				
Failed	>32 Moves	30–32 Moves	27–29 Moves	26 Moves
0	1	2	3	4

D–KEFS Tower Test: Summary of Scores

Totals for Items Administered

Total # Items Administered	Total 1st-Move Time	Total # Moves	Total # Rule Violations	Total Item Completion Times	Total Achievement Score
☐	☐	☐	☐	☐	☐

Primary Measure

	Total Raw Score		Scaled Score
Total Achievement Score	☐	→	☐

Optional Measures

Mean First-Move Time*	Total 1st-Move Times ☐	÷	Total # Items Administered ☐	=	**Ratio Score** ☐	→	**Scaled Score** ☐
Time-Per-Move Ratio*	Total Item-Completion Times ☐	÷	Total # Moves ☐	=	**Ratio Score** ☐	→	**Scaled Score** ☐
Move Accuracy Ratio*	Total # Moves ☐	÷	Total # Minimum Moves ☐	=	**Ratio Score** ☐	→	**Scaled Score** ☐
Total Rule Violations	☐					→	☐
	Total Raw Score						**Cumulative Percentile Rank**
Rule-Violations-Per-Item Ratio	Total # Rule Violations ☐	÷	Total # Items Administered ☐	=	**Ratio Score** ☐	→	**Scaled Score** ☐

Total Cumulative Minimum Moves Possible

Number of Items Administered	Cumulative Minimum Moves Possible
1	1
2	3
3	6
4	10
5	17
6	26
7	39
8	59
9	85

Circle the cumulative minimum number of moves possible for the number of items administered to determine the total number of minimum moves.

* A low or high ratio scaled score on these measures may reflect different cognitive problems; see examiner's manual.

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D-KEFS Proverb Test

Do not discontinue.

		Condition 1: Free Inquiry (Circle Score)			Condition 2: Multiple Choice (Circle Letter Choice/Score)		
		Accuracy Score	+ Abstraction Score	Total Achievement Score (Score 0 if Accuracy = 0)	0 Points (Phon / Unrel)	2 Points	4 Points
Common Proverbs (Items 1–5)	1. You can't judge a book by its cover.	0 1 2	0 2		b a 0	d 2	***c*** ***4***
	2. Don't count your chickens before they are hatched.	0 1 2	0 2		c b 0	d 2	***a*** ***4***
	3. Rome wasn't built in a day.	0 1 2	0 2		a d 0	c 2	***b*** ***4***
	4. Too many cooks spoil the soup.	0 1 2	0 2		d a 0	b 2	***c*** ***4***
	5. People who live in glass houses shouldn't throw stones.	0 1 2	0 2		a c 0	b 2	***d*** ***4***
Uncommon Proverbs (Items 6–8)	6. An old ox plows a straight row.	0 1 2	0 2		d c 0	a 2	***b*** ***4***
	7. A small leak will sink a large ship.	0 1 2	0 2		b d 0	a 2	***c*** ***4***
	8. No bread is without a crust.	0 1 2	0 2		d c 0	a 2	***b*** ***4***

Total Accuracy Score	Total Abstraction Score	Total Achievement Score	Total Achievement Score
▽	▽	▽	▽
☐	☐	☐	☐
		Free Inquiry	**Multiple Choice**

D-KEFS Proverb Test: Summary of Scores

Primary Measures

Total Achievement Score: Free Inquiry

Total Raw Score → **Scaled Score**

Total Achievement Score: Multiple Choice

Total Raw Score → **Cumulative Percentile Rank**

Optional Measures: Free Inquiry

Common Proverb Achievement Score: Free Inquiry Items 1–5

Total Raw Score → **Scaled Score**

Uncommon Proverb Achievement Score: Free Inquiry Items 6–8

Total Raw Score → **Scaled Score**

Accuracy Only Score

Total Raw Score → **Scaled Score**

Abstraction Only Score

Total Raw Score → **Scaled Score**

No/Don't Know Responses

Total Raw Score → **Cumulative Percentile Rank**

Repeated Responses

Total Raw Score → **Cumulative Percentile Rank**

Optional Measures: Multiple Choice

Common Proverb Achievement Score: Multiple Choice Items 1–5

Total Raw Score → **Cumulative Percentile Rank**

Uncommon Proverb Achievement Score: Multiple Choice Items 6–8

Total Raw Score → **Cumulative Percentile Rank**

Total Correct Abstract Choices

Total Raw Score → **Cumulative Percentile Rank**

Total Correct Concrete Choices

Total Raw Score → **Cumulative Percentile Rank**

Total Incorrect Phonemic Choices

Total Raw Score → **Cumulative Percentile Rank**

Total Incorrect Unrelated Choices

Total Raw Score → **Cumulative Percentile Rank**

Total Incorrect Phonemic + Unrelated Choices

Total Raw Score → **Cumulative Percentile Rank**

Note: Cumulative percentile ranks for the D–KEFS were scaled to reflect the percentage of the normative sample that obtained raw scores equal to or worse than the raw score obtained by the examinee.

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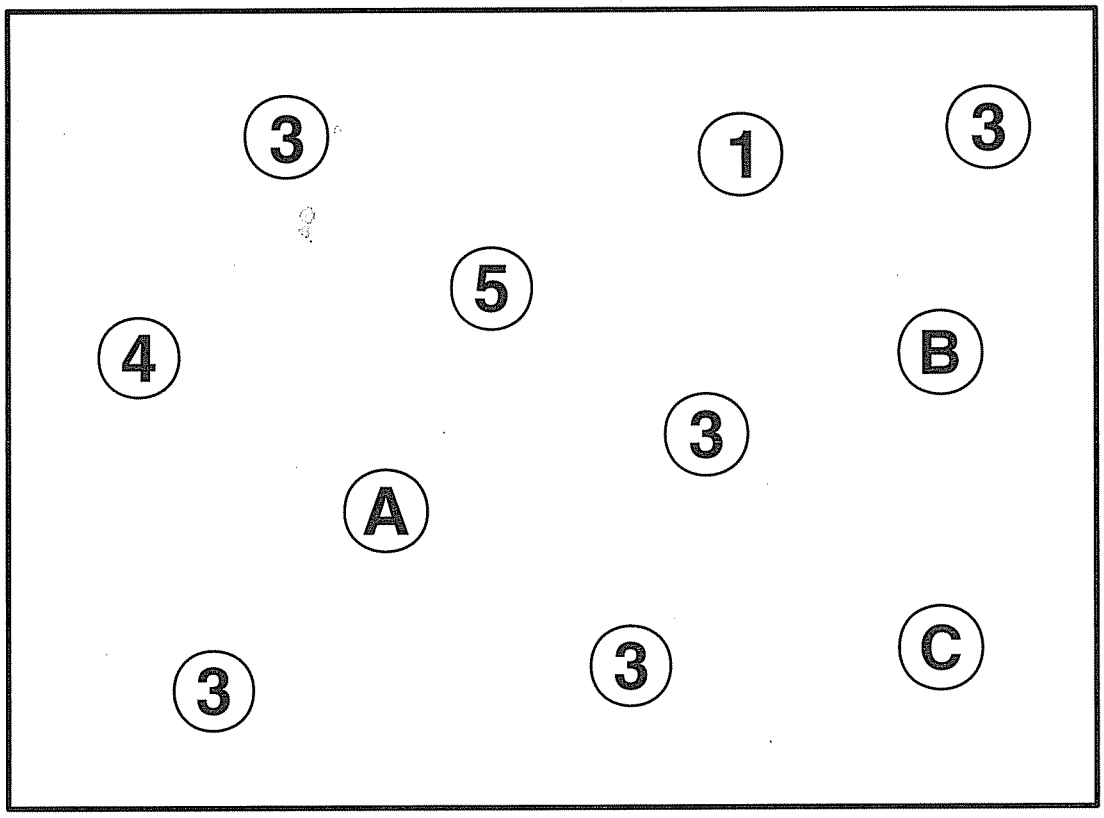
Trail-Making Test

Name _____ Age _____
ID _____ Date _____
Examiner _____
Notes _____

Condition 1
Visual Scanning

Practice



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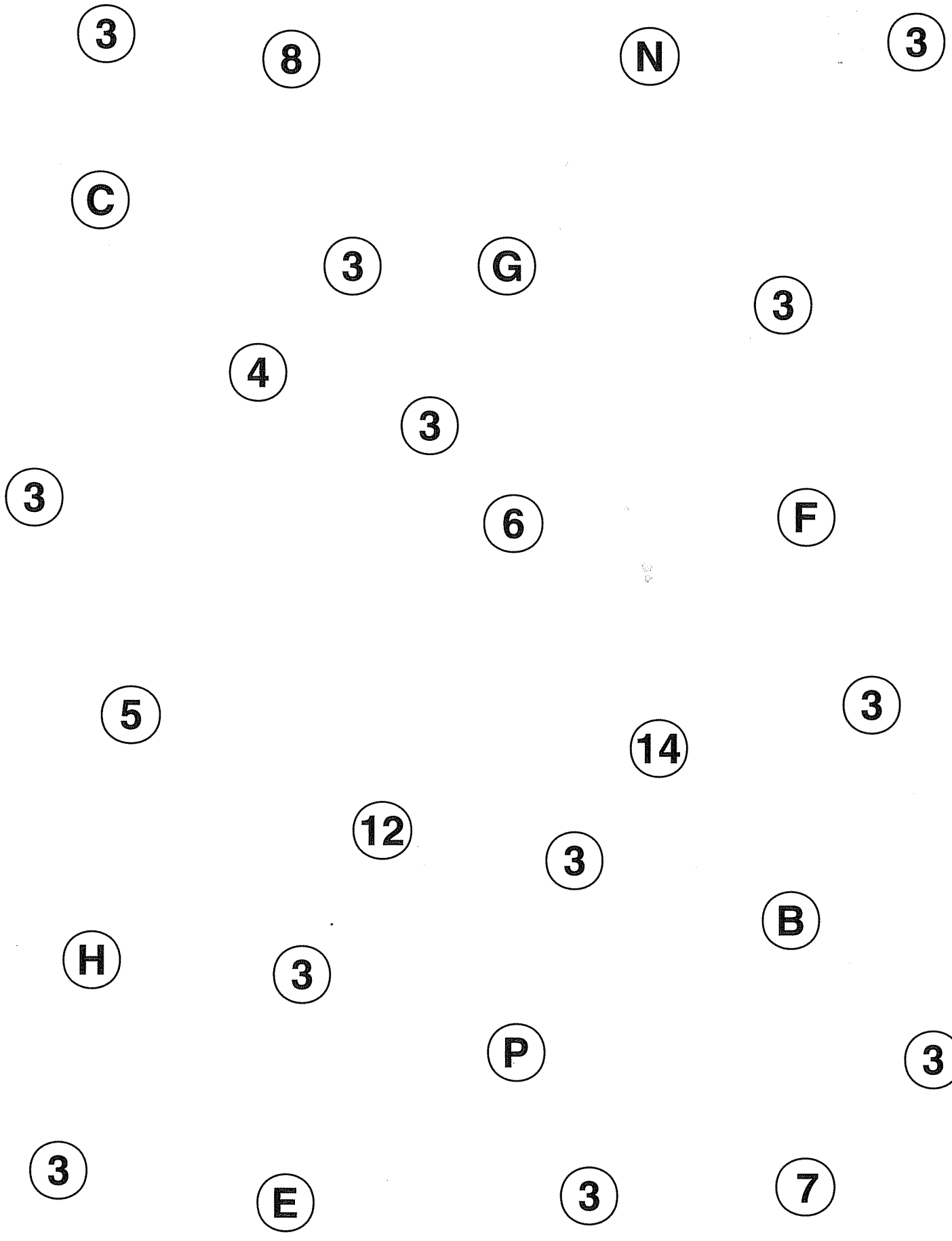
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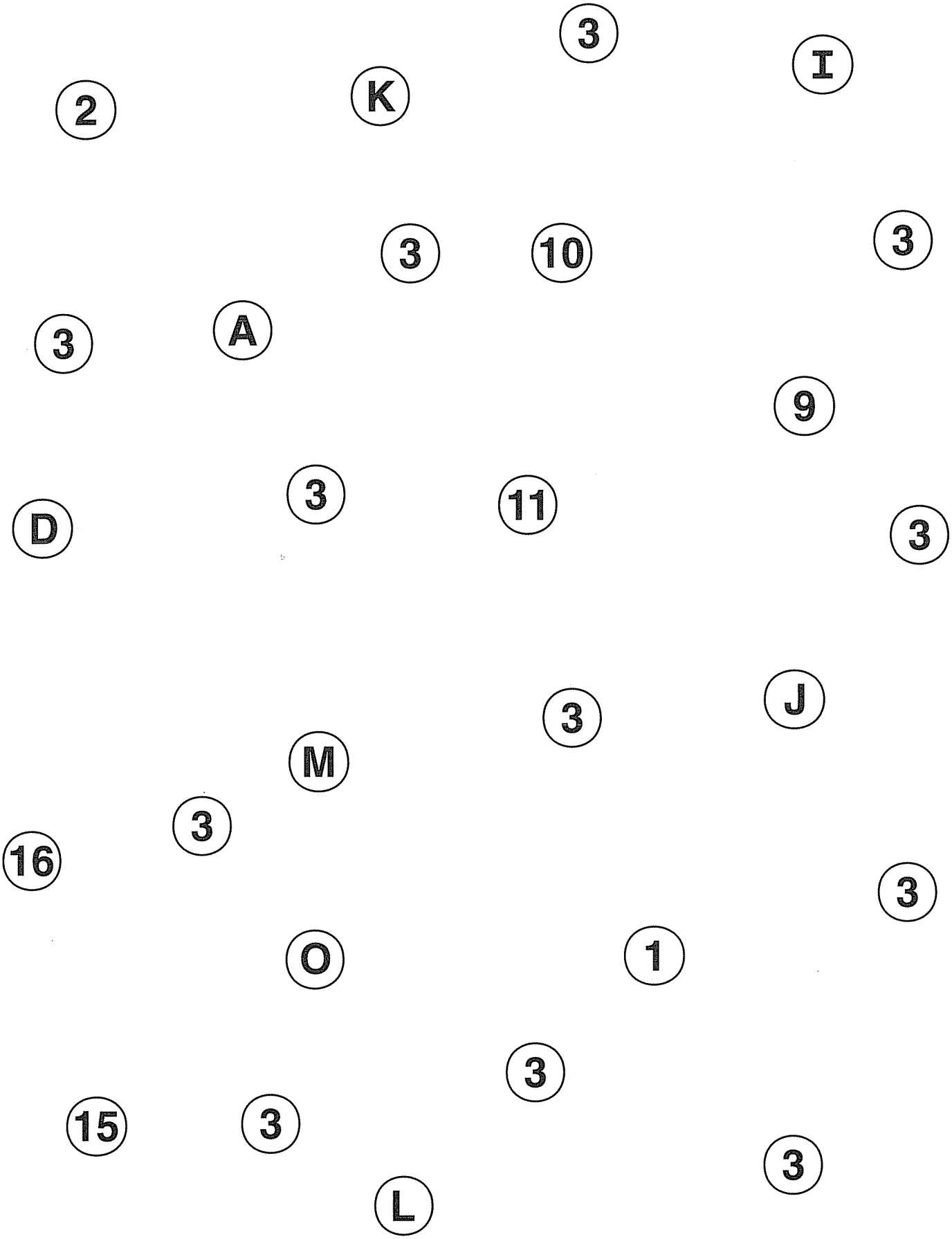
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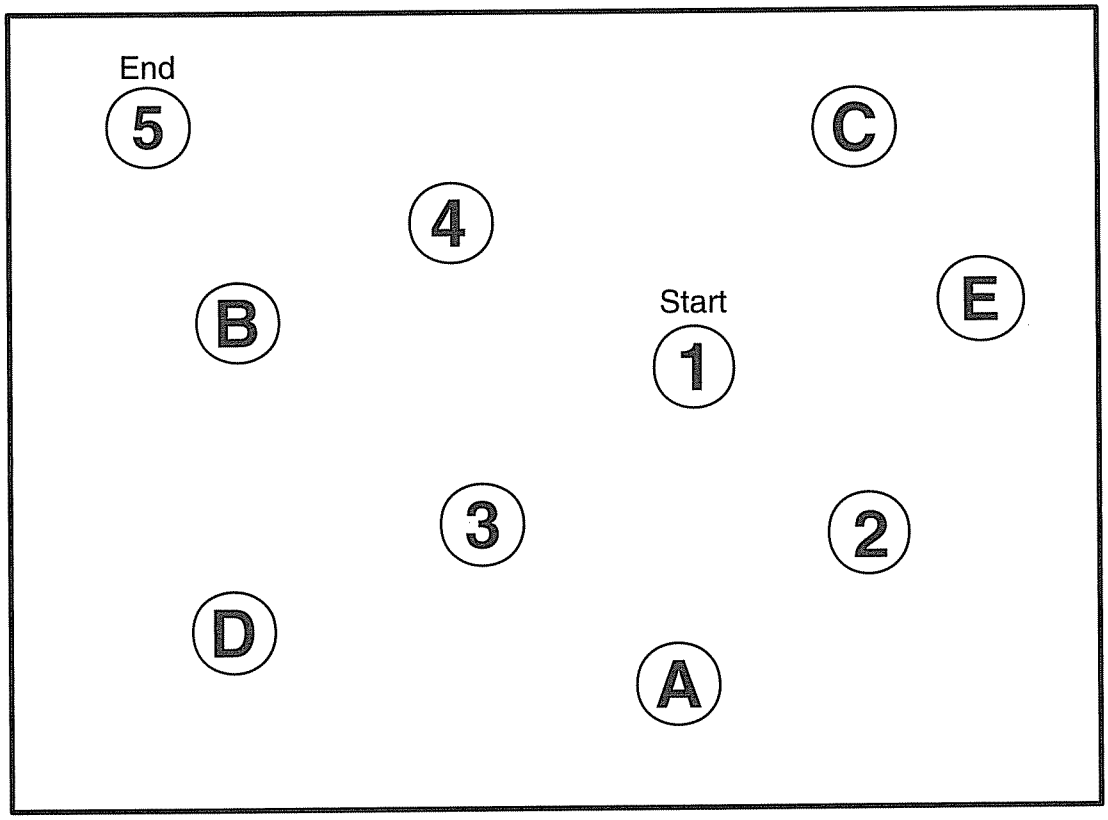
Name _____ Age _____
ID _____ Date _____
Examiner _____
Notes _____

Trail Making Test

Condition 2
Number Sequencing

Practice



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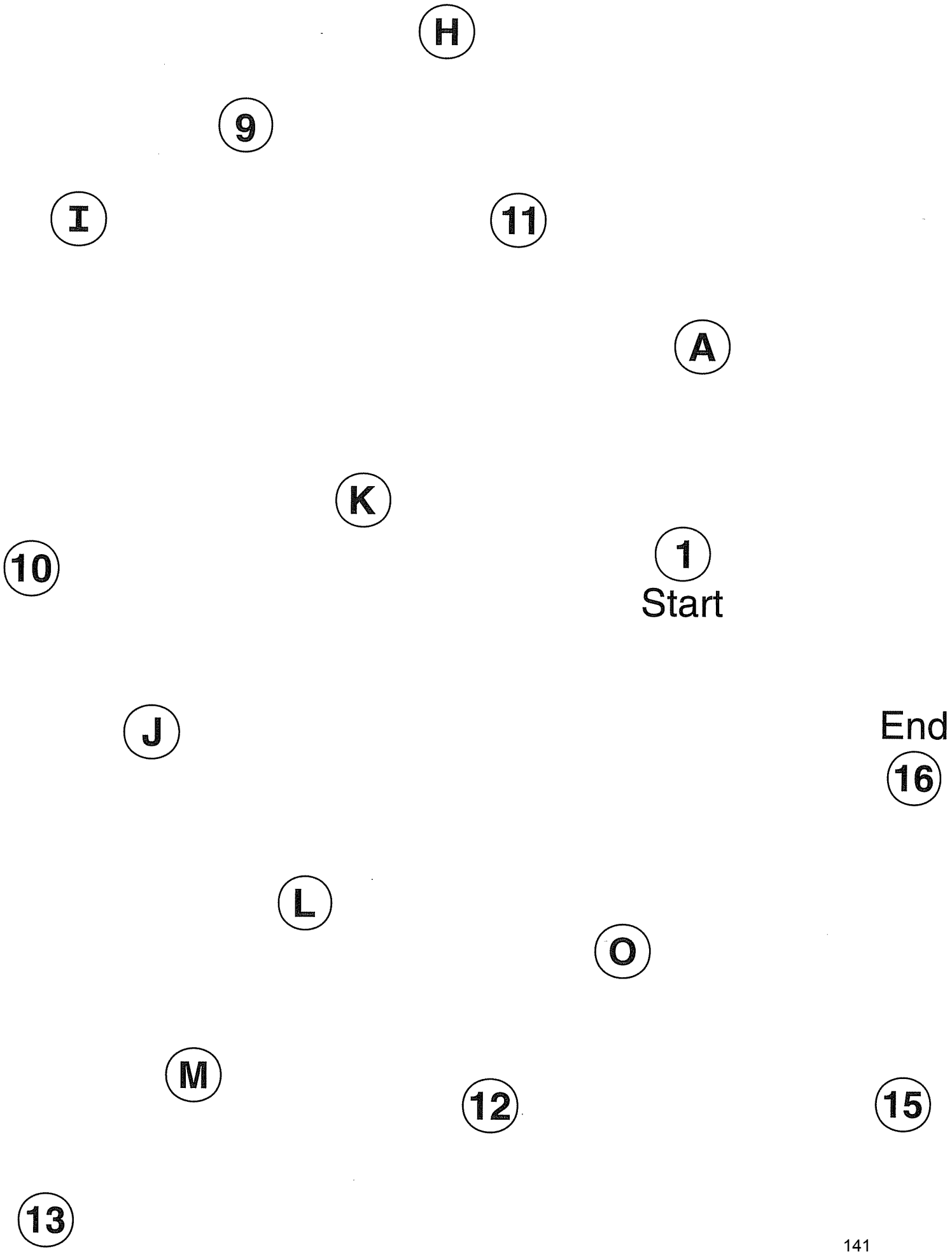
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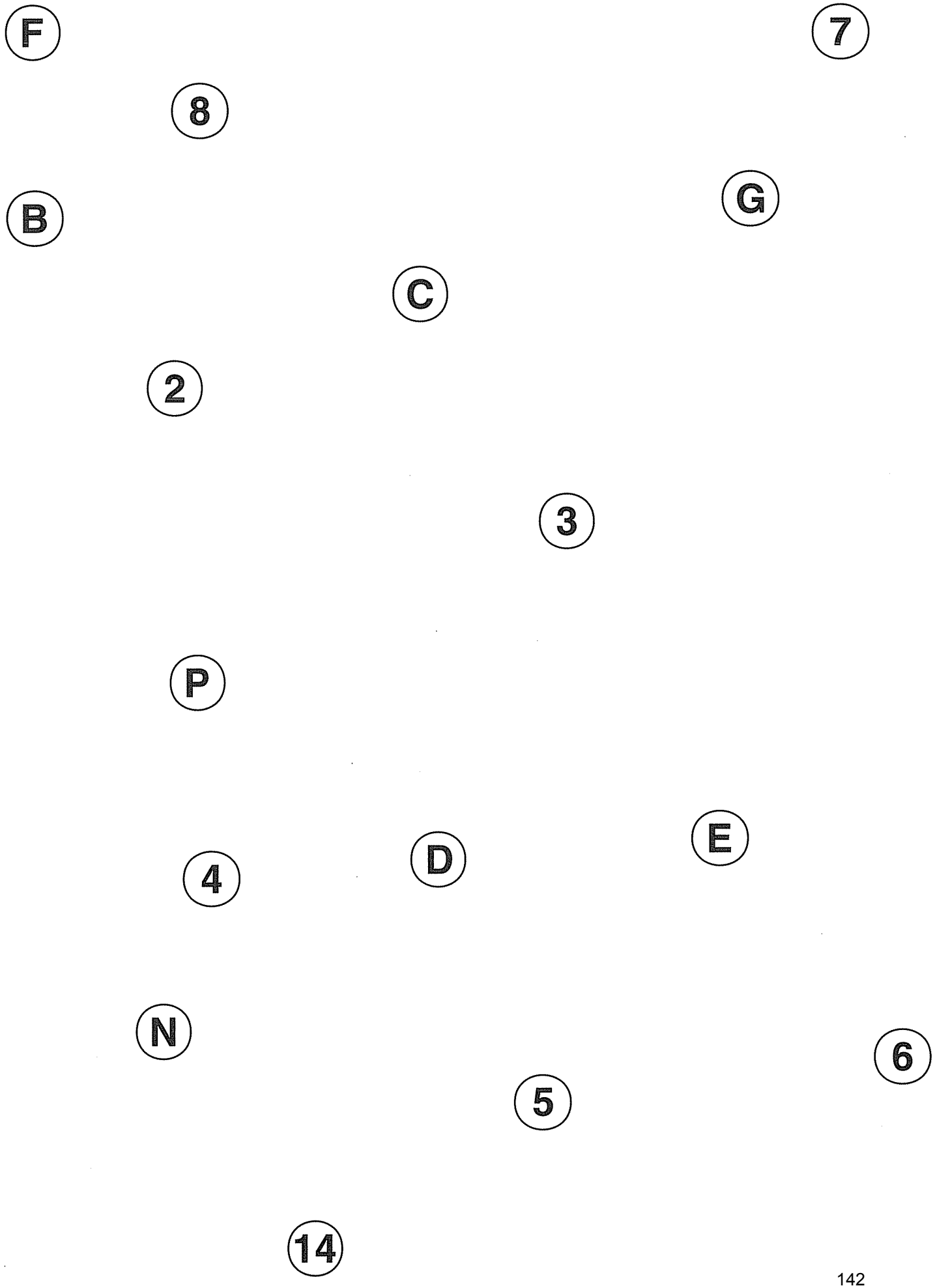
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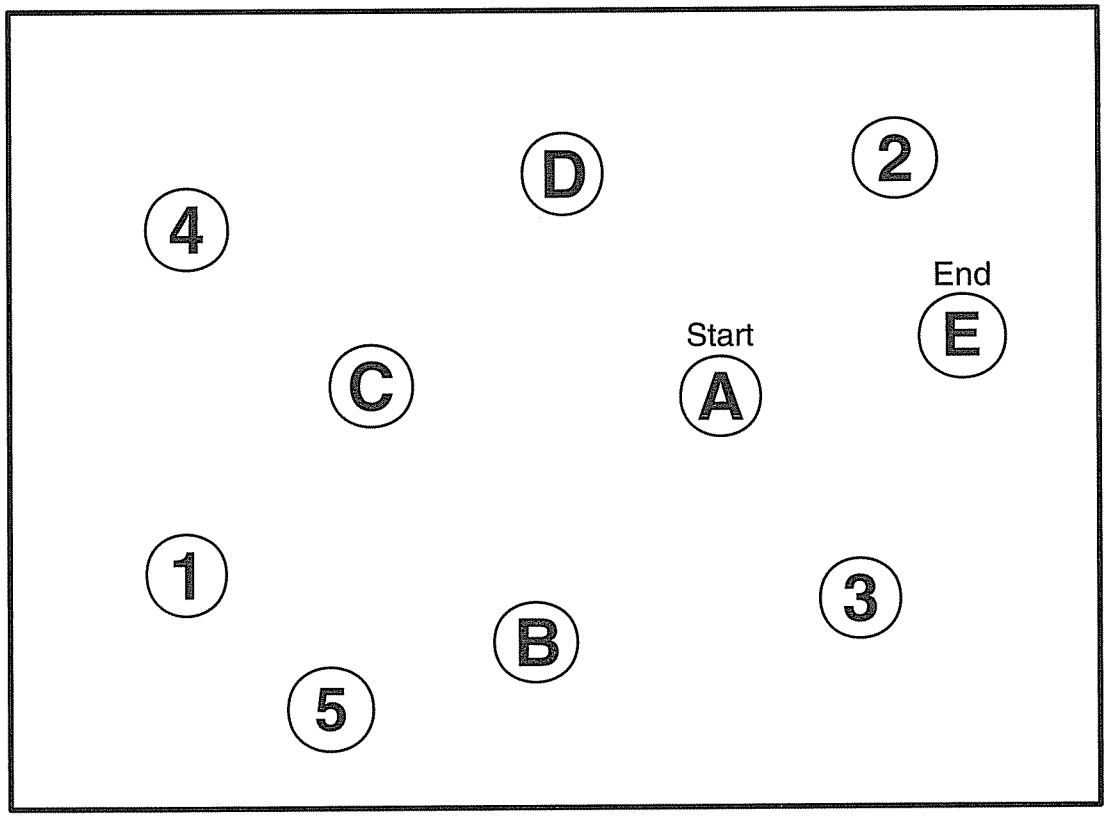
Trail Making Test

Name _____ Age _____
ID _____ Date _____
Examiner _____
Notes _____

Condition 3
Letter Sequencing

Practice



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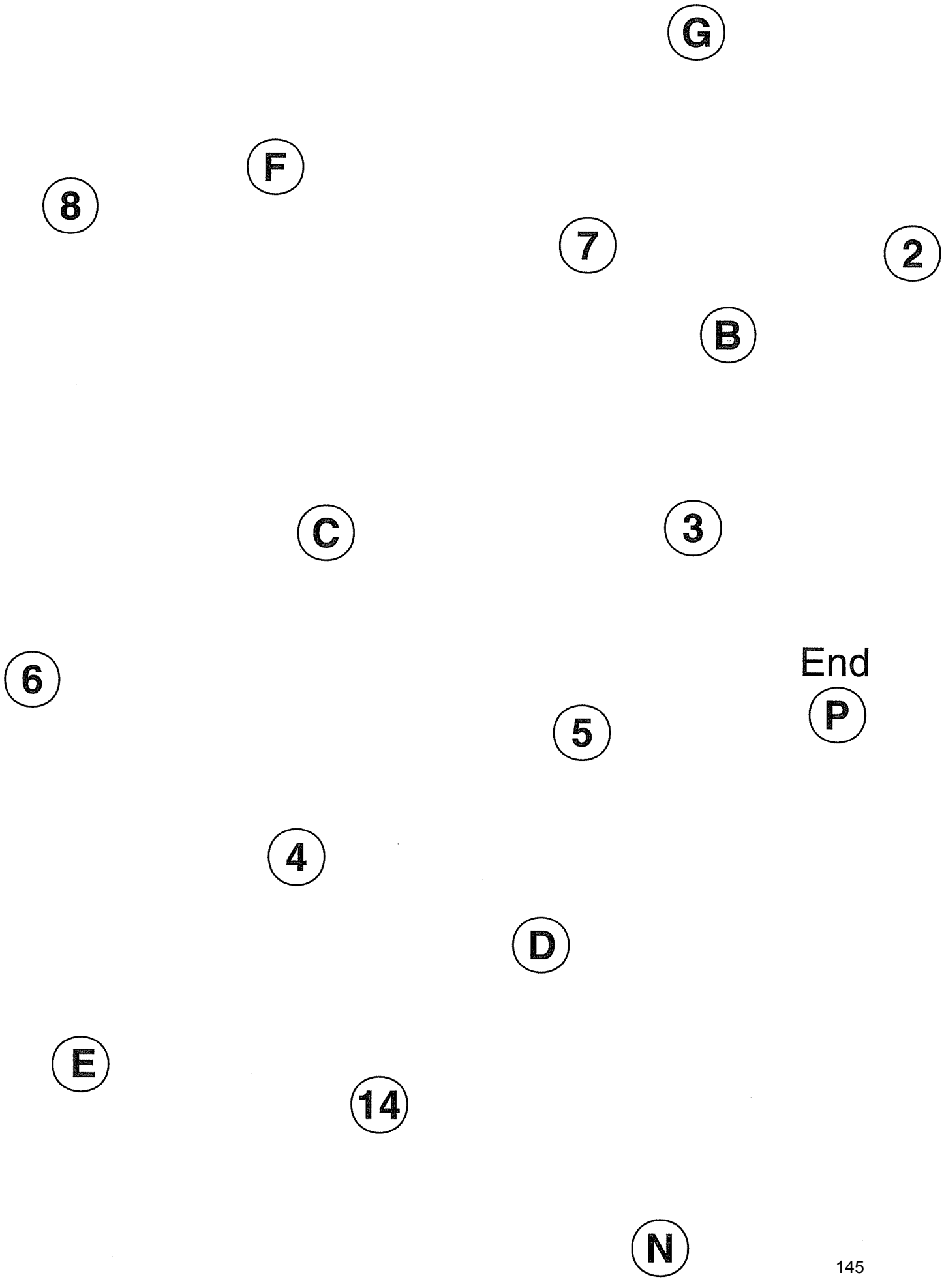
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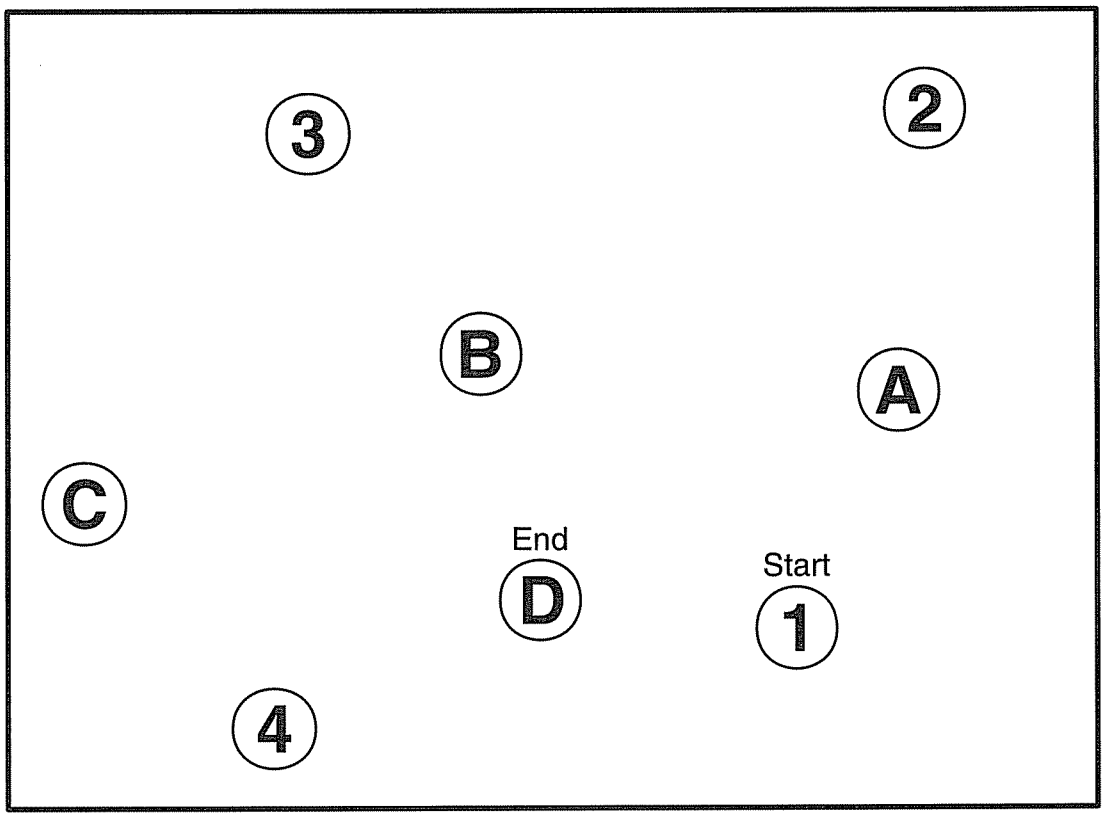
Trail Making Test

Name _____ Age _____
ID _____ Date _____
Examiner _____
Notes _____

Condition 4
Number–Letter Switching

Practice



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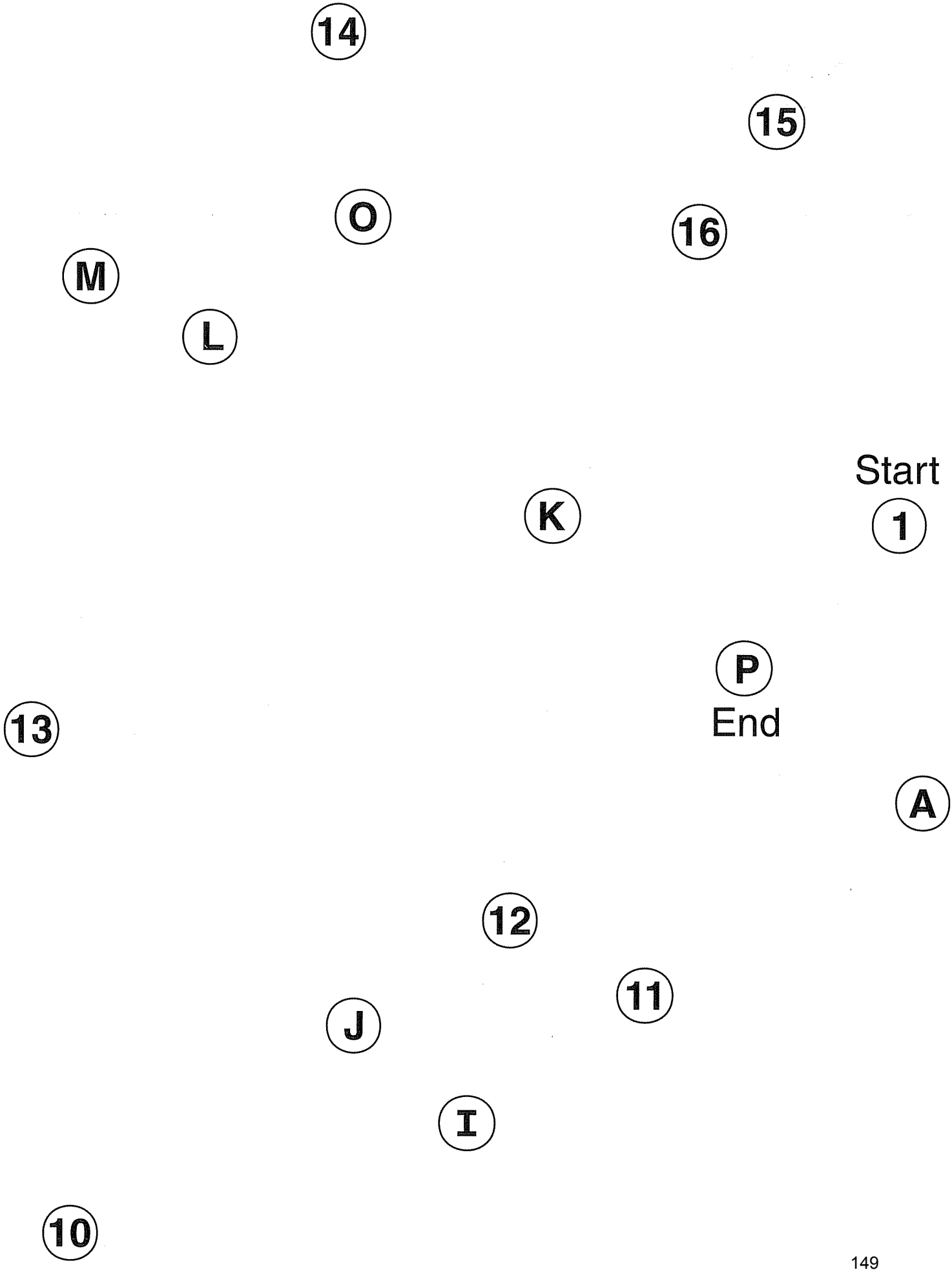
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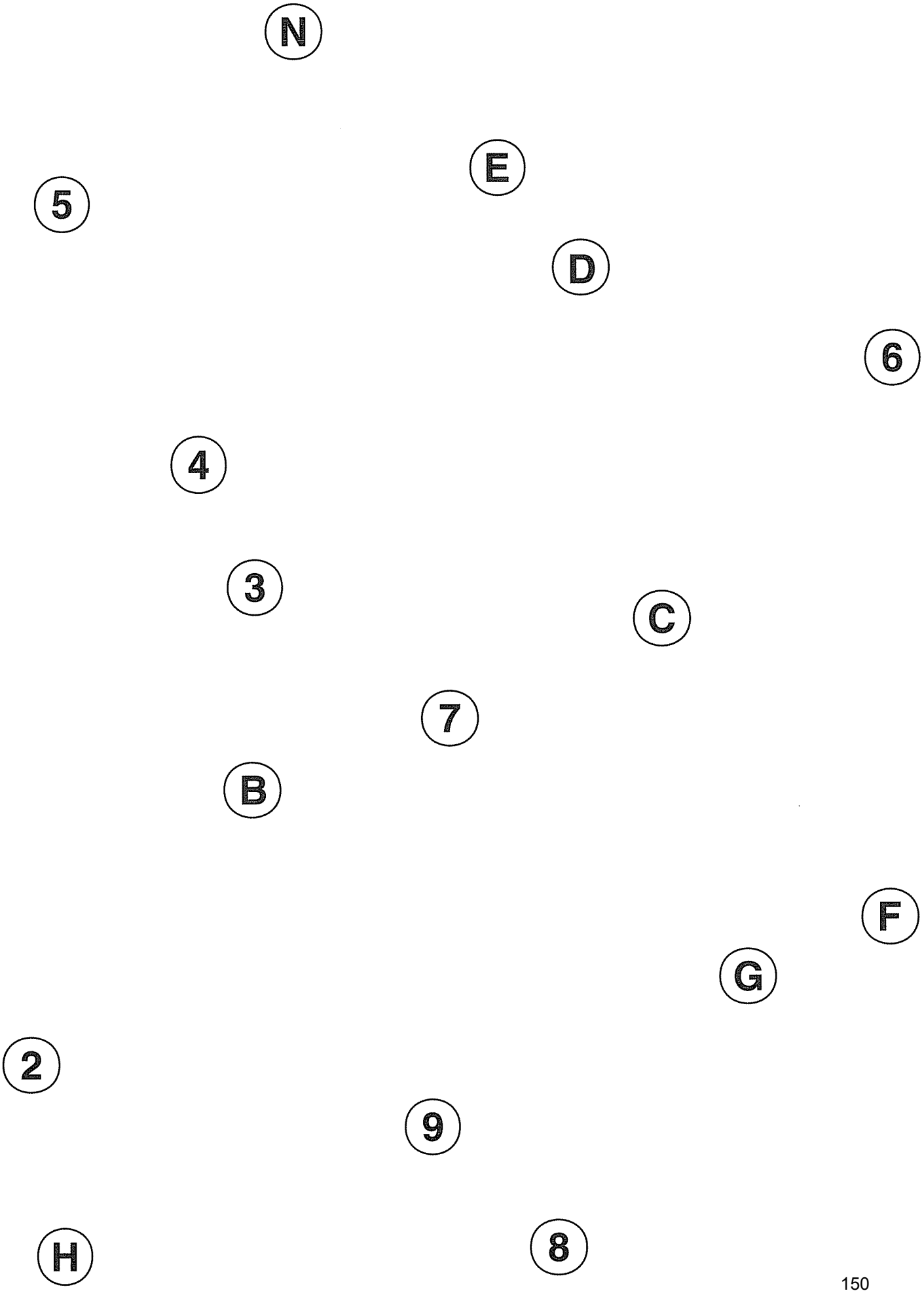
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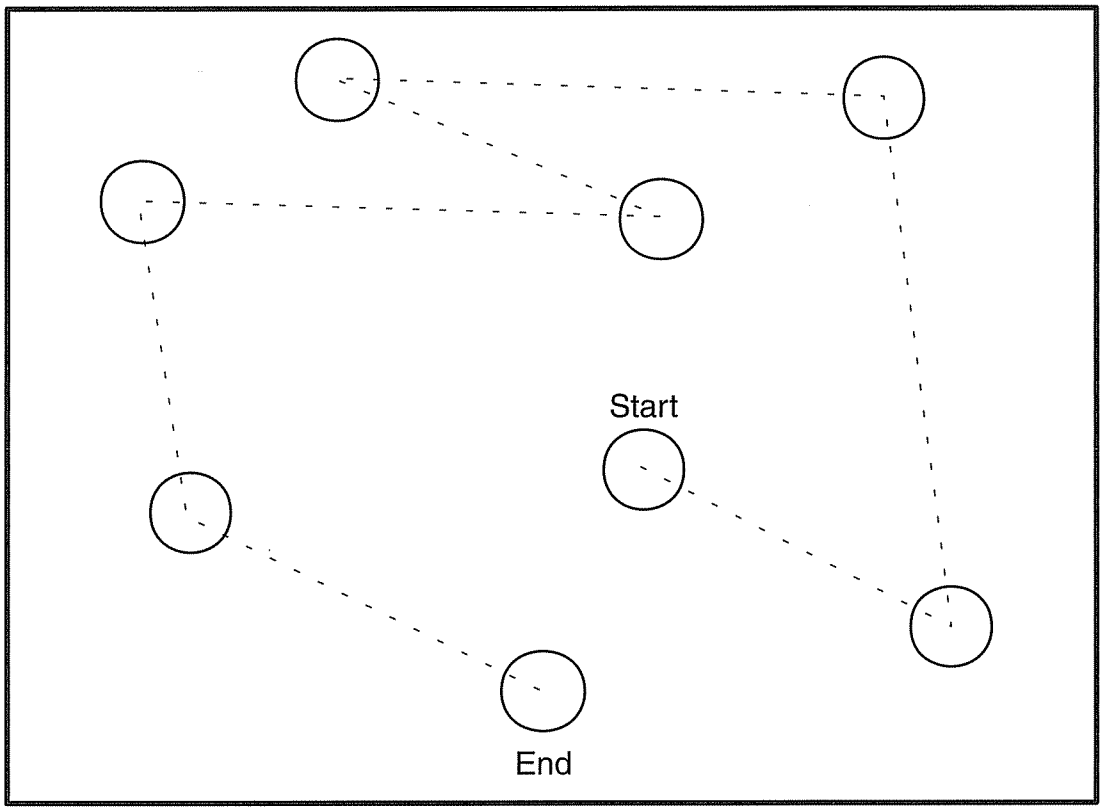
Trail Making Test

Name _____ Age _____
ID _____ Date _____
Examiner _____
Notes _____

Condition 5
Motor Speed

Practice



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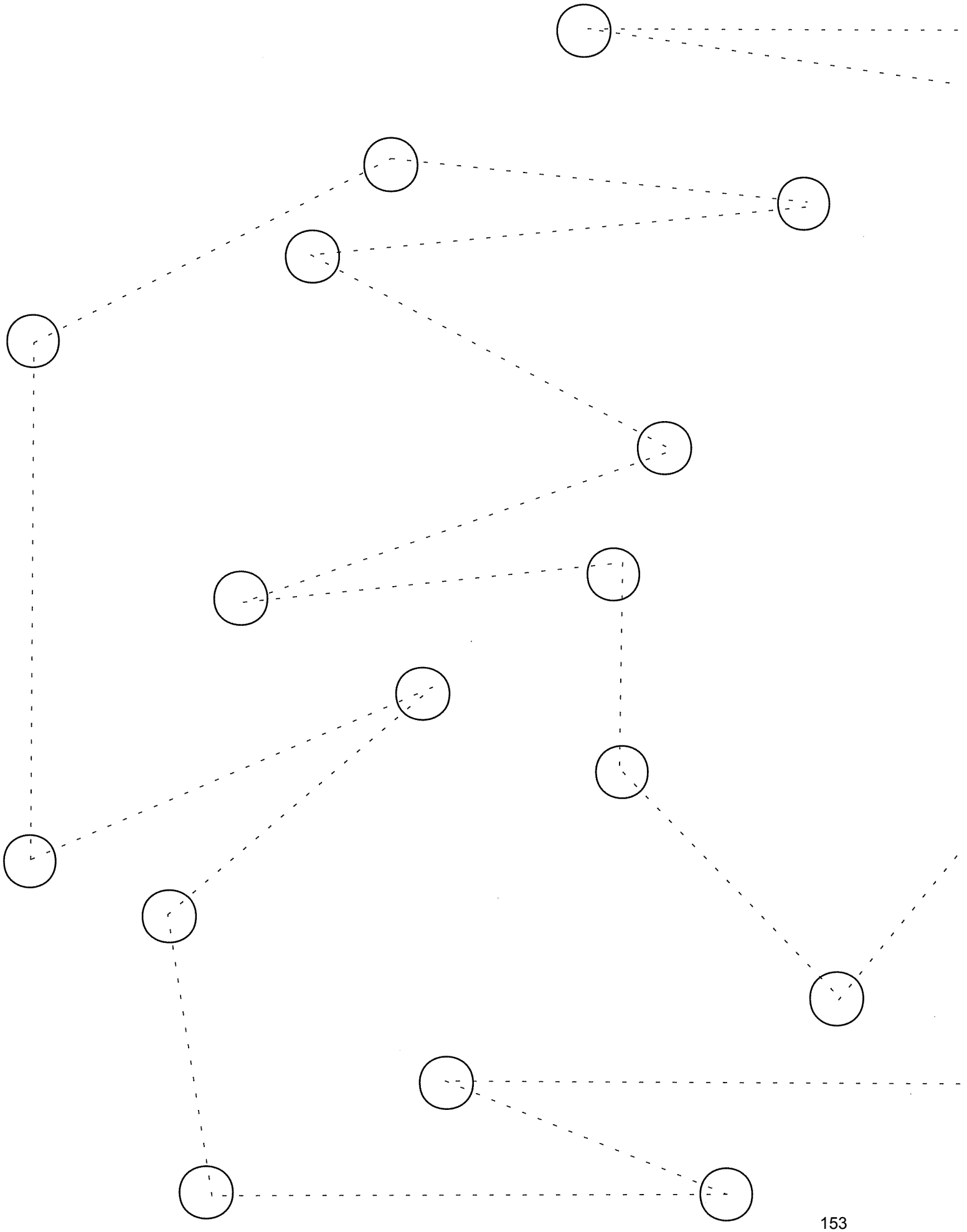

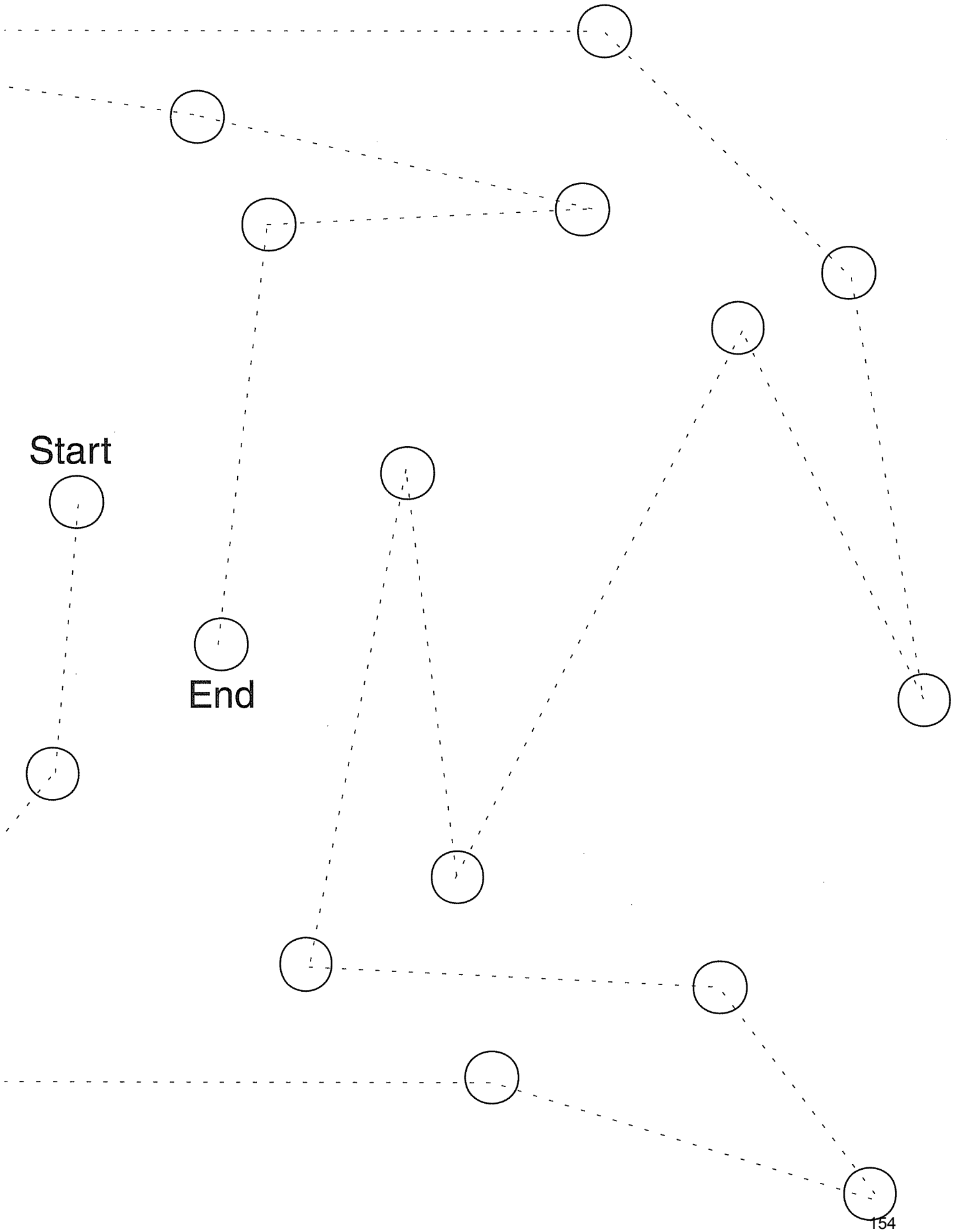
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Design Fluency Test

Name _____ Age _____

ID _____ Date _____

Examiner _____

Notes _____

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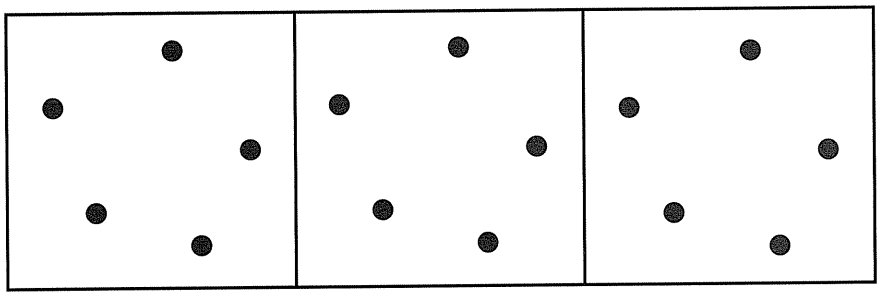
Condition 1
Filled Dots

Practice



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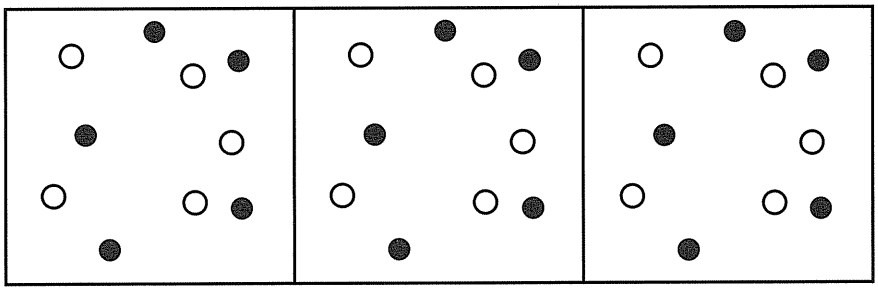
Product Number: 0154091170

Filled Dots

Top

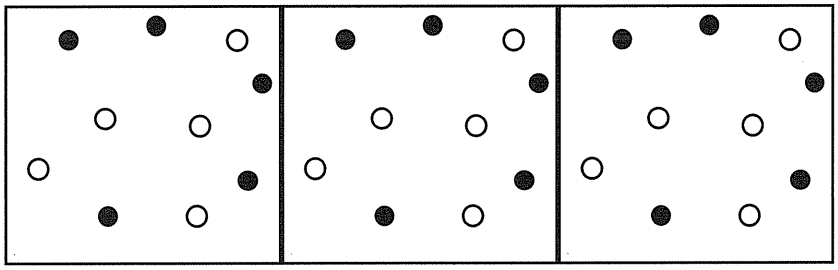
Practice

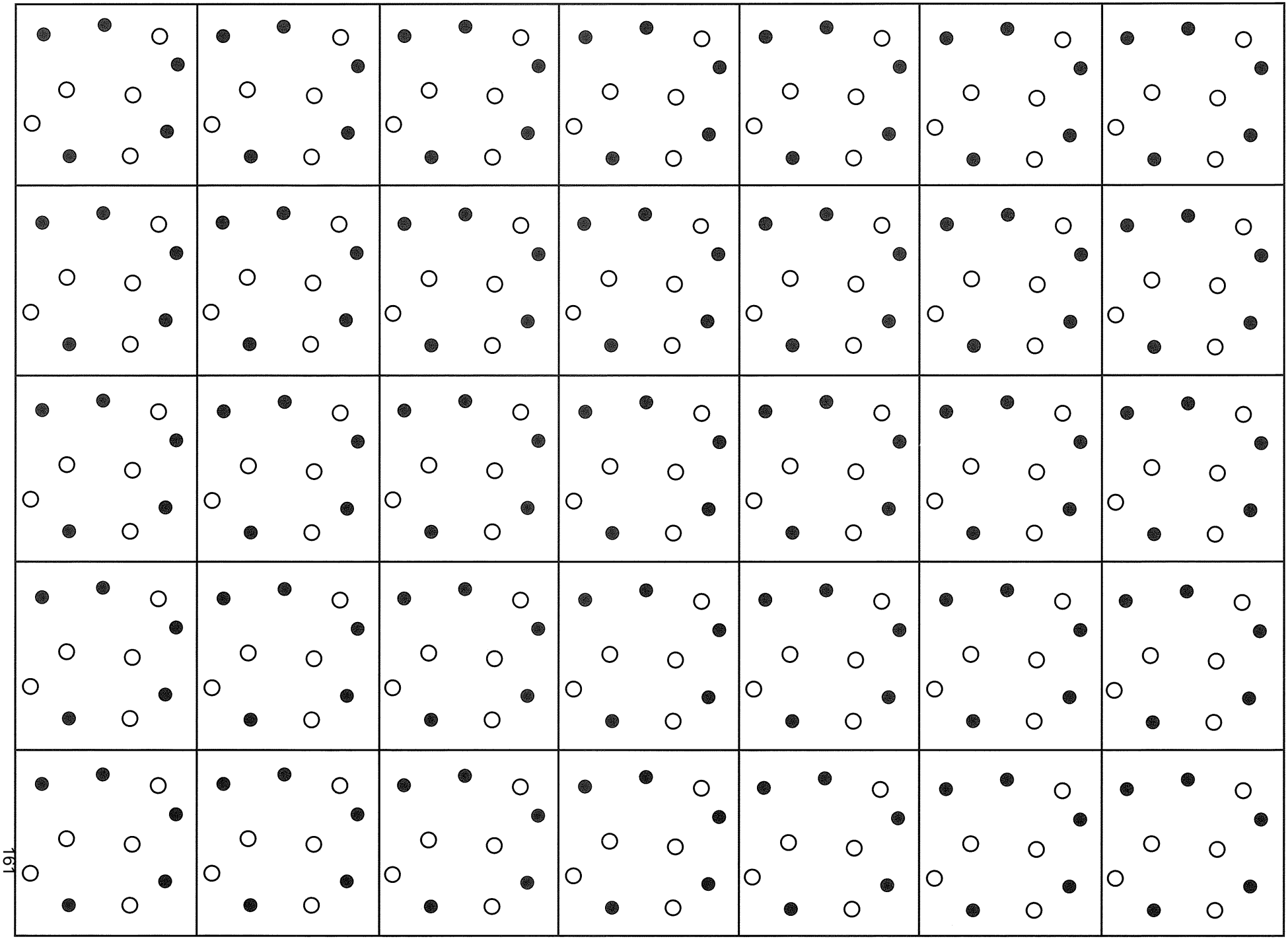


Empty Dots Only

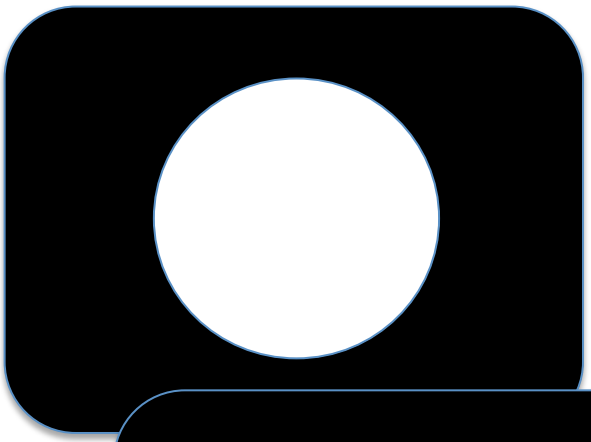
Top

Practice

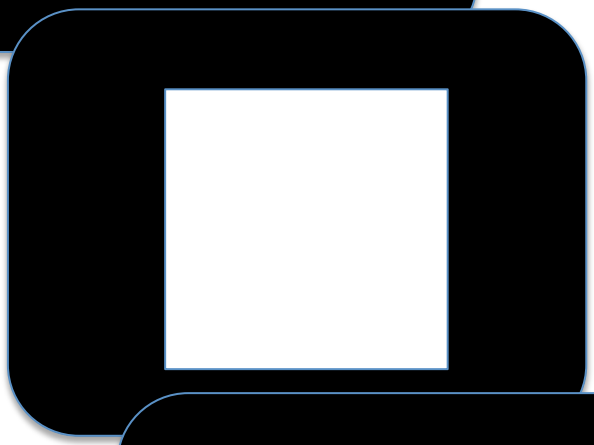




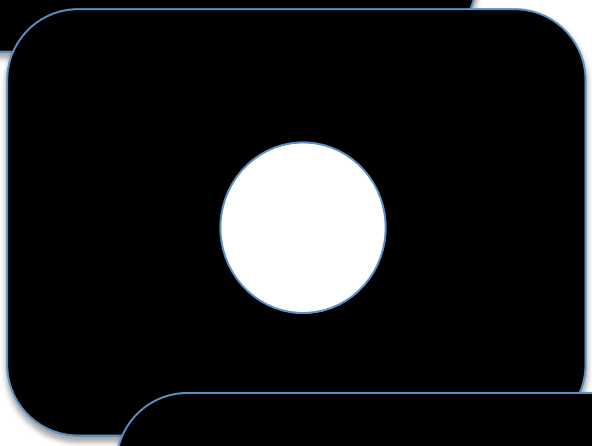
Go/No-Go Task



Go



Go



Go

No Go

Brief Visuospatial Memory Test-Revised

Response Form

Ralph H. B. Benedict, PhD

Test Date ____/____/____

ID# _____

Gender _____ Ethnicity _____ Handedness _____ Age _____

Education _____ Examiner _____

Form Administered: 1 2 3 4 5 6 (circle one)

	Raw score	*T* score	Percentile
Trial 1			
Trial 2			
Trial 3			
Total Recall[1]			
Learning[2]			
Delayed Recall			
Percent Retained[3]			
Recognition Hits			
Recognition False Alarms			
Recognition Discrimination Index[4]			
Recognition Response Bias			
Copy (optional)			

Normative table/comparison group _____

[1]Total Recall = (Trial 1 raw score + Trial 2 raw score + Trial 3 raw score).

[2]Learning = (Higher value of Trial 2 raw score or Trial 3 raw score) – Trial 1 raw score.

[3]Percent Retained = [Delayed Recall raw score ÷ (higher value of Trial 2 raw score or Trial 3 raw score)] x 100.

[4]Recognition Discrimination Index = Recognition Hits raw score – Recognition False Alarms raw score.

Delay Interval Table

Time Trial 3 completed	
Time Delayed Recall started	
Delay interval (minutes)	

T-1

Brief Visuospatial Memory Test–Revised

Response Form

Ralph H. B. Benedict, PhD

Test Date ____/____/____

ID# _____

Gender _____ Ethnicity _____ Handedness _____ Age _____

Education _____ Examiner _____

Form Administered: 1 2 3 4 5 6 (circle one)

	Raw score	*T* score	Percentile
Trial 1			
Trial 2			
Trial 3			
Total Recall[1]			
Learning[2]			
Delayed Recall			
Percent Retained[3]			
Recognition Hits			
Recognition False Alarms			
Recognition Discrimination Index[4]			
Recognition Response Bias			
Copy (optional)			

Normative table/comparison group _____

[1]Total Recall = (Trial 1 raw score + Trial 2 raw score + Trial 3 raw score).
[2]Learning = (Higher value of Trial 2 raw score or Trial 3 raw score) – Trial 1 raw score.
[3]Percent Retained = [Delayed Recall raw score ÷ (higher value of Trial 2 raw score or Trial 3 raw score)] x 100.
[4]Recognition Discrimination Index = Recognition Hits raw score – Recognition False Alarms raw score.

Delay Interval Table

Time Trial 3 completed	
Time Delayed Recall started	
Delay interval (minutes)	

T-1

T-2

DR

Subject ID: _____ Date: _____

Please rate each of the following items in terms of how characteristic they are of you. Use the following scale for answering these items.

1 2 3 4 5
extremely uncharacteristic of me **extremely characteristic of me**

Once in a while I can't control the urge to strike another person.	1	2	3	4	5
Given enough provocation, I may hit another person.	1	2	3	4	5
If somebody hits me, I hit back.	1	2	3	4	5
I get into fights a little more than the average person.	1	2	3	4	5
If I have to resort to violence to protect my rights, I will.	1	2	3	4	5
There are people who pushed me so far that we came to blows.	1	2	3	4	5
I can think of no good reason for ever hitting a person.	1	2	3	4	5
I have threatened people I know.	1	2	3	4	5
I have become so mad that I have broken things.	1	2	3	4	5
I tell my friends openly when I disagree with them.	1	2	3	4	5
I often find myself disagreeing with people.	1	2	3	4	5
When people annoy me, I may tell them what I think of them.	1	2	3	4	5
I can't help getting into arguments when people disagree with me.	1	2	3	4	5
My friends say that I'm somewhat argumentative.	1	2	3	4	5
I flare up quickly but get over it quickly.	1	2	3	4	5
When frustrated, I let my irritation show.	1	2	3	4	5
I sometimes feel like a powder keg ready to explode.	1	2	3	4	5
I am an even-tempered person.	1	2	3	4	5
Some of my friends think I'm a hothead.	1	2	3	4	5
Sometimes I fly off the handle for no good reason.	1	2	3	4	5
I have trouble controlling my temper.	1	2	3	4	5
I am sometimes eaten up with jealousy.	1	2	3	4	5
At times I feel I have gotten a raw deal out of life.	1	2	3	4	5
Other people always seem to get the breaks.	1	2	3	4	5
I wonder why sometimes I feel so bitter about things.	1	2	3	4	5
I know that "friends" talk about me behind my back.	1	2	3	4	5
I am suspicious of overly friendly strangers.	1	2	3	4	5

Psychomotor Vigilance Test

Press the spacebar every time an “x” appears on the screen.

Session 1 _____ID#_____Date_____Time_____AM PM

PITTSBURGH SLEEP QUALITY INDEX

INSTRUCTIONS:
The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, what time have you usually gone to bed at night?

   BED TIME _____

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

   NUMBER OF MINUTES _____

3. During the past month, what time have you usually gotten up in the morning?

   GETTING UP TIME _____

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

   HOURS OF SLEEP PER NIGHT _____

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Wake up in the middle of the night or early morning

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Have to get up to use the bathroom

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Cannot breathe comfortably

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

e) Cough or snore loudly

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

f) Feel too cold

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

g) Feel too hot

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

h) Had bad dreams

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

i) Have pain

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

j) Other reason(s), please describe_____

_____

How often during the past month have you had trouble sleeping because of this?

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

6. During the past month, how would you rate your sleep quality overall?

Very good _____

Fairly good _____

Fairly bad _____

Very bad _____

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

No problem at all _____

Only a very slight problem _____

Somewhat of a problem _____

A very big problem _____

10. Do you have a bed partner or room mate?

No bed partner or room mate _____

Partner/room mate in other room _____

Partner in same room, but not same bed _____

Partner in same bed _____

If you have a room mate or bed partner, ask him/her how often in the past month you have had . . .

a) Loud snoring

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Long pauses between breaths while asleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Legs twitching or jerking while you sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Episodes of disorientation or confusion during sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

e) Other restlessness while you sleep; please describe_____

_____

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

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Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ: Psychiatry Research, 28:193-213, 1989.

Subject #_____ Date:_____

DIRECTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel right now, THAT IS, at this moment.

There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	Not at all	Somewhat	Moderately so	Very much so
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I am tense	1	2	3	4
4. I feel regretful	1	2	3	4
5. I feel at ease	1	2	3	4
6. I feel upset	1	2	3	4
7. I am presently worrying over possible misfortunes	1	2	3	4
8. I feel rested	1	2	3	4
9. I feel anxious	1	2	3	4
10. I feel comfortable	1	2	3	4
11. I feel self-confident	1	2	3	4
12. I feel nervous	1	2	3	4
13. I am jittery	1	2	3	4
14. I feel "high strung"	1	2	3	4
15. I am relaxed	1	2	3	4
16. I feel content	1	2	3	4
17. I am worried	1	2	3	4
18. I feel over-excited and "rattled"	1	2	3	4
19. I feel joyful	1	2	3	4
20. I feel pleasant	1	2	3	4

STAI Form T

Subject #_____ DATE_____

DIRECTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you generally feel.

There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

	Almost never	Sometimes	Often	Almost always
21. I feel pleasant	1	2	3	4
22. I tire quickly	1	2	3	4
23. I feel like crying	1	2	3	4
24. I wish I could be as happy as others seem to be	1	2	3	4
25. I am losing out on things because I can't make up my mind soon enough	1	2	3	4
26. I feel rested	1	2	3	4
27. I am "calm, cool, and collected"	1	2	3	4
28. I feel that difficulties are piling up so that I cannot overcome them	1	2	3	4
29. I worry too much over something that really doesn't matter	1	2	3	4
30. I am happy	1	2	3	4
31. I am inclined to take things hard	1	2	3	4
32. I lack self-confidence	1	2	3	4
33. I feel secure	1	2	3	4
34. I try to avoid facing a crises or difficulty	1	2	3	4
35. I feel blue	1	2	3	4
36. I am content	1	2	3	4
37. Some unimportant thought runs through my mind and bothers me	1	2	3	4
38. I take disappointments so keenly that I can't put them out of my mind	1	2	3	4
39. I am a steady person	1	2	3	4
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	1	2	3	4

ANAM4™

Automated Neuropsychological Assessment Metrics

Quick Start Guide

Scope of This Document

This is a quick start reference to familiarize a first-time user with the basic concepts and operations of the ANAM4™ software.

Disclaimer

The ANAM4™ testing system does not constitute the practice of medicine or the provision of professional health care advice. The information provided by ANAM4™ software is of a general nature and does not represent medical advice, a diagnosis, or prescription for treatment. You are advised to seek the advice of a qualified medical professional or researcher for interpretation of test results. C-SHOP and the University of Oklahoma are not responsible for any decisions made based on information obtained using ANAM4™ software. Your qualified medical professional has the sole responsibility for establishing diagnosis and suggesting appropriate treatment.

Further Reading

For additional information regarding ANAM4™ or ANAM4™ data files, please refer to the ANAM4™ User Guide.

Revision 3, March 2007
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Requirements

Hardware Requirements

The ANAM4™ system is designed for use on personal computer systems. Minimum hardware requirements include the following:

- **Processor speed:** Pentium 90 MHz microprocessor.
- **Memory:** 32 MB RAM.
- **Storage:** The core ANAM4™ test system requires a minimum of approximately 25MB. Due to data storage requirements and to ensure optimal performance, at least 150MB of free space is highly recommended. A full ANAM4™ installation including ancillary modules (ADEPT™/APR™) requires approximately 50MB of space (130MB if the .NET Framework v2.0 is not already present). Due to data storage requirements and to ensure optimal performance, at least 300MB of free space prior to installation is highly recommended.
- **Response device:** Most standard input devices are supported, including a serial mouse, USB mouse and keyboard, and PS/2 mouse and keyboard. When using laptop computers, most internal keyboards and pointing devices will be adequate for most ANAM4 test modules, but the use of external input devices is highly recommended where practical.

Software Requirements

- **Operating system:** Windows 95/98/2000, NT4.0, or XP. To date, ANAM4™ has not been fully tested on Windows ME or Windows Vista.
- **Windows updates:** Application of all Windows updates. Updates are available at: http://update.microsoft.com
- **Flash animation:** For operating systems older than Windows XP, Adobe Flash Player is required to view the opening logo screen. Flash may be acquired via free download: http://www.adobe.com/go/getflashplayer

  Note: When installing Flash Player via the website, uncheck the accompanying Yahoo toolbar before clicking "Install Now" unless you desire the toolbar.

1 Installing and Running ANAM4™

The ANAM4™ test system consists of a library of tests designed for a broad spectrum of clinical and research applications. This library of computer-based tests was constructed to meet the need for precise measurement of cognitive processing efficiency in a variety of psychological assessment contexts that include neuropsychology, readiness to perform, neurotoxicology, pharmacology, and human factors research.

ANAM4™ will be automatically installed from the installation CD. If the installation does not begin automatically, click Start > Run on the task bar. Type your CD drive letter followed by :\Setup (e.g., D:\Setup or E:\Setup). Finally, click **OK** to proceed with the installation.

The default installation directory is C:\Program Files\C-SHOP\ANAM4.

Upon installation, a desktop icon for ANAM4™ will be created.

To run ANAM4™, double-click on the ANAM4™ icon located on your desktop, the AnamMenu.exe file located in the C:\Program Files\C-SHOP\ANAM4 directory, or the ANAM4 program listed in start->Programs->ANAM4.

2 Starting ANAM4™

Starting ANAM4™

1. Double-click the ANAM4 icon on your desktop.

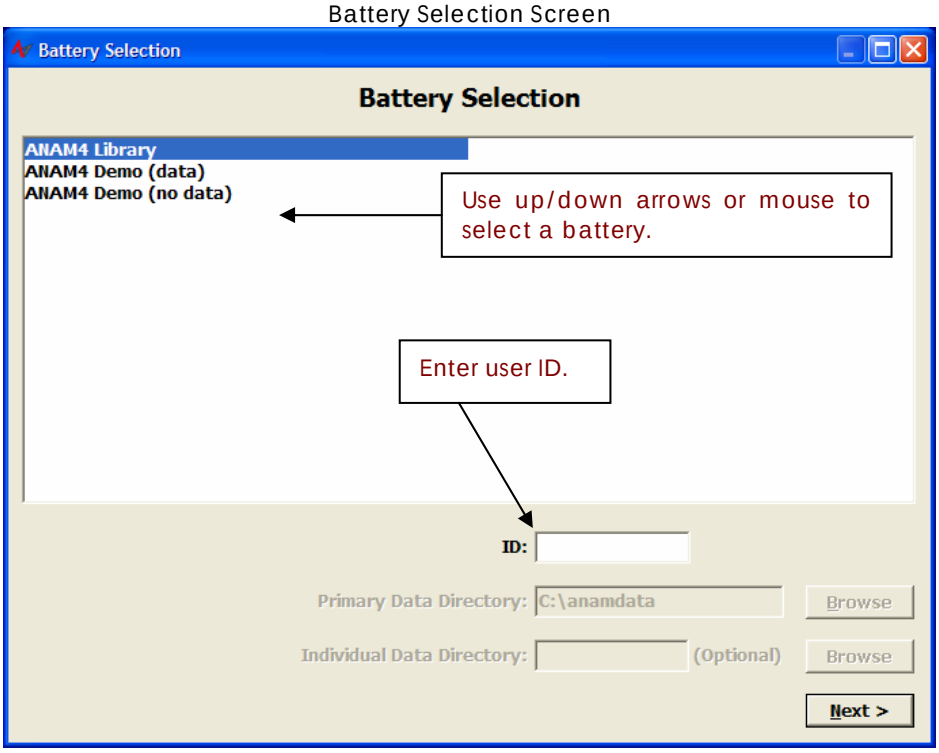
ANAM4 Splash Screen

Selecting a Battery and Entering the User ID

The *Battery Selection* screen allows the user to choose a battery, specify an ID number, and specify data directories.

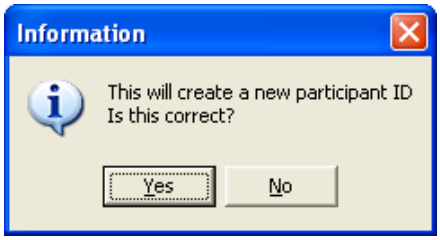
1. Use the up/down cursor keys or mouse to select the desired ANAM4™ battery.

Battery Selection Screen



2. Enter a user ID. The user ID can be any alphanumeric character string.

Note: If a test ID is entered that has never been used on this computer, you will be asked to verify that you are creating a new participant ID. If this is correct, click **Yes**. If the session is a repeat administration for this person (thus, the participant ID has been used previously), you will not receive this prompt.



Changing Data Directories (Folders)

The default data storage directory is C:\anamdata. All data files will be stored in this directory unless specified otherwise.

To change the Primary Data Directory or Individual Data Directory:

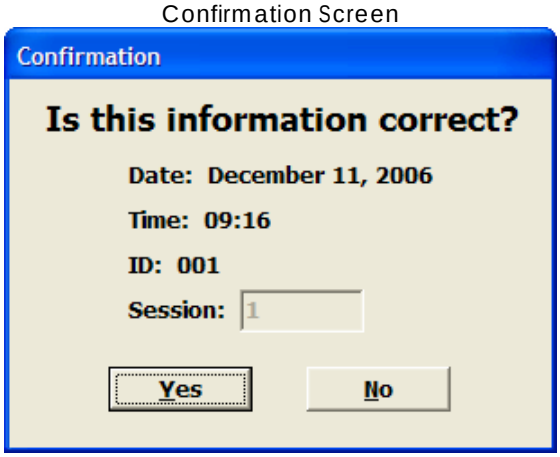
1. Press <**Alt**><**F1**>. This will unlock the *Primary Data Directory* and *Individual Data Directory* fields for modification.
2. Type the path location of the directory for data storage or click **Browse**. If you select Browse, navigate to the directory where you would like to store the ANAM data files.

After confirming all information on the *Battery Selection* screen, Press **Enter** or click **Next** to continue.

Confirming Date, Time, ID, and Session Number

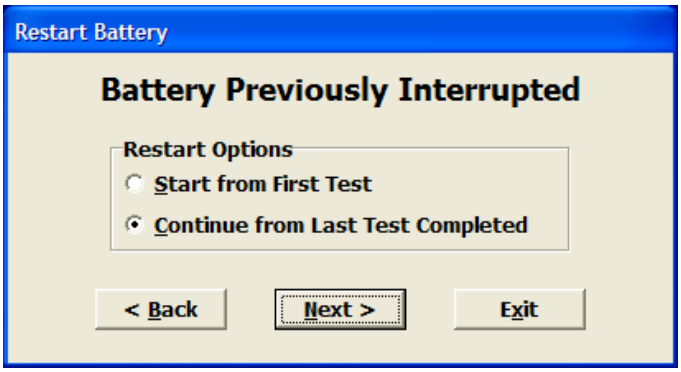
1. Confirm that the Date and Time on your computer are accurately set. If not, click on **No**, close the *Battery Selection* screen that reappears by clicking on the red close button at the upper right corner, correct the Date/Time setting, and restart ANAM4™.
2. Confirm that the correct Session number is about to be run. If you are certain that it needs to be changed, press <**Alt**><**F1**> to unlock the field and enter the desired session number.

Confirmation Screen



Restarting a Previously Cancelled Battery

1. If the specified Session was previously canceled before completion, you may see the following screen asking if you wish to *Start from First Test* or *Continue from Last Test Completed*. You are also allowed to go back to the *Battery Selection* screen.

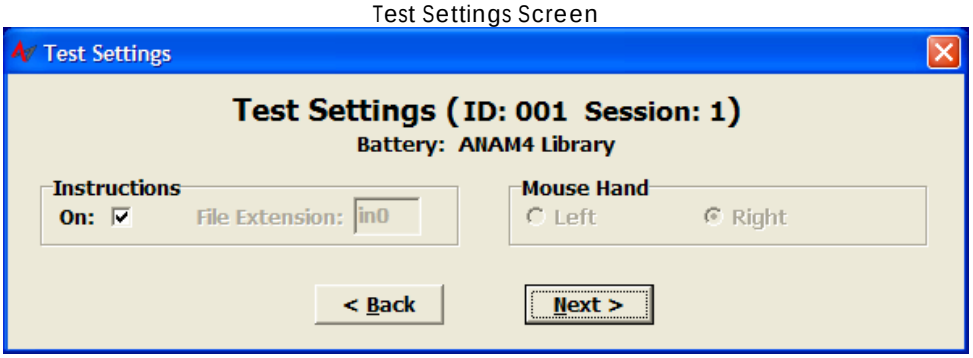


2. Once you have selected the desired option, click on **Next** to continue.

Selecting Test Settings

The *Test Settings* screen allows the user to customize the ANAM4™ test session.

Test Settings Screen



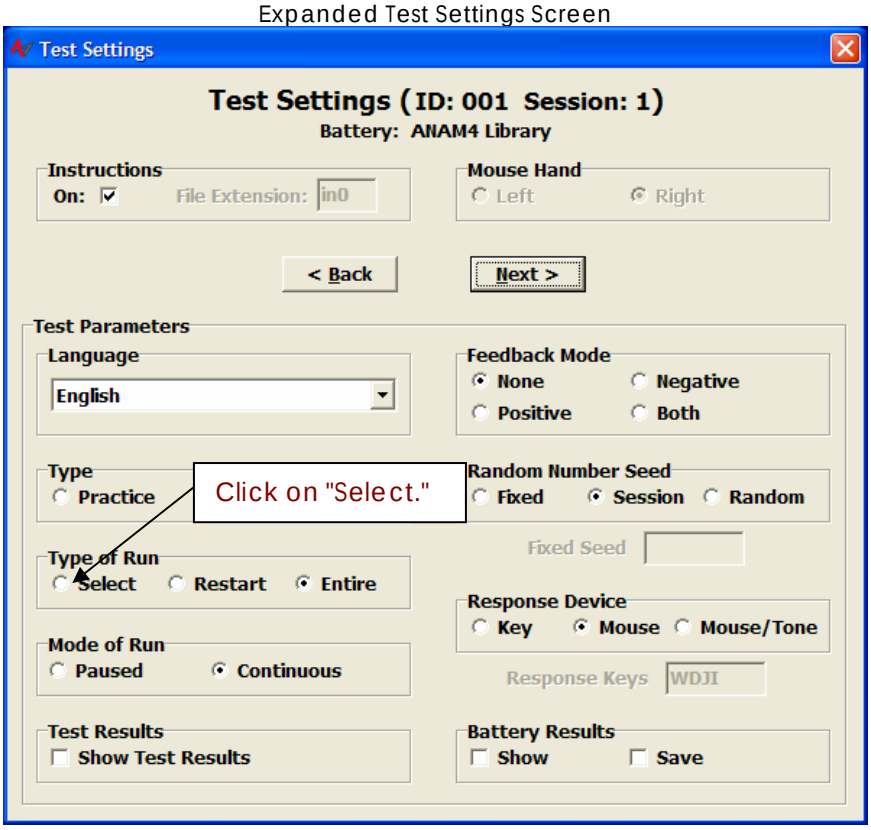
Note: After using the battery a few times for a particular person, you may wish to turn off instructions by deselecting the "Instructions" box. Make sure it is checked **On** the first time through.

1. If you have a participant who uses the computer mouse with the left hand and you wish to obtain responses using the left hand, press <**Alt**><**F1**> to unlock the Mouse Hand setting and select **Left**.
2. If the Test Settings are correct, press **Enter** or click on **Next** to begin the testing.

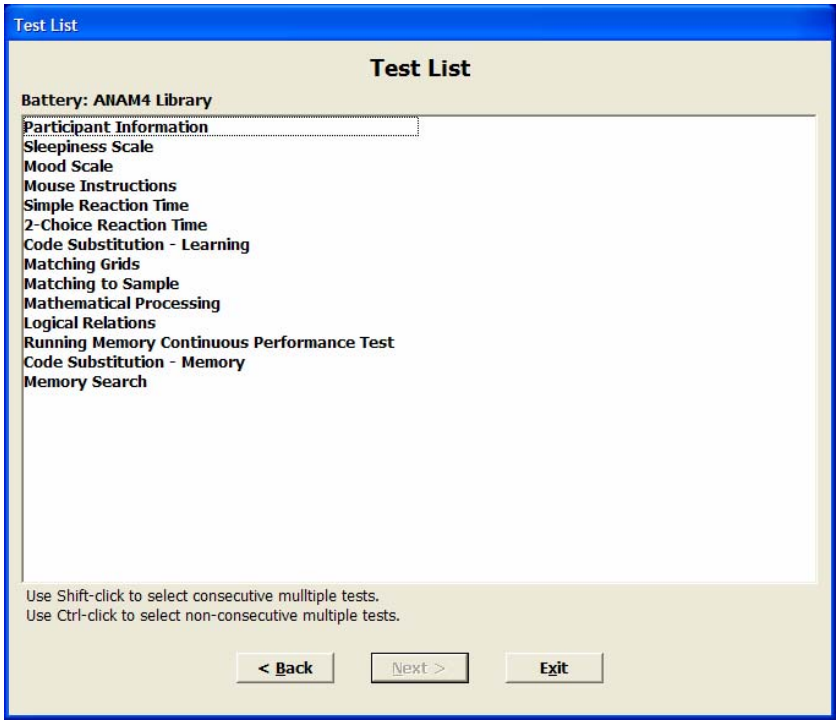
Selecting a Specific Test or Subset of Tests

1. If you wish to select a single test or subset of tests, press <**Alt**><**F2**> and then click on **Select** under Type of Run.

Expanded Test Settings Screen



2. Press **Enter** or click on **Next** to continue. The list of tests within the battery will appear on the next screen.



3. After selecting the desired test or set of tests using the instructions at the bottom of the screen, press **Enter** or click on **Next** to continue.

Proceeding through the Battery

1. Tests will proceed in sequence.

   Note: If instructions are On, the typical sequence for each test is one or more pages of instructions, a screen with the test name, the test itself, and (if selected from the *Test Settings* screen) a feedback screen summarizing individual Test Results.

2. If you wish to abort from any test (end the test without collecting data), press <**Alt**><**F1**> at any time following the instructions screen(s).

   Note: The <**Alt**><**F1**> exit function works ONLY after the display of test instructions is complete.

3. After the test aborts, you will see the above window. If you wish to cancel the rest of the battery, click **Yes**. If you wish to continue with the remaining tests, click **No**.
4. At the conclusion of the battery, you will see a "Thank You" message informing you that the Test Battery is complete.

ANAM4™ Data

Four types of data files are generated following test administration through the ANAM4™ test system as follows:

- Summary Data Files in Text Format (CSV) – summary statistics computed across all items/trials of a given test (without variable labels)
- Raw Data Files in Text Format (CSV) – individual item/trial information (without variable labels)
- Summary Data Files in XML Format – summary statistics computed across all items/trials of a given test (with variable labels)
- Raw Data Files in XML Format – Individual item/trial information (with variable labels).

File Naming

Data filenames are coded in the following manner. The first letter represents the type of file as follows:

- **S** for summary data in text format
- **R** for raw data in text format
- **X** for summary data in XML format
- **Z** for raw data in XML format.

The next sequence of characters corresponds to the participant ID code (of variable length). The ID code is followed by a P or T designating a Practice or Test session, respectively. The final portion of the filename indicates the session number. A three-letter file extension is used to identify the specific test. A list of test extensions can be found in **Chapter 4**.

> Example: ***S32545T01.SRT*** is a summary data file for participant 32545 for Test Session number 1 of the Simple Reaction Time test.

ANAM4™ Data Directories

The default *Primary Data Directory* is C:\anamdata. Data from all completed tests will be saved in this directory. By default, no *Individual Data Directory* is specified. For information on changing the *Primary Data Directory* or *Individual Data Directory*, see **Chapter 2**.

ANAM4™ Tests

ANAM4™ Test Names, Modules, and Extensions

Test Name	Module Name (.exe)	Extension
2-Choice Reaction Time	2choice	.2ch
4-Choice Reaction Time	4choice	.4ch
Code Substitution		
Learning	codesub	.cds
Immediate	codesub	.cdi
Delayed	codesub	.cdd
Demographics	demog	.sub
Digit Reaction Time	digitrt	.drt
Dual Task (Tracking / Memory)	dualtask	.dtn
Grammatical Reasoning	gram	.grm
Logical Relations	logical	.lrs
Manikin	manikin	.mkn
Matching Grids	matching	.mtg
Matching to Sample	mat2samp	.m2s
Mathematical Processing	math	.mth
Memory Search	stern	.stn
Mental State Exam	mse	.mse
Mood Scale	mood	.moo
Procedural Reaction Time	procrt	.pro
Pursuit Tracking	pursuit	.pur
Reaction Time	react	.rct
Relative Judgment	reljudg	.rlj
Running Memory CPT	runcpt	.cpt
Simple Reaction Time	simplert	.srt
Sleepiness Scale	sleepsc	.slp
Spatial Processing - Simultaneous	dspat	.spd
Spatial Processing - Delayed	spat	.spa
Standard CPT	stdcpt	.scp
Stroop Test	stroop	.str
Switching	switch	.swt
Symbolic Reaction Time	symbolrt	.sym
Tapping	tapping	.tpl, .tpr
Tower Puzzle	tower	.atp
Unstable Tracking	track	.trk
Visual Vigilance	visvig	.vis

For More Information

ANAM4™ User Manual
www.c-shop.ou.edu/literature/manual.pdf

Quick Start Guide for the ADEPT™ Software
www.c-shop.ou.edu/literature/ADEPTquickstart.pdf

Quick Start Guide for the APR™ Software
www.c-shop.ou.edu/literature/APRquickstart.pdf

ANAM4™ Technical Literature
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Technical Support
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BDI®-II

Date:

Subject ID: _____ Marital Status: _____ Age: _____ Sex: _____

Occupation: _____ Education: _____

Instructions: This questionnaire consists of 21 groups of statements. Please read each group of statements carefully, and then pick out the **one statement** in each group that best describes the way you have been feeling during the **past two weeks, including today.** Circle the number beside the statement you have picked. If several statements in the group seem to apply equally well, circle the highest number for that group. Be sure that you do not choose more than one statement for any group, including Item 16 (Changes in Sleeping Pattern) or Item 18 (Changes in Appetite).

1. Sadness
- 0 I do not feel sad.
- 1 I feel sad much of the time.
- 2 I am sad all the time.
- 3 I am so sad or unhappy that I can't stand it.

2. Pessimism
- 0 I am not discouraged about my future.
- 1 I feel more discouraged about my future than I used to be.
- 2 I do not expect things to work out for me.
- 3 I feel my future is hopeless and will only get worse.

3. Past Failure
- 0 I do not feel like a failure.
- 1 I have failed more than I should have.
- 2 As I look back, I see a lot of failures.
- 3 I feel I am a total failure as a person.

4. Loss of Pleasure
- 0 I get as much pleasure as I ever did from the things I enjoy.
- 1 I don't enjoy things as much as I used to.
- 2 I get very little pleasure from the things I used to enjoy.
- 3 I can't get any pleasure from the things I used to enjoy.

5. Guilty Feelings
- 0 I don't feel particularly guilty.
- 1 I feel guilty over many things I have done or should have done.
- 2 I feel quite guilty most of the time.
- 3 I feel guilty all of the time.

6. Punishment Feelings
- 0 I don't feel I am being punished.
- 1 I feel I may be punished.
- 2 I expect to be punished.
- 3 I feel I am being punished.

7. Self-Dislike
- 0 I feel the same about myself as ever.
- 1 I have lost confidence in myself.
- 2 I am disappointed in myself.
- 3 I dislike myself.

8. Self-Criticalness
- 0 I don't criticize or blame myself more than usual.
- 1 I am more critical of myself than I used to be.
- 2 I criticize myself for all of my faults.
- 3 I blame myself for everything bad that happens.

9. Suicidal Thoughts or Wishes
- 0 I don't have any thoughts of killing myself.
- 1 I have thoughts of killing myself, but I would not carry them out.
- 2 I would like to kill myself.
- 3 I would kill myself if I had the chance.

10. Crying
- 0 I don't cry any more than I used to.
- 1 I cry more than I used to.
- 2 I cry over every little thing.
- 3 I feel like crying, but I can't.

Subtotal Page 1

Continued on Back

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Product Number 0154018392

11. Agitation

0 I am no more restless or wound up than usual.
1 I feel more restless or wound up than usual.
2 I am so restless or agitated that it's hard to stay still.
3 I am so restless or agitated that I have to keep moving or doing something.

12. Loss of Interest

0 I have not lost interest in other people or activities.
1 I am less interested in other people or things than before.
2 I have lost most of my interest in other people or things.
3 It's hard to get interested in anything.

13. Indecisiveness

0 I make decisions about as well as ever.
1 I find it more difficult to make decisions than usual.
2 I have much greater difficulty in making decisions than I used to.
3 I have trouble making any decisions.

14. Worthlessness

0 I do not feel I am worthless.
1 I don't consider myself as worthwhile and useful as I used to.
2 I feel more worthless as compared to other people.
3 I feel utterly worthless.

15. Loss of Energy

0 I have as much energy as ever.
1 I have less energy than I used to have.
2 I don't have enough energy to do very much.
3 I don't have enough energy to do anything.

16. Changes in Sleeping Pattern

0 I have not experienced any change in my sleeping pattern.

1a I sleep somewhat more than usual.
1b I sleep somewhat less than usual.

2a I sleep a lot more than usual.
2b I sleep a lot less than usual.

3a I sleep most of the day.
3b I wake up 1–2 hours early and can't get back to sleep.

17. Irritability

0 I am no more irritable than usual.
1 I am more irritable than usual.
2 I am much more irritable than usual.
3 I am irritable all the time.

18. Changes in Appetite

0 I have not experienced any change in my appetite.

1a My appetite is somewhat less than usual.
1b My appetite is somewhat greater than usual.

2a My appetite is much less than before.
2b My appetite is much greater than usual.

3a I have no appetite at all.
3b I crave food all the time.

19. Concentration Difficulty

0 I can concentrate as well as ever.
1 I can't concentrate as well as usual.
2 It's hard to keep my mind on anything for very long.
3 I find I can't concentrate on anything.

20. Tiredness or Fatigue

0 I am no more tired or fatigued than usual.
1 I get more tired or fatigued more easily than usual.
2 I am too tired or fatigued to do a lot of the things I used to do.
3 I am too tired or fatigued to do most of the things I used to do.

21. Loss of Interest in Sex

0 I have not noticed any recent change in my interest in sex.
1 I am less interested in sex than I used to be.
2 I am much less interested in sex now.
3 I have lost interest in sex completely.

_____	Subtotal Page 2
_____	Subtotal Page 1
_____	Total Score

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WASI-II Record Form

WECHSLER ABBREVIATED SCALE OF INTELLIGENCE® — SECOND EDITION

Calculation of Examinee's Age	Year	Month	Day
Test Date			
Test Age			

ID:

Sex: ☐ F ☐ M Handedness: ☐ R ☐ L

Address/School/Testing Site:

Highest Education/Grade:

Examiner Name:

Total Raw Score to *T* Score Conversion

Subtest	Raw Score	*T* Scores			
Block Design					
Vocabulary					
Matrix Reasoning					
Similarities					
Sum of *T* Scores					
		Verbal Comp.	Perc. Rsng.	Full Scale–4	Full Scale–2

Examinee Visual/Hearing Aids During Testing

Check type of aid examinee needed:	Used	Not Used
☐ Glasses	☐	☐
☐ Prescription Lenses	☐	☐
☐ Assisted Listening Device	☐	☐
☐ Other:	☐	☐

Sum of *T* Scores to Composite Score Conversion

Scale	Sum of *T* Scores	Composite Score	Percentile Rank	Confidence Interval 90% or 95%
Verbal Comp.		VCI		–
Perc. Rsng.		PRI		–
Full Scale–4		FSIQ–4		–
Full Scale–2		FSIQ–2		–

Ranges of Expected Scores

Scores	Confidence Level 90%	68%
FSIQ–4		
WISC-IV FSIQ	–	–
WAIS-IV FSIQ	–	–

Subtest *T* Score Profile

	Verbal Comprehension		Perceptual Reasoning	
	VC	SI	BD	MR
80				
75				
70				
65				
60				
55				
50				
45				
40				
35				
30				
25				
20				

Composite Score Profile

	VCI	PRI	FSIQ
160			
155			
150			
145			
140			
135			
130			
125			
120			
115			
110			
105			
100			
95			
90			
85			
80			
75			
70			
65			
60			
55			
50			
45			
40			

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PsychCorp

Product Number 0158981596

1. Block Design

(Time limit: See item)

Start
Ages 6–8: Item 1
Ages 9–90: Item 3

Reverse
Ages 9–90: Does not obtain a perfect score on *either* Item 3 or Item 4, administer the preceding items in reverse order until two consecutive perfect scores are obtained.

Discontinue
After 2 consecutive scores of 0.

Stop
Ages 6–8: After Item 11.

Record & Score
Items 1–4: Score 0, 1, or 2 points.
Items 5–13: Score 0, 4, 5, 6, or 7 points.

		Design	Presentation Method	Time Limit	Completion Time		Constructed Design		Score			
6–8	1.	Examinee / Examiner	Model and Picture	30"	Trial 1	Trial 2	Trial 1	Trial 2	0	1	2	
	2.		Model and Picture	30"	Trial 1	Trial 2	Trial 1	Trial 2	0	1	2	
9–90	3.		Model and Picture	45"	Trial 1	Trial 2	Trial 1	Trial 2	0	1	2	
	4.		Model and Picture	45"	Trial 1	Trial 2	Trial 1	Trial 2	0	1	2	
	5.		Picture	60"					0	21–60: 4	16–20: 5	11–15: 6	1–10: 7
	6.		Picture	60"					0	21–60: 4	16–20: 5	11–15: 6	1–10: 7
	7.		Picture	60"					0	21–60: 4	16–20: 5	11–15: 6	1–10: 7
	8.		Picture	60"					0	21–60: 4	16–20: 5	11–15: 6	1–10: 7
	9.		Picture	120"					0	71–120: 4	46–70: 5	31–45: 6	1–30: 7
	10.		Picture	120"					0	61–120: 4	46–60: 5	36–45: 6	1–35: 7
	11.		Picture	120"					0	61–120: 4	46–60: 5	36–45: 6	1–35: 7
6–8 STOP	12.		Picture	120"					0	61–120: 4	46–60: 5	36–45: 6	1–35: 7
	13.		Picture	120"					0	101–120: 4	81–100: 5	56–80: 6	1–55: 7

Maximum Raw Score
Ages 6–8: 57
Ages 9–90: 71

Block Design Total Raw Score ☐

2. Vocabulary

Start
Ages 6–90: Item 4

Reverse
Ages 6–90: Does not obtain a perfect score on *either* Item 4 or Item 5, administer the preceding items in reverse order until two consecutive perfect scores are obtained.

Discontinue
After 3 consecutive scores of 0.

Stop
Age 6: After Item 22.
Ages 7–11: After Item 25.
Ages 12–14: After Item 28.

Record & Score
Items 1–3: Score 0 or 1 point.
Items 4–5: Score 0 or 2 points.
Items 6–31: Score 0, 1, or 2 points.
See the Manual for sample responses.

	Item	Response	Score
	1. Fish		0 1
	2. Shovel		0 1
	3. Shell		0 1
6–90	†4. Shirt		0 2
	5. Car		0 2
	6. Lamp		0 1 2
	7. Bird		0 1 2
	8. Tongue		0 1 2
	9. Pet		0 1 2
	10. Lunch		0 1 2
	11. Bell		0 1 2
	12. Calendar		0 1 2
	13. Alligator		0 1 2
	14. Dance		0 1 2

†If the examinee provides a 2-point response that requires feedback or gives an incorrect (0 point) response, provide corrective feedback as instructed in the Manual.

continue

2. Vocabulary *(continued)*

Discontinue after 3 consecutive scores of 0.

	Item	Response	Score
	15. Summer		0 1 2
	16. Reveal		0 1 2
	17. Decade		0 1 2
	18. Entertain		0 1 2
	19. Tradition		0 1 2
	20. Enthusiastic		0 1 2
	21. Improvise		0 1 2
	22. Haste		0 1 2
6 STOP	23. Trend		0 1 2
	24. Impulse		0 1 2
	25. Ruminate		0 1 2
7–11 STOP	26. Mollify		0 1 2
	27. Extirpate		0 1 2
	28. Panacea		0 1 2
12–14 STOP			

continue

2. Vocabulary *(continued)*

Discontinue after **3** consecutive scores of 0.

Item	Response	Score
29. Perfunctory		0 1 2
30. Insipid		0 1 2
31. Pavid		0 1 2

Maximum Raw Score
Age 6: 41
Ages 7–11: 47
Ages 12–14: 53
Ages 15–90: 59

Vocabulary Total Raw Score ____

3. Matrix Reasoning

Start
Ages 6–8: Sample Items A & B, then Item 1
Ages 9–90: Sample Items A & B, then Item 4

Reverse
Ages 9–90: Does not obtain a perfect score on *either* Item 4 or Item 5, administer the preceding items in **reverse** order until two consecutive perfect scores are obtained.

Discontinue
After **3** consecutive scores of 0.

Stop
Ages 6–8: After Item 24.

Record & Score
Score **0** or **1** point.
Correct responses are in **color**.

	Item	Response	Score
6–90	SA.	1 **2** 3 4 5	
	SB.	1 2 **3** 4 5	
6–8	1.	1 **2** 3 4 5	0 1
	2.	**1** 2 3 4 5	0 1
	3.	1 2 **3** 4 5	0 1
9–90	4.	**1** 2 3 4 5	0 1
	5.	1 2 3 4 **5**	0 1
	6.	**1** 2 3 4 5	0 1
	7.	1 2 **3** 4 5	0 1
	8.	1 2 **3** 4 5	0 1
	9.	1 2 3 **4** 5	0 1
	10.	1 **2** 3 4 5	0 1
	11.	1 2 **3** 4 5	0 1
	12.	1 2 3 **4** 5	0 1
	13.	**1** 2 3 4 5	0 1
	14.	1 2 3 **4** 5	0 1
	15.	1 **2** 3 4 5	0 1
	16.	1 2 3 4 **5**	0 1
	17.	1 2 3 **4** 5	0 1
	18.	1 **2** 3 4 5	0 1
	19.	1 2 3 **4** 5	0 1
	20.	1 **2** 3 4 5	0 1
	21.	1 2 **3** 4 5	0 1
	22.	1 2 **3** 4 5	0 1
	23.	**1** 2 3 4 5	0 1
6–8 STOP	24.	1 2 3 **4** 5	0 1
	25.	1 2 3 **4** 5	0 1
	26.	1 **2** 3 4 5	0 1
	27.	1 2 3 4 **5**	0 1
	28.	1 2 3 4 **5**	0 1
	29.	**1** 2 3 4 5	0 1
	30.	1 **2** 3 4 5	0 1

Maximum Raw Score
Ages 6–8: 24
Ages 9–90: 30

Matrix Reasoning Total Raw Score ____

4. Similarities

Start
Ages 6–8: Item 1
Ages 9–90: Item 4

Reverse
Ages 9–90: Does not obtain a perfect score on *either* Item 4 or Item 5, administer the preceding items in **reverse** order until two consecutive perfect scores are obtained.

Discontinue
After **3** consecutive scores of 0.

Stop
Ages 6–8: After Item 22.

Record & Score
Items 1–3: Score **0** or **1** point. Correct responses are in **color**.
Items 4–5: Score **0** or **2** points.
Items 6–24: Score **0**, **1**, or **2** points. See Manual for sample responses.

	Picture Item	Response	Score
6–8	†1.	1 2 **3** 4 5	0 1

Picture Item	Response	Score
2.	1 2 3 **4** 5	0 1

Picture Item	Response	Score
3.	1 **2** 3 4 5	0 1

	Verbal Items	Response	Score
9–90	§† 4. Green–Blue		0 2
	§† 5. Square–Triangle		0 2
	6. Cow–Bear		0 1 2
	7. Shirt–Jacket		0 1 2
	8. Pen–Crayon		0 1 2
	9. Hat–Umbrella		0 1 2
	10. Airplane–Bus		0 1 2
	11. Door–Window		0 1 2
	12. Child–Adult		0 1 2

§If the examinee provides a response that suggests he or she does not understand the task, provide the specified prompt in the Manual.

†If the examinee provides a 2-point response that requires feedback or provides an incorrect (0 point) response, provide corrective feedback as instructed in the Manual.

continue

4. Similarities *(continued)*

Discontinue after **3** consecutive scores of 0.

Verbal Items	Response	Score
13. Shoulder–Ankle		0 1 2
14. Love–Hate		0 1 2
15. Smooth–Rough		0 1 2
16. Hand–Flag		0 1 2
17. Wall–Line		0 1 2
18. Heat–Wind		0 1 2
19. More–Less		0 1 2
20. Shadow–Echo		0 1 2
21. Tradition–Habit		0 1 2
22. Peace–War		0 1 2
6–8 STOP 23. Time–Progress		0 1 2
24. Memory–Practice		0 1 2

Maximum Raw Score
Ages 6–8: 41
Ages 9–90: 45

Similarities Total Raw Score ____ / 20

WASI®-II

WECHSLER ABBREVIATED SCALE OF INTELLIGENCE®— SECOND EDITION

Examinee Name: _____ Age: _____

Parent/Guardian Name: _____

Examiner Name: _____

Record Form

Behavioral Observations

Referral source/Reason for referral/Presenting complaint(s)

Physical appearance

Language (e.g., first/native language, other language, English fluency, expressive and receptive language ability, articulation)

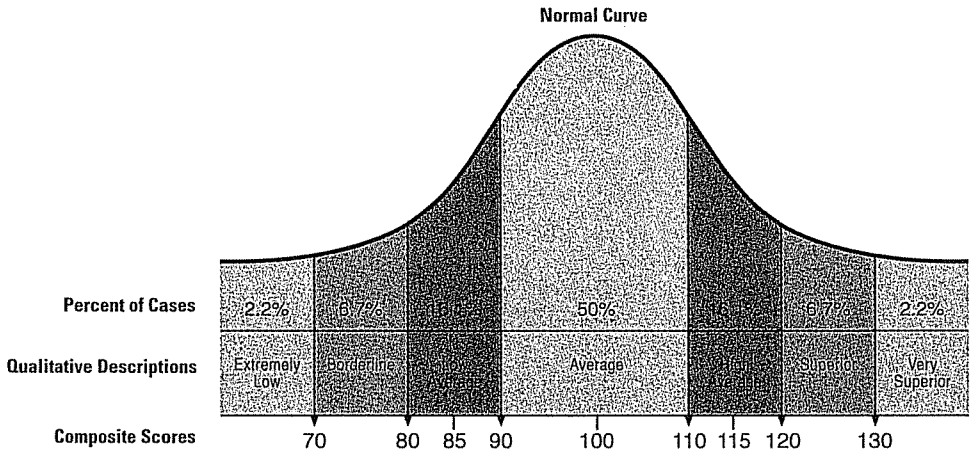
Attention and concentration

Attitude toward testing (e.g., rapport, eager to speak, working habits, interest, motivation, reaction to success/failure)

Affect/Mood

Unusual behaviors/Verbalizations (e.g., perseverations, stereotypic movements, bizarre and atypical verbalizations)

Other notes



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CD-RISC

Subject #: Date: _____ Time: _____

_____

Think about how you have been feeling over the past month. Using the scale below, please rate each of the following statements for how well they describe you **DURING THE PAST MONTH**.

0	**1**	**2**	**3**	**4**
not true at all	**rarely true**	**sometimes true**	**often true**	**true nearly all the time**

1. _____ Able to adapt to change
2. _____ Close and secure relationships
3. _____ Sometimes fate or God can help
4. _____ Can deal with whatever comes
5. _____ Past success gives confidence for new challenge
6. _____ See the humorous side of things
7. _____ Coping with stress strengthens
8. _____ Tend to bounce back after illness or hardship
9. _____ Things happen for a reason
10. _____ Best effort no matter what
11. _____ You can achieve your goals
12. _____ When things look hopeless, I don't give up
13. _____ Know where to turn for help
14. _____ Under pressure, focus and think clearly
15. _____ Prefer to take the lead in problem solving
16. _____ Not easily discouraged by failure
17. _____ Think of self as strong person
18. _____ Make unpopular or difficult decisions
19. _____ Can handle unpleasant feelings
20. _____ Have to act on a hunch
21. _____ Strong sense of purpose
22. _____ In control of your life
23. _____ I like challenges
24. _____ You work to attain your goals
25. _____ Pride in your achievements

Craig Handicap Assessment and Reporting Technique Scoring Short Form

1. How many hours in a typical 24-hour day do you have someone with you to provide physical assistance for personal care activities such as eating, bathing, dressing, toileting and mobility?

_____ hours paid assistance _____ hours unpaid (family, others)

PHYSICAL INDEPENDENCE

A. Total the hours of paid and unpaid care, multiply by 4, and subtract that number from 100.

100
minus
_____.
=

2. How much time is someone with you in your home to assist you with activities that require remembering, decision making, or judgment?

1_____ Someone else is always with me to observe or supervise.
2_____ Someone else is always around, but they only check on me now and then.
3_____ Sometimes I am left alone for an hour or two.
4_____ Sometimes I am left alone for most of the day
5_____ I have been left alone all day and all night, but someone checks in on me.
6_____ I am left alone without anyone checking on me.

3. How much of the time is someone with you to help you with remembering, decision making, or judgment when you go away from your home?

1_____ I am restricted from leaving, even with someone else.
2_____ Someone is always with me to help with remembering, decision making or judgment when I go anywhere.
3_____ I go to places on my own as long as they are familiar.
4_____ I do not need help going anywhere.

COGNITIVE INDEPENDENCE

A. Assign points as follows: response #1 = 0 points; response #2 = 1 point; response #3 = 2 points; response #4 = 3 points; response #5 = 4 points; and response #6 = 5 points.

_____.
x11
=
_____.

B. Multiply points in "A" by 11.

+

C. Assign points as follows: response #1 = 0 points; response #2 = 1 point; response #3 = 2 points; and response #4 = 3 points.

_____.
x15
=
_____.

D. Multiply points in "C" by 15.

=

Add the sums of "B" and "D". If the total sum is greater than 100, enter 100.

4. On a typical day, how many hours are you out of bed? _____ hours

5. In a typical week, how many days do you get out of your house and go somewhere? _____days

6. In the last year, how many nights have you spent away from your home (excluding hospitalizations?)
_____ none _____ 1-2 _____ 3-4 _____ 5 or more

MOBILITY

A. Multiply the number of hours out of bed by 3. _____.

\+

B. Multiply the number of days per week out of the house by 7. _____.

\+

C. Assign points as follows: no nights out = 0; 1-2 nights out = 10; 3-4 nights out = 15; 5 or more nights = 20. If the total sum is greater than 100, enter 100. _____.

=

Add the sums of "A", "B", and "C". If the total sum is greater than 100, enter 100. [ ]

7. How many hours per week do you spend working in a job for which you get paid? hours_____

8. How many hours per week do you spend in school working toward a degree or in an accredited technical training program (including hours in class and studying)? hours

9. How many hours per week do you spend in active homemaking including parenting, housekeeping, and food preparation? _____ hours

10. How many hours per week do you spend in home maintenance activities such as gardening, house repairs or home improvement? _____ hours

11. How many hours per week do you spend in recreational activities such as sports, exercise, playing cards, or going to movies? Please do not include time spent watching TV or listening to the radio._____hours

OCCUPATION

A. Multiply the number of hours working by 2.5. _____.

\+

B. Multiply the number of hours in school by 2.5. _____.

\+

C. Multiply the number of hours in active homemaking by 2.5. _____.

\+

D. Multiply the number of hours in home maintenance by 2.5. _____.

\+

E. Multiply the number of recreational activities by 1.25 _____.

=

Add the sums of "A", "B", "C", "D", and "E". If the total sum is greater than 100, enter 100. [ ]

SOCIAL INTEGRATION

12. How many people do you live with?

13. Is one of them your spouse or significant other?

14. of the people you live with how many are relatives?

15. How many business or organizational associates do you visit, phone, or write to at least once a month? _____ Associates

16. How many friends (non-relatives contacted outside business or organizational settings) do you visit, phone, or write to at least once a month?_____Friends

17. With how many strangers have you initiated a conversation in the last month (for example, to ask information or place an order)?

    none ____ 1-2 ____ 3-5 ____ 6 or more

A. Assign 38 points if living with spouse/partner OR assign 25 points if living with unrelated roommate and/or an attendant.

   Add an additional six points for every relative that lives in the household.

_____.
+

B. Multiply number of business associates by 2.5. A maximum score for this component is 25 points.

_____.
+

C. If living with more than one roommate, add extra roommate to number of friends contacted monthly. Multiply by 13. A Maximum score for this component is 65 points.

_____.
+

D. Assign points as follows: none = 0 points; 1-2 = 15 points; 3-5 = 23 points; 6 or more = 30 points.

_____.

=

Add the sums from "A", "B", "C", and "D". If the total sum is greater than 100, enter 100.

18. Approximately what was the combined annual income, in the last year, of **all family members in your household**? (consider all sources including wages and earnings, disability benefits, pensions and retirement income, income from court settlements, investments and trust funds, child support and alimony, contributions from relatives, and any other source.)

a. Less than 25,000 - If no ask e; if yes ask b
b. Less than 20,000 - If no code 22500; if yes ask c
c. Less than 15,000 - If no code 17500; if yes ask d
d. Less than 10,000 - If no code 12500; if yes code 5000
e. Less than 35,000 - If no ask f; if yes code 30000
f. Less than 50,000 - If no ask g; if yes code 42500
g. Less than 75,000 - If no code h; if yes code 62500
h. 75,000 or more code 80000

19. Approximately how much did you pay last year for medical care expenses? (Consider any amounts paid by yourself or the family members in your household and **not reimbursed** by insurance or benefits.)

a. Less than 1000 if "no" ask b if "yes" code 500.
b. Less than 2500 if "no" ask c if "yes" code 1750.
c. Less than 5000 if "no" ask d if "yes" code 3750.
d. Less than 10000 if "no" code e if "yes" code 7500.
e. 10000 or more code 15000

ECONOMIC SELF SUFFICIENCY

A. Calculate family size by adding respondent, plus partner (if living with respondent), plus other relatives in household.

_____.
Family size

_____.
(#19)
minus

B. Subtract the unreimbursed medical expenses from the annual income (amount in question #19 minus amount in question #20.

_____.
(#20)

C. Determine poverty level from family size calculated in "A".

=

D. Divide the value from "B" by the poverty level from "C".

_____.
divided by

E. Multiply by 50

_____.
Poverty level

*50
=

_____.

=

If the total sum is greater than 100, enter 100.

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Revised and updated materials help increase the accuracy of personality assessment.

Purpose: 22 nonoverlapping full scales provide a comprehensive assessment of adult psychopathology in ages 18 years and older

Age Range: Adult
Elder Adult

Admin: Individual or group

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Qualification: C

Sample Reports: N/A

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The 344 PAI items constitute 22 nonoverlapping scales covering the constructs most relevant to a broad-based assessment of mental disorders: 4 validity scales, 11 clinical scales, 5 treatment scales, and 2 interpersonal scales. To facilitate interpretation and to cover the full range of complex clinical constructs, 10 scales contain conceptually derived subscales.

The PAI Clinical scales were developed to provide information about critical diagnostic features of 11 important clinical constructs. These 11 scales may be divided into three broad classes of disorders: those within the neurotic spectrum, those within the psychotic spectrum, and those associated with behavior disorder or impulse control problems.

The Treatment scales were developed to provide indicators of potential complications in treatment that would not necessarily be apparent from diagnostic information. These five scales include two indicators of potential for harm to self or others, two measures of the respondent's environmental circumstances, and one indicator of the respondent's motivation for treatment.

The Interpersonal scales were developed to provide an assessment of the respondent's interpersonal style along two dimensions: a warmly affiliative versus a cold rejecting style, and a dominating/controlling versus a meekly submissive style. These axes provide a useful way of conceptualizing many different mental disorders: persons at the extremes of these dimensions may present with a variety of disorders. A number of studies provide evidence that diagnostic groups differ on these dimensions.

The PAI includes a Borderline Features scale and an Antisocial Features scale. Both of these scales specifically assess character pathology. The Borderline Features scale is the only PAI scale that has four subscales, reflecting the factorial complexity of the construct. The Antisocial Features scale includes a total of three facets: one assessing antisocial behaviors, and the other two assessing antisocial traits.

Subject ID: _____ Date: _____

The following questions concern your alcohol consumption. Place an X in one box that best describes your answer to each question.

Questions	0	1	2	3	4	
1. How often do you have a drink containing alcohol?	Never	Monthly or less	2-4 times a month	2-3 times a week	4 or more times a week	
2. How many drinks containing alcohol do you have on a typical day when you are drinking?	1 or 2	3 or 4	5 or 6	7 to 9	10 or more	
3. How often do you have six or more drinks on one occasion?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily	
4. How often during the last year have you found that you were not able to stop drinking once you had started?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily	
5. How often during the last year have you failed to do what was normally expected of you because of drinking?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily	
6. How often during the last year have you needed a first drink in the morning to get yourself going after a heavy drinking session?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily	
7. How often during the last year have you had a feeling of guilt or remorse after drinking?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily	
8. How often during the last year have you been unable to remember what happened the night before because of your drinking?	Never	Less than monthly	Monthly	Weekly	Daily or almost daily	
9. Have you or someone else been injured because of your drinking?	No		Yes, but not in the last year		Yes, during the last year	
10. Has a relative, friend, doctor, or other health care worker been concerned about your drinking or suggested you cut down?	No		Yes, but not in the last year		Yes, during the last year	
					Total	

Rivermead Post Concussion Symptoms Questionnaire

Modified (Rpq-3 And Rpq-13)[42] Printed With Permission: Modified Scoring System From Eyres 2005 [28]

Subject ID: Date:

After a head injury or accident some people experience symptoms that can cause worry or nuisance. We would like to know if you now suffer any of the symptoms given below. Because many of these symptoms occur normally, we would like you to compare yourself now with before the accident. For each symptom listed below please circle the number that most closely represents your answer.

0 = not experienced at all
1 = no more of a problem
2 = a mild problem
3 = a moderate problem
4 = a severe problem

Compared with **before** the accident, do you **now** (i.e., over the last 24 hours) suffer from:

	not experienced	no more of a problem	mild problem	moderate problem	severe problem
Headaches	0	1	2	3	4
Feelings of dizziness	0	1	2	3	4
Nausea and/or vomiting	0	1	2	3	4
Noise sensitivity (easily upset by loud noise)	0	1	2	3	4
Sleep disturbance	0	1	2	3	4
Fatigue, tiring more easily	0	1	2	3	4
Being irritable, easily angered	0	1	2	3	4
Feeling depressed or tearful	0	1	2	3	4
Feeling frustrated or impatient	0	1	2	3	4
Forgetfulness, poor memory	0	1	2	3	4
Poor concentration	0	1	2	3	4
Taking longer to think	0	1	2	3	4
Blurred vision	0	1	2	3	4
Light sensitivity (easily upset by bright light)	0	1	2	3	4
Double vision	0	1	2	3	4
Restlessness	0	1	2	3	4
Are you experiencing any other difficulties? Please specify, and rate as above.					
1.	0	1	2	3	4
2.	0	1	2	3	4

Administration only:

RPQ-3 *(total for first three items)*	
RPQ-13 *(total for next 13 items)*	

http://www.maa.nsw.gov.au/default.aspx?MenuID=148

Administration only

Individual item scores reflect the presence and severity of post concussive symptoms. Post concussive symptoms, as measured by the RPQ, may arise for different reasons subsequent to (although not necessarily directly because of) a traumatic brain injury. The symptoms overlap with broader conditions, such as pain, fatigue and mental health conditions such as depression[72].

The questionnaire can be repeated to monitor a patient's progress over time. There may be changes in the severity of symptoms, or the range of symptoms. Typical recovery is reflected in a reduction of symptoms and their severity within three months.

Scoring

The scoring system has been modified from Eyres, 2005[24].

The items are scored in two groups. The first group (RPQ-3) consists of the first three items (headaches, feelings of dizziness and nausea) and the second group (RPQ-13) comprises the next 13 items. The total score for RPQ-3 items is potentially 0–12 and is associated with early symptom clusters of post concussive symptoms. If there is a higher score on the RPQ-3, earlier reassessment and closer monitoring is recommended.

The RPQ-13 score is potentially 0–52, where higher scores reflect greater severity of post concussive symptoms. The RPQ-13 items are associated with a later cluster of symptoms, although the RPQ-3 symptoms of headaches, dizziness and nausea may also be present. The later cluster of symptoms is associated with having a greater impact on participation, psychosocial functioning and lifestyle. Symptoms are likely to resolve within three months. A gradual resumption of usual activities is recommended during this period, appropriate to symptoms. If the symptoms do not resolve within three months, consideration of referral for specialist assessment or treatment services is recommended.

References:

Eyres, S., Carey, A., Gilworth, G., Neumann, V., Tennant, A. (2005). Construct validity and reliability of the Rivermead Post Concussion Symptoms Questionnaire. *Clinical Rehabilitation*, 19, 878-887.

King, N. S., Crawford, S., Wenden, F.J., Moss, N.E.G. Wade, D.T. (1995). The Rivermead Post Concussion Symptoms Questionnaire: a measure of symptoms commonly experienced after head injury and its reliability *Journal of Neurology*, 242, 587-592.

Potter, S., Leigh, E., Wade, D., Fleminger, S. (2006). The Rivermead Post Concussion Symptoms Questionnaire *Journal of Neurology*, October 1-12.

http://www.maa.nsw.gov.au/default.aspx?MenuID=148

Subject ID: _____ Session: _____ Study: _____ Date: ____/____/____

Snaith-Hamilton Pleasure Scale

This questionnaire is designed to measure your ability to experience pleasure in the last few days.
It is important to read each statement very carefully.
Circle the answer that corresponds to how much you agree or disagree with each statement.

1.	I would enjoy my favorite television or radio program.	Strongly Disagree	Disagree	Agree	Strongly Agree
2.	I would enjoy being with my family or close friends.	Definitely Agree	Agree	Disagree	Strongly Disagree
3.	I would find pleasure in my hobbies and past-times.	Strongly Disagree	Disagree	Agree	Strongly Agree
4.	I would be able to enjoy my favorite meal.	Definitely Agree	Agree	Disagree	Strongly Disagree
5.	I would enjoy a warm bath or refreshing shower.	Definitely Agree	Agree	Disagree	Strongly Disagree
6.	I would find pleasure in the scent of flowers or the smell of a fresh sea breeze or freshly baked bread.	Strongly Disagree	Disagree	Agree	Strongly Agree
7.	I would enjoy seeing other people's smiling faces.	Definitely Agree	Agree	Disagree	Strongly Disagree
8.	I would enjoy looking smart when I have made an effort with my appearance.	Strongly Disagree	Disagree	Agree	Strongly Agree
9.	I would enjoy reading a book, magazine, or newspaper.	Definitely Agree	Agree	Disagree	Strongly Disagree
10.	I would enjoy a cup of tea or coffee or my favorite drink.	Strongly Disagree	Disagree	Agree	Strongly Agree
11.	I would find pleasure in small things, e.g. bright sunny day, a telephone call from a friend.	Strongly Disagree	Disagree	Agree	Strongly Agree
12.	I would be able to enjoy a beautiful landscape or view.	Definitely Agree	Agree	Disagree	Strongly Disagree
13.	I would get pleasure from helping others.	Strongly Disagree	Disagree	Agree	Strongly Agree
14.	I would feel pleasure when I receive praise from other people.	Definitely Agree	Agree	Disagree	Strongly Disagree

Satisfaction with Life Scale

Below are five statements with which you may agree or disagree.
Indicate your agreement with each item by placing the appropriate number on the line preceding that item.

Please be open and honest in your responding.

The 7-point scale is as follows:

1 = strongly disagree
2 = disagree
3 = slightly disagree
4 = neither agree nor disagree
5 = slightly agree
6 = agree
7 = strongly agree

__ 1. In most ways my life is close to my ideal.
__ 2. The conditions of my life are excellent.
__ 3. I am satisfied with my life.
__ 4. So far I have gotten the important things I want in life.
__ 5. If I could live my life over, I would change almost nothing.

EDINBURGH HANDEDNESS SURVEY

Subject ID#:_____

Date: _____

Please indicate your preferences in the use of hands in the following activities by putting a + in the appropriate column. Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, put ++. If in any case you are really indifference put + in both columns.

Some of the activities require both hands. In these cases the part of the task, or object, for which the hand preference is wanted is indicated in brackets.

Please try to answer all the questions, and only leave a blank if you have no experience at all of the object or task.

		LEFT	RIGHT
1	Writing		
2	Drawing		
3	Throwing		
4	Scissors		
5	Toothbrush		
6	Knife [without fork]		
7	Spoon		
8	Broom [upper hand]		
9	Striking Match [match]		
10	Opening Box [lid]		

Do not write below this line

L.Q.:_____ DECILE: _____

Have you ever used marijuana?

For our purposes, marijuana usage is considered any instance in which you intentionally consumed (smoked, ingested, etc.) any quantity of marijuana.

☐ **NO** ☐ **YES**

At what age did you start? _____

At what specific age (in years) was your marijuana usage the heaviest? _____

During your lifetime, approximately how many occasions have you used marijuana?

☐ 0-50 ☐ 51-100 ☐ 101-500 ☐ 501s-1000 ☐ 1001-5000 ☐ over 5000

Consider the extent of marijuana use throughout your lifetime. Please approximate the number of times per month on average which you used marijuana at the following ages:

16-18 years of age	19-21 years of age	22-24 years of age	25-27 years of age	28-30 years of age	30+ years of age

During your lifetime, on average, how many times per month have you used marijuana?

_____

In the past <u>four weeks</u>, did you use marijuana?

☐ **NO** ☐ **YES**

How often? _____ daily / weekly (*circle one*)

On average, how much do you consume per occasion? _____

If YES, please review the printed calendar reflecting all the days in the past month. Indicate the number of times you used marijuana on each of these days. If you abstained from marijuana use during a given day, please write a “0” on that day. Please fill out every day in the calendar with your best guess of marijuana use.

Test 9 Sentence Reading Fluency

Administration Overview

- This test has a 3-minute time limit.
- You will need a stopwatch or a watch or clock with a second hand to administer this test.
- If you are not using a stopwatch, note the *exact starting time* in minutes and seconds.
- Give the subject *exactly 3 minutes* to complete as many items as possible.
- Record the *exact finishing time* in minutes and seconds on the Test Record.
- Use the Response Booklet and a pencil with eraser for this test.

Scoring

- 1 = Correct response
  0 = Incorrect response
- Use the Sentence Reading Fluency Scoring Guide to score this test.
- When calculating the number correct, do not include points for sample items or the practice exercise.
- Record *both* the Number Correct and the Number Incorrect on the Test Record. Do not count unattempted items as incorrect.

Starting Point

- Administer Sample Items A and B and the Practice Exercise to all subjects.

Sample Items

Open Response Booklet to Sentence Reading Fluency sample items and place directly in front of subject. Say: **I want you to read some sentences and decide if the answer is yes or no.**

Point to Sample Item A and say: **Look at this sentence. It says, "A cow is an animal."** (Pause.) **Is that true?** (Pause for response.) **Because the answer is yes, you would circle the letter** *Y* (point to circled *Y*). **Now look at the second sentence. It says, "A fish can read."** (Pause.) **Is that true?** (Pause for response.) **Because the answer is no, you would circle the letter** *N* (point to circled *N*).

A. A cow is an animal.	(Y)	N
B. A fish can read.	Y	(N)

Practice Exercise

Give subject a pencil with eraser and say: **Now look at the next four sentences. Draw a circle around the correct answer for each sentence. Work as quickly as you can without making mistakes. Go ahead.**

C. An apple is blue.	Y	(N)
D. A wheel is round.	(Y)	N
E. A man has two legs.	(Y)	N
F. Ice is hot.	Y	(N)

◆ ***C–F: Error***
Say: **Read the sentence aloud and tell me if the answer is "yes" or "no."** If subject still gives incorrect answer, explain sentence and correct answer.

◆ ***C–F: No Response***
Say: **Read the sentence aloud and tell me if the answer is "yes" or "no."** If subject cannot read sentence, point to next sentence and say: **Try the next one.**

❖ ***2 or Fewer Correct***
If subject has 2 or fewer items correct on Practice Exercise, record score of 0 for Test 9 Sentence Reading Fluency without administering test items.

Test Items

Open Response Booklet to Sentence Reading Fluency test items and hold up booklet so subject cannot study items. Say: **Start here** (point to first sentence) **and read as many sentences as you can. Decide if the answer is yes or no. After you get to the bottom** (point to bottom of first column), **go to the top** (point to top of second column). **There are three pages. Keep working until I tell you to stop. Work as quickly as you can without making mistakes. If you do make a mistake, cross out the one you do not want. If you have trouble reading a word or cannot think of the answer, skip that one and go on to the next one. You will have three minutes. Tell me if you finish before I say, "Stop."**

Place Response Booklet, opened to test items, directly in front of subject and say: **Go ahead.** Begin timing 3 minutes.

Make sure subject continues to top of next page after completing each page.

❖ ***No Stopwatch***
If not using stopwatch, record *exact starting time* in minutes and seconds.

❖ ***Early Finish***
If subject finishes test items in less than 3 minutes, record *exact finishing time* in minutes and seconds on Test Record.

Allow subject to work for *exactly 3 minutes* and then say: **Stop. Put your pencil down.** Collect pencil and Response Booklet.

Record *exact finishing time* in minutes and seconds on Test Record.

End of Test 9
Sentence Reading
Fluency

Test 9 Sentence Reading Fluency

Sample Items

A. A cow is an animal. ..... (Y) N

B. A fish can read. ..... Y (N)

Practice Exercise

C. An apple is blue. ..... Y N

D. A wheel is round. ..... Y N

E. A man has two legs. ..... Y N

F. Ice is hot. ..... Y N

1. Fire is hot. ..... Y N
2. Dogs can eat. ..... Y N
3. A bird can fly. ..... Y N
4. Cats have five legs. ..... Y N
5. A clock tells time. ..... Y N
6. A bus has wings. ..... Y N
7. Cars have four wheels. ..... Y N
8. People can drive cars. ..... Y N
9. Candy is sweet. ..... Y N
10. A penny is round. ..... Y N
11. Milk is always blue. ..... Y N
12. Some days are sunny. ..... Y N
13. Windows can be washed. ..... Y N
14. Lawn chairs love to dance. ..... Y N
15. Birds sleep in big beds. ..... Y N
16. Most snakes fly through trees. ..... Y N
17. People like to drink gum. ..... Y N
18. A table has six arms. ..... Y N
19. An eagle is a bird. ..... Y N
20. Tires are always flat. ..... Y N
21. Pilots fly red bikes. ..... Y N
22. A train goes on the track. ..... Y N
23. A shoe goes on your head. ..... Y N
24. A bird may build a nest. ..... Y N
25. Milk comes out of gas pumps. ..... Y N
26. A door may have a lock. ..... Y N
27. A hat goes on your foot. ..... Y N
28. Elephants are large animals. ..... Y N
29. Many spiders can spin webs. ..... Y N
30. A butterfly has ten wings. ..... Y N
31. Glasses help people to hear. ..... Y N
32. Most poodles graduate from school. ..... Y N
33. Some fish live in the ocean. ..... Y N
34. The color of grass is red. ..... Y N
35. A school bus has a driver. ..... Y N
36. A plumber may fix a leak. ..... Y N
37. Snow is often green in color. ..... Y N
38. May is the month after March. ..... Y N
39. Most houses have only one room. ..... Y N
40. A fan may produce a breeze. ..... Y N
41. Many people like to play games. ..... Y N
42. People love to swim in puddles. ..... Y N
43. A beaver roars like a lion. ..... Y N
44. Some children like to watch cartoons. .... Y N
45. Some children fly kites on windy days. ..... Y N
46. Some people take medicine for colds. .... Y N
47. Berries can be different colors. ..... Y N
48. A dog may bark at a cat. ..... Y N
49. A boat can talk to a man. ..... Y N

Go to the next page →

50. You can drink milk through a straw. ..... Y N

51. A bicycle needs gas each day. ..... Y N

52. Fish like to prepare gourmet dinners. ..... Y N

53. An ocean has plenty of water. ..... Y N

54. Candy is always bitter to taste. ..... Y N

55. A magazine has only fourteen pages. ..... Y N

56. Children may eat soup with a spoon. ..... Y N

57. A plant's roots are above the ground. ..... Y N

58. Most people smile when they are sad. ..... Y N

59. All monkeys talk in complete sentences. ..... Y N

60. May is the last day of the week. ..... Y N

61. Big horses often sleep in small garages. ..... Y N

62. Floodwaters can cause soil erosion. ..... Y N

63. Winter is a season of the year. ..... Y N

64. Most people drive airplanes to the store. ..... Y N

65. A monkey is an insect that flies. ..... Y N

66. All mountains are very flat on top. ..... Y N

67. Roosters like to ride the bus to school. ..... Y N

68. Some people buy new homes in small towns. ..... Y N

69. Most people use keys to comb their hair. ..... Y N

70. A highway can have more than one lane. ..... Y N

71. A carpenter may build things with wood. ..... Y N

72. A hospital has more than one doctor. ..... Y N

73. Plans cannot be revised in a meeting. ..... Y N

74. Mice run in marathon races on Saturdays. ..... Y N

75. There are many different types of jewelry. ..... Y N

76. Some adults rent apartments in large cities. ..... Y N

77. Squirrels always deposit their money in banks. ..... Y N

78. Photo albums may hold many pictures. ..... Y N

79. Games can be played with a deck of cards. ..... Y N

80. A pitcher may be used to pour water. ..... Y N

81. Many bears walk down the middle of streets. ..... Y N

82. A trailer can be used to transport horses. ..... Y N

83. An old flashlight may need batteries to operate. ..... Y N

84. Some librarians put books back in the oven. ..... Y N

85. Some boys like to go swimming on hot days. ..... Y N

86. A car is so much bigger than a bus. ..... Y N

Go to the next page →

87. Most dogs can fly over the tops of mountains. ..... Y N

88. Tennis is a game some people like to play. ..... Y N

89. Parts of a hidden cavern may be unexplored. ..... Y N

90. Money is often used to start forest fires. ..... Y N

91. Every year all cars need to have new engines. ..... Y N

92. A lion eats paper when it is hungry. ..... Y N

93. You can see only one color in a rainbow. ..... Y N

94. A talented athlete may like several different sports. ..... Y N

95. Most people fill their pillows with rocks before sleeping. ..... Y N

96. The letter *A* is the last letter of the alphabet. ..... Y N

97. Children and adults are all the same height and weight. ..... Y N

98. One may see flowers along a trail in the spring. ..... Y N

99. Drivers may use a map to find certain locations. ..... Y N

100. People can use credit cards to buy clothes and supplies. ..... Y N

101. Calendars display the months, weeks, and days of a year. ..... Y N

102. A classroom teacher works all day in a grocery store. ..... Y N

103. Large dinosaurs may be found roaming in most national parks. ..... Y N

104. Some people like to go to another country for vacation. ..... Y N

105. A hammer is often used to write a funny story. ..... Y N

106. A map is used to help you find some numbers. ..... Y N

107. You may see an acrobat walk a tightrope at the circus. ..... Y N

108. A person can make a hotel reservation for just one night. ..... Y N

109. A variety of animal species can be found in the jungle. ..... Y N

110. Drivers never get tickets when they go over the speed limit. ..... Y N

Received: 5 September 2017 | Revised: 20 December 2017 | Accepted: 1 January 2018

DOI: 10.1002/hbm.23951

RESEARCH ARTICLE

WILEY

Time-dependent differences in cortical measures and their associations with behavioral measures following mild traumatic brain injury

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Funding information
U.S. Army Medical Research and Materiel Command, Grant/Award Numbers: W81XWH-11-1-0056, W81XWH-12-1-0109, W81XWH-12-1-0386

Abstract

There is currently a critical need to establish an improved understanding of time-dependent differences in brain structure following mild traumatic brain injury (mTBI). We compared differences in brain structure, specifically cortical thickness (CT), cortical volume (CV), and cortical surface area (CSA) in 54 individuals who sustained a recent mTBI and 33 healthy controls (HCs). Individuals with mTBI were split into three groups, depending on their time since injury. By comparing structural measures between mTBI and HC groups, differences in CT reflected cortical thickening within several areas following 0–3 (time-point, TP1) and 3–6 months (TP2) post-mTBI. Compared with the HC group, the mTBI group at TP2 showed lower CSA within several areas. Compared with the mTBI group at TP2, the mTBI group during the most chronic stage (TP3: 6–18 months post-mTBI) showed significantly higher CSA in several areas. All the above reported differences in CT and CSA were significant at a cluster-forming $p < .01$ (corrected for multiple comparisons). We also found that in the mTBI group at TP2, CT within two clusters (i.e., the left rostral middle frontal gyrus (L. RMFG) and the right postcentral gyrus (R. PostCG)) was negatively correlated with basic attention abilities (L. RMFG: $r = -.41$, $p = .05$ and R. PostCG: $r = -.44$, $p = .03$). Our findings suggest that alterations in CT and associated neuropsychological assessments may be more prominent during the early stages of mTBI. However, alterations in CSA may reflect compensatory structural recovery during the chronic stages of mTBI.

KEYWORDS
concussion, cortical plasticity, cortical structure, cortical surface area, cortical thickness, cortical volume, sleep

1 | INTRODUCTION

Traumatic brain injury (TBI) is a highly prevalent condition, affecting an estimated 1.7 million annually in the United States (Faul, Xu, Wald, & Coronado, 2010). Of these, it is estimated that ~75% of injuries can be classified as mild traumatic brain injury (mTBI) (Centers for Disease Control and Prevention (CDC), 2003), often described as "concussion." Most mTBIs resolve quickly and without complications (McCrea et al., 2003). However, a significant proportion of individuals who sustain an mTBI continue to experience chronic postconcussive symptoms, which may include deficits in attention, concentration, and memory, and chronic complaints of fatigue, headaches, mood lability, and sleep difficulties (Bigler, 2008; Haboubi, Long, Koshy, & Ward, 2001; Packard, 2008; Pare, Rabin, Fogel, & Pepin, 2009). Notably, ~50% of patients with an mTBI will experience chronic sleep disruption in the months and years after their injury (Orff, Ayalon, & Drummond, 2009), including poor sleep quality, delayed sleep phase, daytime hypersomnia, and/or impaired daytime vigilance (Baumann, Werth, Stocker, Ludwig, & Bassetti, 2007; Castriotta et al., 2007; Makley et al., 2008; Parcell,

Abbreviations: CSA, cortical surface area; CT, cortical thickness; CV, cortical volume; ESS, Epworth Sleepiness Scale; HCs, healthy controls; MTBI, mild traumatic brain injury; TBI, traumatic brain injury; TP, time-point; TPs, time-points.

Ponsford, Redman, & Rajaratnam, 2008; Rao et al., 2008; Verma, Anand, & Verma, 2007; Williams, Lazic, & Ogilvie, 2008). Moreover, the presence of a sleep problem following an mTBI is problematic, as it is typically associated with poorer recovery and exacerbation of neuropsychiatric complications (Gilbert, Kark, Gehrman, & Bogdanova, 2015). Finally, recent evidence suggests that sleep may play a critical role in brain repair and recovery processes by enhancing neurotoxin clearance (Xie et al., 2013) and increasing the proliferation of oligodendrocyte precursor cells, which are necessary for myelin repair and regrowth (Bellesi et al., 2013). *Sleep is essential to recovery* but patients with mTBI often obtain insufficient quantity and quality of sleep to optimize recovery.

Although the effects of mTBI on specific brain areas and its long-term effect on brain and behavior have been previously investigated (Dean et al., 2013; Dean and Sterr, 2013; McInnes, Friesen, MacKenzie, Westwood, & Boe, 2017), the natural progression of recovery from mTBI has not been clearly documented using multiple structural imaging techniques. For instance, it would be useful to know how cerebral gray and white matter volumes or their morphology differ over the natural course of recovery so that departures from normal can be identified and appropriate interventions initiated as soon as possible. At present, our understanding of the recovery process has been hindered by the inconsistency of injury time frames studied across various investigations. For example, previous studies have explored functional, structural, and symptomatic complaints within 1 month post-mTBI (Ling, Klimaj, Toulouse, & Mayer, 2013; Paniak et al., 2002), 3 months post-mTBI (Laborey et al., 2014; Ling et al., 2013; Wang et al., 2015), and 6 months or more post-mTBI (De Kruijk et al., 2002; Novack, Alderson, Bush, Meythaler, & Canupp, 2000; Zhou et al., 2013). Studies on mTBI, conducted at a given time-point postinjury, provide valuable information about postconcussive symptoms and functional and structural recovery. However, when injury groups are studied in isolation, it is difficult to visualize the larger picture of brain recovery. Therefore, a better understanding of the complex brain mechanisms that unfold in the months following mTBI is needed, which might lead to more reliable and cost-effective rehabilitation techniques for those suffering from mTBI. Keeping that in mind, in our study, we subcategorized mTBI individuals into three groups depending on their time since injury (0–3 months, 3–6 months, and 6–18 months).

In recent years, a number of structural brain measures, such as cortical thickness (CT), cortical volume (CV), and cortical surface area (CSA) have been proposed to be of importance in evaluating changes in brain structure following mTBI (Dall'Acqua et al., 2016; Govindarajan et al., 2016; Zhou et al., 2013). Although these cortical metrics of brain structure tend to covary together to some extent, following an mTBI, they each reflect different facets of morphology that contribute uniquely to overall brain function. Cortical measures also play a potentially important role in evaluating attention abilities and sleep quality (Altena, Vrenken, Van Der Werf, van den Heuvel, & Van Someren, 2010; Spira et al., 2016; Stoffers et al., 2012; Westlye, Grydeland, Walhovd, & Fjell, 2011). For instance, in mTBI patients, significant cortical thinning in the right precuneus and anterior cingulate gyrus was associated with poor performance on memory and attention tasks (Zhou et al., 2013). In patients with persistent insomnia, cortical thinning was reported in the anterior cingulate cortex, precentral cortex, and the lateral prefrontal cortex (Suh, Kim, Dang-Vu, Joo, & Shin, 2016). Reduced CV within the superior frontal cortex was also reported to be associated with poor sleep quality (Chao, Mohlenhoff, Weiner, & Neylan, 2014; Sexton, Storsve, Walhovd, Johansen-Berg, & Fjell, 2014). Reduced gray matter volume within the bilateral lateral orbitofrontal cortices and bilateral inferior frontal gyri pars orbitalis was also associated with sleep interruptions due to repeated awakenings (Lim et al., 2016). Nonetheless, it is unclear the extent to which different structural measures of the brain and their associated capacities pertaining to better attention abilities and sleep vary independently of one another or whether the dynamics of one structural measure depends on the dynamics of another following mTBI. Previously, Mota and Herculano-Houzel (2015) showed the interdependent nature of structural measures, such as cortical folding, CSA, and CT, reporting that the changes in cortical folding depended not only on CSA but also on CT. Taken together, such studies interpret the dependence of brain performance on the integrated impact of surface area and cortical thickness in a healthy brain, but this possibility has not been extended to TBI. While prior structural neuroimaging has not been able to reliably identify consistent morphological changes associated with mTBI, it is conceivable that these metrics, when applied in conjunction with one another, may prove more sensitive to subtle changes during the recovery process.

In this study, our primary goal was to explore differences in multiple brain structural measures, such as CT, CV, and CSA at different stages post-mTBI. Our second goal was to examine the association between the three brain morphology metrics, attentional processes, and sleep-related outcomes for all the *regions of interest* which showed differences in structural measures at the various time points in the year following injury. We hypothesized that the differences in each of the three brain morphological measures would (i) display unique and significant structural differences across different stages post-mTBI and (ii) show that differences in CT, CV, and CSA would correlate with differences in attention and sleep measures.

2 | MATERIALS AND METHODS

2.1 | Participants

A total of 87 adults, recruited from the general population within the greater metropolitan area of Boston, MA and New England, participated in this study. Thirty-three participants were included as healthy controls (HCs, mean age = 24.52 ± 3.0 years, 19 female) and 54 participants with a recent mTBI were included in the mTBI group (mean age = 22.40 ± 4.6 years, 33 female, time since injury between 0 and 18 months, mean = 5.73 ± 3.9 months). Any participant from the HC group or mTBI group with any history of drug or alcohol abuse or current use of illicit substances was excluded. Current alcohol use was required to be lower than the Center for Disease Control criteria for excessive alcohol use (www.cic.gov/alcohol). All HCs were recruited as part of a separate study (although no data from these subjects regarding cortical thickness, volume, or surface area

TABLE 1 Demographic characteristics of healthy controls and mTBI participants

Demographics	Healthy controls ($N = 33$)	MTBI overall ($N = 54$)	MTBI (TP1) ($N = 18$)	MTBI (TP2) ($N = 22$)	MTBI (TP3) ($N = 14$)	Statistical significance
Mean age (S.D.)	24.52 (3.0)[a]	22.40 (4.6)	24.56 (6.1)[b]	21.77 (3.5)	20.61 (2.6)[a,b]	$F(3,86) = 4.98^*$
(in years)						
Gender	58	61	61	64	57	$\chi^2(3) = 0.26$
(% female)						
Time-since-injury (TSI) in months	-	$0 < TSI \leq 18$	$0 < TSI \leq 3$	$3 < TSI \leq 6$	$6 < TSI \leq 18$	-
ATT	-	105.02 (13.4)	104.05 (9.1)	108.45 (12.9)	100.86 (17.8)	$F(2,53) = 1.47$
ESS	-	8.89 (3.6)	8.39 (3.6)	8.86 (4.0)	9.57 (3.1)	$F(2,53) = 0.41$
PSQI	-	6.25 (2.7)	5.67 (2.4)	6.59 (2.9)	6.50 (2.6)	$F(2,53) = 0.66$

Note. Abbreviation: TP = time-point.
Superscripts "a" and "b" denote the groups that significantly differ at $^*p < .05$.

have been published previously) but with the same scanning parameters and on the same scanner as the mTBI group. Neuropsychological testing was completed at the Social Cognitive and Affective Neuroscience laboratory located at McLean Hospital. All participants underwent high-resolution anatomical brain imaging using a Siemens Tim Trio 3T scanner (Erlangen, Germany) located at the McLean Hospital Imaging Center.

2.1.1 | Inclusion/exclusion criteria for HCs

All the HCs were screened via a comprehensive telephone interview and were excluded if there was any history of psychiatric or neurological disorder, significant medical problems—including head injury, sleep disorders—or current use of psychotropic medications that could affect neuroimaging. Additionally, the inclusion eligibility of all the HCs was determined using the Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders (DSM-IV Axis I Disorders) (SCID) (First, Spitzer, Gibbon, & Williams, 2002). All the HCs met inclusion criteria and none of them met diagnostic criteria for any current/lifetime Axis I disorder.

2.1.2 | Inclusion/exclusion criteria for mTBI individuals

An mTBI was defined based on the criteria established by the American Congress on Rehabilitation Medicine (Head, 1993) and later adopted by the Department of Veterans Affairs and the Department of Defense (Management of Concussion/mTBI Working Group, 2009) as a traumatically induced event that was associated with an alteration in mental state (e.g., confusion, disorientation), consciousness (i.e., loss of consciousness <30 min; alteration of consciousness up to 24 h) and post-traumatic amnesia up to 24 h. Individuals with any history of neurological, mood, or psychotic disorder with an onset prior to the mTBI, or who suffered a loss of consciousness exceeding 30 min following an injury were excluded. Although the study was funded by the U.S. Army Medical Research and Materiel Command, none of the participants were active duty military and none of the head injuries were caused by exposure to combat.

2.1.3 | Grouping of mTBI individuals

In this study, eligible individuals with mTBI were grouped into one of three subcategories based on time-since injury: <3 months, between 3 and 6 months, and between 6 and 18 months. Eighteen individuals experienced an mTBI (mean age = 24.56 ± 6.09 years, 11 female) within the preceding 3 months (TP1), 22 experienced an mTBI (mean age = 21.77 ± 3.53 years, 14 female) between 3 and 6 months prior to evaluation (TP2), and 14 experienced an mTBI (mean age = 20.61 ± 2.56 years, 8 female) between 6 and 18 months prior to the evaluation (TP3). Groups were different in "age" ($F(3,86) = 4.98$, $p < .05$, one-way ANOVA), but not "gender" ($\chi^2(3) = 0.26$, $p > .05$, Pearson's Chi-square). Demographic information of all the groups (HCs and three mTBI groups) is summarized in Table 1.

2.1.4 | Consent, compensation, and IRB approval

Written consent was obtained from each participant before the experiment. Additionally, each participant was thoroughly briefed on the potential risks and benefits of the study and participants were financially compensated for their time. The experimental protocol was approved by the Institutional Review Board of McLean Hospital, Partners Health Care, and the U.S. Army Human Research Protections Office (HRPO). All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

2.2 | Data acquisition

2.2.1 | Magnetic resonance imaging

All participants were instructed to rest, relax, and try their best to stay motionless during scanning. Neuroanatomical data were acquired using a 3D magnetization-prepared rapid acquisition gradient echo (MPRAGE) sequence which consisted of 176 sagittal slices (voxel resolution = 1 × 1 mm, field of view (FOV) = 256 mm) with TR/TE/FA/inversion time of 2100 ms/2.30 ms/12°/1100 ms encompassing the whole brain.

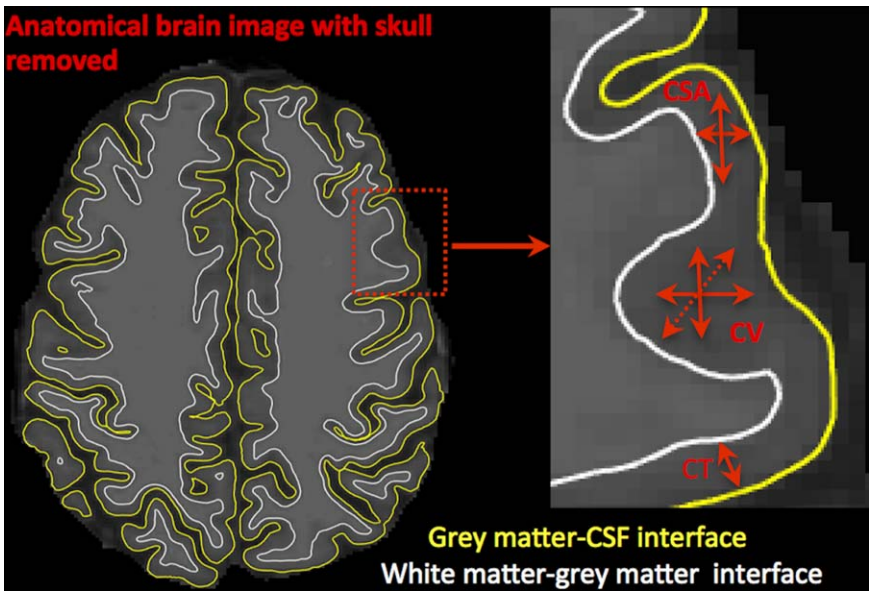

FIGURE 1 Cortical thickness (CT), cortical volume (CV), and cortical surface area (CSA). Representation of cortical measures (CT, CV, and CSA) within original anatomical brain image [Color figure can be viewed at wileyonlinelibrary.com]

2.2.2 | Attention and sleep measures

The mTBI participants completed three well-validated assessments: The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) (Randolph, Tierney, Mohr, & Chase, 1998) for attention (ATT), a combination of digit span and coding subtests, the Epworth Sleepiness Scale (ESS) (Johns, 1991) and the Pittsburgh Sleep Quality Index (PSQI) (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). No such data were recorded from HCs. The RBANS ATT index is a measure of speed and accuracy of information processing, with a mean of 100 and standard deviation of 15. Here a lower RBANS ATT index score represents difficulty in basic attention processing. The use of the RBANS has been shown to be a clinically valid and reliable screening tool for patients with traumatic brain injury (McKay, Casey, Wertheimer, & Fichtenberg, 2007). ESS measures the severity of daytime sleepiness and PSQI is a measure of sleep problems, which takes into account several facets of sleep, including sleep latency, sleep duration, and sleep disturbances. ESS scores range from 0 to 24, where higher scores represent severe excessive daytime sleepiness and PSQI scores range from 0 to 21, where higher scores represent poor sleep quality. A subset of other, unrelated behavioral data from this mTBI sample have been reported elsewhere (Killgore et al., 2016).

2.3 | Data analysis

2.3.1 | Identification of affected brain areas following mTBI

The "recon-all" pipeline in FreeSurfer (version 6.0) (https://surfer.nmr.mgh.harvard.edu/fswiki) was used to process anatomical images for all the participants (HCs and individuals with mTBI). Processing involved motion-correction, brain extraction (i.e., removal of skull, skin, neck, and eye-balls), automated transformation to the Talairach co-ordinate system, intensity correction, volumetric segmentation, and smoothing using a 15 mm full-width at half-maximum (FWHM) Gaussian kernel. For each HC and mTBI participant, we visually inspected raw T1-weighted image data to determine any possible imaging artifacts, which could affect FreeSurfer's segmentation accuracy. Accuracy of the FreeSurfer generated skull-stripped brain masks and brain surfaces (pial and white) were visually inspected for all the participants from the HC and mTBI groups. The measures of CT, CV, and CSA were calculated separately for the left and the right hemispheres for each participant. CT is defined as the mean distance from the white–grey matter interface to the nearest point on the pial surface (grey matter–CSF interface) and from that point on the pial surface back to grey/white matter interface (Fischl and Dale, 2000), CV is defined as the amount of grey matter that lies between the white–grey matter interface and pial matter (Winkler et al., 2010), and CSA is the sum of the areas of the triangles making up the surface model and is defined as the extent of the two-dimensional surface enclosed by the outer layer of the cerebral cortex (http://cna.hanyang.ac.kr/research/research02.htm) (Fischl, Sereno, & Dale, 1999) (Figure 1). For vertex-by-vertex general linear model (GLM) estimation across the left and the right cortical surface, CT, CV, and CSA were used as individual dependent variables. This method was used to generate statistical parametric maps to identify the brain areas, which showed significantly different CT, CV, or CSA in those with a mTBI (TP1, TP2, or TP3) compared to HCs and within three TPs (TP1 versus TP2, TP1 versus TP3, and TP2 versus TP3). These statistical maps display the distribution of p values. Effects of "age" (demeaned) and "gender" were regressed out when performing group analyses. As the group-wise sample size in our study is small and the differences in brain structure between HCs and mTBI groups and within the mTBI groups are not expected to be localized finely, we selected a moderately larger smoothing kernel size of 15 mm. Moreover, unlike volume-based analysis, larger smoothing kernel size in surface-based analysis never extends into bone/air/white matter. Furthermore, we used a cluster forming threshold (CFT) of $p < 0.01$. Multiple comparisons were

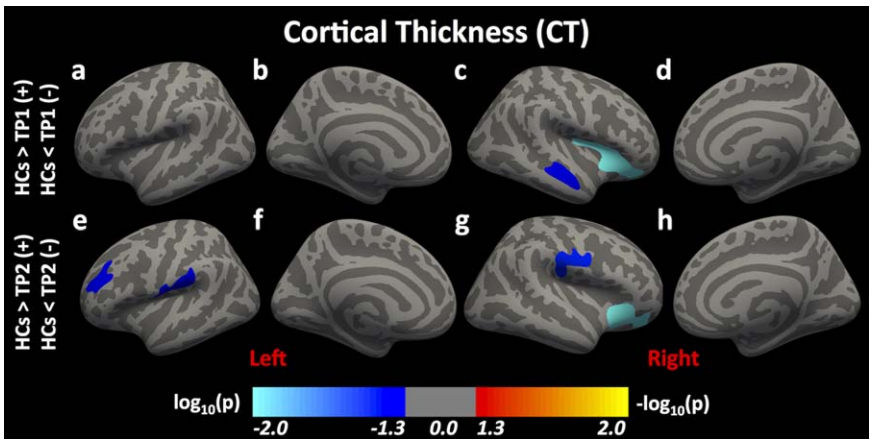

FIGURE 2 Differences in cortical thickness (CT) following mTBI. Here, we report significant differences in CT between HCs and individuals with mTBI at time-points (TPs) 1 and 2 [Color figure can be viewed at wileyonlinelibrary.com]

corrected at a clusterwise statistical threshold (CWP) of $p < 0.05$ using Monte-Carlo simulations.

2.3.2 | Association between structural measures, ATT, and sleep measures

The method described above was used to generate statistical parametric maps to identify the brain areas, which showed significant differences in CT, CV, or CSA when compared across each of the three time-points and when compared to HC group. Multiple brain regions identified over the whole brain, which showed significant differences in CT, CV, or CSA between mTBI groups and HC group or across time-points (i.e., from TP1 to TP2, and/or from TP1 to TP3 and/or from TP2 to TP3), were selected as *regions of interest* (ROIs). Subject-wise CT, CV, and CSA of corresponding ROIs were calculated by performing a whole brain parcellation into 34 brain areas using the "Desikan–Killiany" atlas (Desikan et al., 2006). In this atlas, the automated method used to subdivide the human cerebral cortex into 34 cortical ROIs is both anatomically valid and reliable with average intraclass correlation coefficients of 0.835 across all of the ROIs (Desikan et al., 2006). Partial correlation analyses were performed between structural measures (CT, CV, and CSA), attention (RBANS ATT), and sleep measures (ESS and PSQI) for all ROIs identified during the initial analysis, after considering the effects of "age" (demeaned), "gender," and corresponding whole-brain structural measures. The correlation analysis was performed only for the ROIs; therefore, partial correlations were not corrected for multiple comparisons.

3 | RESULTS

3.1 | Structural measures for HCs versus three mTBI groups

CT: Compared to HCs, 2 clusters—the right insula and the right superior temporal gyrus (STG)—in the mTBI group at TP1 showed significantly greater CT (Figure 2a–d). Compared to HCs, 4 clusters—the left rostral middle frontal gyrus (RMFG), the left supramarginal gyrus (SMG), the right lateral orbitofrontal cortex (LOFC), and the right postcentral gyrus (PostCG)—in the mTBI group at TP2 showed significantly greater CT (Figure 2e–h). These findings are summarized in Table 2. There were no significant difference in CT between HCs and mTBI group at TP3. Within the three TPs also, we did not find significant differences in CT, that is, for TP1 versus TP2, for TP2 versus TP3, or for TP1 versus TP3.

CV: We did not find significant differences in CV when compared between HCs and any of the three mTBI groups and within three mTBI groups.

CSA: Compared to HCs, 3 clusters—the right PostCG, the right inferior temporal cortex, and the right superior frontal cortex—in the mTBI group at TP2 showed significantly lower CSA (Figure 3a–d). There were no significant difference in CSA between HCs and mTBI groups at TP1 or TP3. These findings are summarized in Table 3. Within the three-mTBI groups, 3 clusters—the left STC, the left PostCG, and the right isthmus of cingulate gyrus—in the mTBI group at TP3 showed significantly higher CSA compared to TP2 (Figure 3e–h). These findings are summarized in Table 4.

3.2 | Correlation analysis between structural measures, RBANS ATT, and sleep measures

For two ROIs—the right postcentral gyrus (R. PostCG) and the left rostral middle frontal gyrus (L. RMFG)—there were negative correlations between CT and the RBANS ATT index within TP2 (R. PostCG: $r = -.44$, $p = .03$ and L. RMFG: $r = -.41$, $p = .05$) (Figure 4a,b). However, the mTBI groups were not significantly different on RBANS ATT ($F(2,53) = 1.47$, $p = .24$, one-way ANOVA), ESS ($F(2,53) = 0.41$, $= 0.66$, one-way ANOVA) or PSQI ($F(2,53) = 0.66$, $p = .52$, one-way ANOVA) (Table 1).

3.2.1 | Impressions

Bilateral cortical thickening was observed during the acute stages of mTBI (i.e., within 0–3 and 3–6 months post-mTBI) compared to HCs. During the less acute stage of mTBI (i.e., 3–6 months post-mTBI), CSA was lower as compared to HCs. During the chronic stage of mTBI (i.e., 6–18 months post-mTBI), CSA was higher in comparison to acute stages of mTBI (i.e., 3–6 months post-mTBI). Moreover, in mTBI

TABLE 2 Comparison of cortical thickness (CT) between healthy controls (HCs) and individuals with an mTBI at time-points 1, 2, and 3

Cluster number	MNIX, MNIY, MNIZ (Peak)	Annotation (Peak)	Cluster size (Voxels)	(+) HCs > TP 1/2/3 (−) HCs < TP 1/2/3
Cortical thickness (CT): HCs versus mTBI (TP1)				
Left hemisphere (LH)				
None				
Right hemisphere (RH)				
1	31.5, 21.2, −0.1	Insula	3901	(−)
2	48.8, −19.8, −6.3	Superior temporal gyrus	1297	(−)
Cortical thickness (CT): HCs versus mTBI (TP2)				
Left hemisphere (LH)				
1	−32.6, 41.1, 19.3	Rostral middle frontal gyrus	1453	(−)
2	−56.5, −23.9, 21.4	Supramarginal gyrus	1859	(−)
Right hemisphere (RH)				
1	29.5, 24.9, −8.4	Lateral orbitofrontal cortex	2387	(−)
2	62.9, −12.1, 23.7	Postcentral gyrus	2280	(−)
Cortical thickness (CT): HCs versus mTBI (TP3)				
Left hemisphere (LH)/right hemisphere (RH)				
None				

Note. Abbreviations: HCs = healthy controls; mTBI = mild traumatic brain injury; TP = time-point.

individuals, higher CT of the left PostCG and the right RMFG within TP2 was associated with lower attention scores.

4 | DISCUSSION

In this study, we document time-dependent differences across several measures of brain structure following an mTBI. Our findings suggest that cortical alterations in thickness and their associated behavioral outcomes may occur at early stage of mTBI. However, cortical alterations in surface area are suggestive of trends of potential partial physical recovery with greater time since injury.

4.1 | Time-dependent cortical differences following mTBI

CT: In general, previous studies on CT following an mTBI reported thinning and thickening of the cortex (Govindarajan et al., 2016; Wang et al., 2015). It has been suggested that cortical differences might depend on several factors, including the time since injury, symptom severity, regional microedema, localized microhemorrhages, and cytotoxic edema (Lewen, Fredriksson, Li, Olsson, & Hillered, 1999; Wang et al., 2015). It was also suggested that due to subsequent cortical thinning after several weeks, differences in cortical thickness were

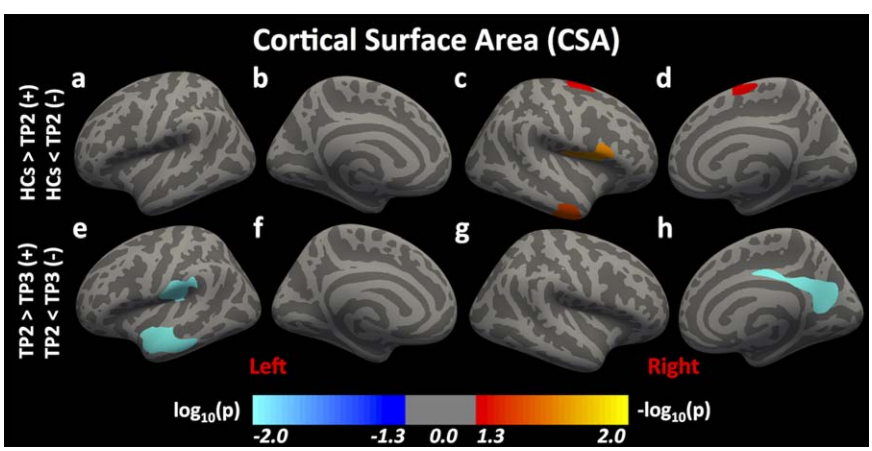

FIGURE 3 Differences in cortical surface area (CSA) following mTBI. Here, we report significant differences in CSA between HCs and individuals with mTBI at time-point (TP) 2 and between mTBI groups at TPs 2 and 3 [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 3 Comparison of cortical surface area (CSA) between healthy controls (HCs) and individuals with an mTBI at time-points 1, 2, and 3

Cluster number	MNIX, MNIY, MNIZ (Peak)	Annotation (Peak)	Cluster size (Voxels)	(+) HCs > TP 1/2/3 (−) HCs < TP 1/2/3
Cortical surface area (CSA): HCs versus MTBI (TP1)				
Left hemisphere (LH)/right hemisphere (RH)				
None				
Cortical surface area (CSA): HCs versus MTBI (TP2)				
Left hemisphere (LH)				
None				
Right hemisphere (RH)				
1	40.9, −3.3, 18.0	Postcentral gyrus	2488	(+)
2	46.4, −5.7, −38.7	Inferior temporal cortex	1835	(+)
3	23.1, 2.2, 60.9	Superior frontal cortex	2047	(+)
Cortical surface area (CSA): HCs versus MTBI (TP3)				
Left hemisphere (LH)/right hemisphere (RH)				
None				

Note. Abbreviations: HCs = healthy controls; TP = time-point.

undetectable at later time points (Govindarajan et al., 2016; Lewen et al., 1999; Tate et al., 2014). However, in this study, compared to HCs, we reported thickening within the right insula and the right STG among mTBI individuals who were between 0 and 3 months of injury and within the left RMFG, left SMG, right LOFC, and right PostCG among mTBI individuals who were between 3 and 6 months of injury.

Recently, brain regions including the insula, STC, and PostCG have been shown to display greater neural activation among individuals with mTBI relative to controls (Dretsch et al., 2017). In that study, it was proposed that several psychological health symptoms such as depression and attentional bias toward negatively valenced stimuli could be responsible for the neural hyperacivation within several regions of interest in the mTBI group. However, the validity of similar mechanisms resulting in cortical thickening within these regions following an mTBI still needs to be confirmed. In a separate study, higher numbers of mTBIs were also associated with reduced CT within the bilateral insula and right middle temporal gyrus (List, Ott, Bukowski, Lindenberg, & Floel, 2015). In that study, it was hypothesized that recurrent mTBIs may induce distinct alterations, especially thinning of the cortex. Consistent with our findings, it was proposed that cortical alterations from the acute phase following an mTBI may normalize in the chronic phase. Moreover, cortical thickening within the right RMFG was reported immediately following an mTBI (Wang et al., 2015). At 3 months post-mTBI, no more cortical thinning was observed in the supramarginal gyrus (Govindarajan et al., 2016). However, we observed thickening of the supramarginal gyrus at 3 months post-mTBI. During the first year after mTBI, changes in CT indicated thickening of the prefrontal cortex, including orbitofrontal cortex in mTBI patients (Dall'Acqua et al., 2017; Wilde et al., 2012). Cortical thickening during initial scans following an mTBI and cortical thinning in later scans may reflect progressive normalization of CT, that is, physical recovery from brain lesions (Lewen et al., 1999; Wang et al., 2015). In addition, the brain areas, such as RMFG, which are more susceptible to direct impacts following a frontal–rear axis head injury, may result in the release of excitotoxins from damaged tissues causing inflammatory reactions, including microedema (Barkhoudarian, Hovda, & Giza, 2011; Lillie, Urban, Lynch, Whitlow, &

TABLE 4 Comparison of cortical surface area (CSA) between mTBI time-point (TP) 2 and TP3

mTBI: time-point 2 (TP2) versus time-point 3 (TP3)				
Cluster number	**MNIX, MNIY, MNIZ (Peak)**	**Annotation (Peak)**	**Cluster Size (Voxels)**	**(+) TP 2 > TP 3 (−) TP 2 < TP 3**
Cortical surface area (CSA)				
Left hemisphere (LH)				
1	−52.2, 7.4, −14.6	Superior temporal cortex	3587	(−)
2	−56.0, −17.5, 16.2	Postcentral gyrus	2892	(−)
Right hemisphere (RH)				
1	5.4, −47.2, 30.1	Isthmus cingulate	3480	(−)

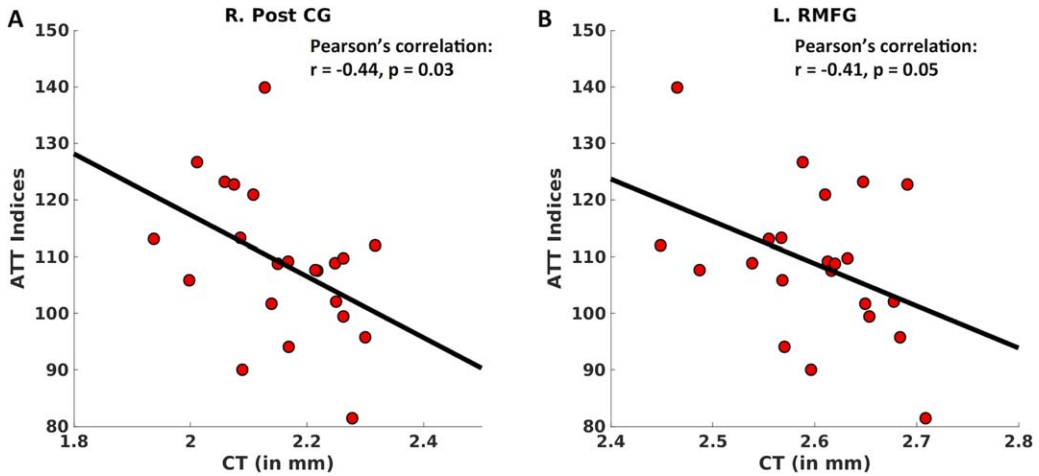

FIGURE 4 Significant partial correlations between RBANS ATT and cortical thickness (CT). After regressing out the effects of age, gender, and whole-brain CT, here we plot significant correlations found between RBANS ATT and CT for both the ROIs (a) the right postcentral gyrus (R. PostCG) ($r = -.44$, $p = .03$) and (b) the left rostral middle frontal gyrus (R. RMFG) ($r = -.41$, $p = .05$) [Color figure can be viewed at wileyonlinelibrary.com]

Stitzel, 2013; Patterson and Holahan, 2012; Urban et al., 2012). These inflammatory reactions have been reported to elevate fractional anisotropy, thicken the cortical regions initially but cause cortical thinning over time with the reduction of microedema (Lewen et al., 1999; Ling et al., 2013).

CV: CV is a composite of both CT and CSA, therefore, changes in CV could be due to changes in either CT or CSA, or both. Therefore, significant increase in CT and significant reduction in CSA or vice versa could be responsible for an unknown CV proportionality across the cortex or even the absence of differences in CV in the three mTBI groups, as observed in our study. Previously in a study on gene identification, it was reported that measures of grey matter volume are less sensitive than CT or CSA, where CT and CSA are also distinct from genetic origins (Winkler et al., 2010). In that study, there was no clear interpretation made from regional grey matter volume differences in terms of genetic influences. In the same study, it was also reported that since the variability in CSA was higher compared to CT, variability on CV might therefore be more associated with CSA as compared to CT. Our findings are partially consistent with these mechanisms as we also found more variability in CT measures as compared to CV and CSA. We acknowledge the fact that the preceding analogy is not ideal and is made between mTBI groups and a gene identification study but the geometrical relationships between these three cortical measures (CT, CV, and CSA) and relatively more dependence of CV on CSA compared to CT may partially explain the underlying mechanisms behind our findings.

CSA: We observed greater CSA at the later stages of mTBI (i.e., 6 and 18 months post-mTBI). Specifically, we found that there were many regions with significantly lower CSA at TP2 compared to HCs but greater CSA at TP3 compared to TP2. The observed differences in CSA contrast with prior findings, as decreases in CSA were previously reported to be one of the earlier existing and sensitive biomarkers for the quantification of brain damage following mTBI (Dall'Acqua et al., 2016). However, larger CSA was shown by others to be associated with complex brain interactions and better cognitive skills (Raznahan et al., 2011; Schnack et al., 2015). In humans, a larger proportion of CSA due to larger surface convolutions is attributed to an extended and dynamic network of brain projections (Hofman, 2014). This generation of an extended dynamic network may not be quick and immediate but might instead be a slow process, which could be the backbone for brain plasticity resulting in compensation of behavioral skills following an injury. Significant increases in CSA, regardless of increases in CT, have also been associated with an increase in radial column units during expansion of the neocortex in primate evolution (Rakic, 2009). Integration of these neocortical columns at higher levels of information processing sets the neural basis of multiple brain regions and their unique features to interact dynamically, which could result in greater synaptic plasticity (Budd and Kisvarday, 2012; Hofman, 2014). Moreover, at the chronic stage of mTBI (i.e., 6–18 months post-mTBI), increases in CV rather than CT and CSA individually, which can account for changes in both CT and CSA, could be an indication of an increase in the formation of dendrites resulting in modest remodeling of the cortex over time (Killgore et al., 2016). These improvements in functional and structural abnormalities could also be closely associated with beneficial neural reorganization of the affected brain hemisphere. Experience-based changes in brain structure over time, also known as experience-dependent neural plasticity, were also found to be beneficial for reducing behavioral and physical disorders (Kerr, Cheng, & Jones, 2011).

In sum, the differences in multiple structural measures following an mTBI might indicate that various brain systems change at different rates. Previous brain imaging studies on mild, moderate, and severe TBI showed that although TBI patients performed equally well as HCs, they recruited a larger number of brain areas, including the frontal and posterior cortices (da Costa et al., 2015; Turner and Levine, 2008). Larger recruitment of these areas during later stages of mTBI could be due to reduced involvement of damaged brain areas immediately after an mTBI or greater compensatory recruitment in more chronic stages.

Diffusion imaging studies on TBI have also reported microstructural white-matter alterations that differ at various stages following injury, such as axonal swelling and/or an increase in glial cells (Pasternak et al., 2014), causing variations in CT, CV, or CSA across the recovery period following mTBI.

4.2 | Attention and sleep measures following mTBI

We observed that between 3 and 6 months post-mTBI, abnormally higher cortical thickening within the left RMFG and right PostCG compared to HCs, was negatively associated with performance on measures of attention. Previous work has shown that both RMFG and PostCG are reliably associated with attention capacities. For instance, it was reported that the posterior region within the rostral middle frontal cortex is activated by various cognitive tasks, *including* the ones designed to engage in internal monitoring of action, error and attention (Amodio and Frith, 2006). A positive correlation between thickness within the left posterior middle frontal cortex and performance on a dichotic listening task (a measure of executive attention) further suggested that the left middle frontal cortex is part of an executive attention network (Andersson, Ystad, Lundervold, & Lundervold, 2009). Furthermore, the PostCG or somatosensory cortex, which is the most anterior portion of the parietal lobe, is also one of the three major major sites (intraparietal, postcentral, and precentral) of activation for attention (Corbetta, 1998). A study on a group of right hemisphere stroke patients also suggested a vital role of the PostCG/somatosensory cortex in visuospatial attention (Balslev, Odoj, & Karnath, 2013). Thus, it is clear that the RMFG and PostCG play an important role in attention.

Interestingly, in this study, we did not observe significant differences in attention or sleep measures between any of the three mTBI groups. There was no significant association observed between increased CSA and improved attention abilities or sleep quality. One possible explanation may involve the construct of "cognitive reserve," or the ability to maintain cognitive functioning in the presence of brain damage or degenerative process (Stern, 2009, 2012). Previously, it was found that increased cognitive reserve might play a protective role against obstructive sleep apnea syndrome (OSAS)-related cognitive decline, *including* intelligence and attention (Alchanatis et al., 2005). Given the fact that our data did not include specific cognitive measures relevant to a range of sleep disorders, it is beyond the scope of our study to directly confirm that cognitive reserve played a role in the nonsignificant differences in attention and sleep measures across the three time-points. Regarding the sleep measures we used, another possibility is that some of the specific features of sleep biology are not well captured by self-reported measures (Lim et al., 2016). Future research in these areas is therefore needed to investigate these intriguing possibilities further.

4.3 | What are the benefits of using multiple structural measures?

In this study, we report the time-line of differences in multiple cortical measures, especially CT and CSA, following mTBI. In particular, we report that when CT was significantly different following mTBI, there were no differences observed in CSA, whereas when CT did not differ across time-points, CSA appeared to be higher, which could be due to greater cortical folding. Human brain development is associated with increased cortical folding, which leads to a progressively more convoluted brain structure and gyrification along spatial and temporal scales (Armstrong, Schleicher, Omran, Curtis, & Zilles, 1995; Richman, Stewart, Hutchinson, & Caviness, 1975). Compared to other species, the folds in the human brain are unique and are associated with specific behavioral skills (Gautam, Anstey, Wen, Sachdev, & Cherbuin, 2015; Gregory et al., 2016). Approximately one-third of the brain's cortical surface is visible, whereas two-thirds of the surface is hidden from view among its folds, leading to overall greater CSA and extra space for the accommodation of additional neurons (Toro, 2012). Cortical folding also shortens the distance of cortical connections by reducing the fiber length necessary between neural regions, resulting in reduced conduction delays across axons (Buzsaki, Logothetis, & Singer, 2013; Chklovskii, Mel, & Svoboda, 2004). Mathematically, there is an interdependent relationship between cortical folding and structural cortical measures. More specifically, it is suggested that the amount of cortical folding increases as CSA increases, where CT becomes an important factor to consider (Mota and Herculano-Houzel, 2015). These relationships suggest that more brain folds lead to more CSA, and thicker cortex could be responsible for restricted brain folds, and both, that is, brain folds or CSA and CT might have unique contribution toward stronger behavioral responses. Therefore, it becomes crucial to consider multiple cortical measures to better understand the time-dependent differences in brain structure following an mTBI or in general.

5 | LIMITATIONS

The present findings should be interpreted with consideration of the following, noted, limitations. First, despite having a relatively large sample size for this type of neuroimaging study, we categorized mTBI individuals into only three subcategories based on previous literature. It was, therefore, not possible to examine more fine-grained differences in associations at the acute and subacute periods postinjury. We also suggest that future studies consider employing more precise ranges of time-since-injury onsets, with particular emphasis on explicating the various periods of recovery after 6 months, which would be important for identifying the later recovery mechanisms of mTBI. Second, we did not have attention and sleep data collected from HCs, making it difficult to ascertain the extent to which individuals with mTBI experienced weaker attention abilities, higher daytime sleepiness, and worse sleep quality than the average healthy adult. Finally, the research design of our study is cross-sectional in nature. Consequently, the identified brain clusters reflect significant differences across three discrete time-points and not longitudinal changes over time within a given individual. Future work would benefit from following mTBI patients longitudinally to determine whether the differences observed here are consistent when calculated in a longitudinal design.

6 | CONCLUSIONS

In summary, CT and CSA each show unique and specific patterns of differences in brain structure following mTBI. For CT, these patterns of differentiation from HCs and associated weaker attention abilities are most prominent in the first 6 months postinjury. With greater time since injury extending into the short-term and long-term chronic phases, we observe differences in CSA indicative of progressive but partial brain structural recovery, particularly characterized by increased CSA. These findings demonstrate the importance of analyzing multiple brain structural measures in order to more comprehensively understand the neural mechanisms involved following an mTBI, which may reflect brain damage during the early postacute period but compensatory physical recovery during the more chronic stages of mTBI.

ACKNOWLEDGMENTS

This research was supported by grants from the U.S. Army Medical Research and Materiel Command to WDSK (11-1-0056, and W81XWH-12-1-0386) and SLR (W81XWH-12-1-0109). The opinions, interpretations, conclusions, and recommendations in this article are solely those of the authors and are not necessarily endorsed by the Department of Defense or the U.S. Army Medical Research and Materiel Command.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare with regard to this work.

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How to cite this article: Bajaj S, Dailey NS, Rosso IM, Rauch SL, Killgore WDS. Time-dependent differences in cortical measures and their associations with behavioral measures following mild traumatic brain injury. *Hum Brain Mapp*. 2018;39:1886–1897. https://doi.org/10.1002/hbm.23951

frontiers in Behavioral Neuroscience

ORIGINAL RESEARCH
published: 27 June 2018
doi: 10.3389/fnbeh.2018.00118

Elevated Aggression and Reduced White Matter Integrity in Mild Traumatic Brain Injury: A DTI Study

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Mild traumatic brain injury (mTBI) remains the most commonly reported head injury in the United States, and is associated with a wide range of post-concussive symptoms including physical, cognitive and affective impairments. Elevated aggression has been documented in mTBI; however, the neural mechanisms associated with aggression at the chronic stage of recovery remain poorly understood. In the present study, we investigated the association between white matter integrity and aggression in mTBI using diffusion tensor imaging (DTI). Twenty-six age-matched adults participated in the study, including 16 healthy controls (HCs) and 10 individuals in the chronic stage of recovery (either 6-months or 12 months post-mTBI). Psychological measures of aggression included the Buss-Perry Aggression Questionnaire and the Personality Assessment Inventory (PAI). Axonal pathways implicated in affective processing were studied, including the corpus callosum, anterior thalamic radiation, cingulum and uncinate fasciculus, and measures of white matter integrity included fractional anisotropy (FA), mean diffusivity (MD), radial diffusivity (RD) and axial diffusivity (AD). We found that adults with mTBI in the chronic stage of recovery had higher levels aggression. Individuals with mTBI also had greater RD in the corpus callosum compared to HCs, indicating reduced fiber integrity. Furthermore, we observed a significant association between reduced white matter integrity in the corpus callosum and greater aggression. Our findings provide additional evidence for underlying neuroanatomical mechanisms of aggression, although future research will be necessary to characterize the specific relationship between aggression and the white matter pathways we identified.

Keywords: mild traumatic brain injury, aggression, white matter integrity, diffusion tensor imaging, corpus callosum, post-concussive symptoms

OPEN ACCESS

Edited by:
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Chang-hyun Park, Catholic University of Korea, South Korea

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Received: *10 November 2017*
Accepted: *28 May 2018*
Published: *27 June 2018*

Citation:
Dailey NS, Smith R, Bajaj S, Alkozei A, Gottschlich MK, Raikes AC, Satterfield BC and Killgore WDS (2018) Elevated Aggression and Reduced White Matter Integrity in Mild Traumatic Brain Injury: A DTI Study. Front. Behav. Neurosci. 12:118. doi: 10.3389/fnbeh.2018.00118

INTRODUCTION

Mild traumatic brain injury (mTBI) accounts for roughly 75% of the 1.5 million head injuries reported annually in the United States (Centers for Disease Control and Prevention, 2003). However, not all individuals who sustain a mTBI seek medical treatment, making it difficult to identify and track post-concussive symptomology and long-term disabilities in this population. During the acute and subacute phases of recovery, symptoms generally fall into one of three categories, including physical (i.e., headaches, dizziness and sleep disruptions), cognitive

(i.e., impaired attention and memory, reduced processing speed and poor concentration) and affective (i.e., increased irritability, anxiety and depression) disruptions (Prince and Bruhns, 2017). Furthermore, aggression is one of the most common affective symptoms, with upwards of 40% of individuals reporting increased aggression, hostility, or irritability after sustaining a mTBI (Kim et al., 1999; Bailie et al., 2015; Epstein et al., 2016; Roy et al., 2017).

One possible avenue through which to gain a better understanding of aggression in mTBI is to examine acquired pathology within the neural systems that contribute to affective/emotional behavior. Emotional episodes are believed to arise from interactions between cognitive, physiological and behavioral processes, such that bodily/behavioral reactions are first initiated in response to a situation (and its cognitive interpretation), and these reactions are then perceived and interpreted at multiple levels—leading to the behavioral expression, experience, recognition and subsequent regulation of the elicited emotion (Lindquist et al., 2012; Barrett and Satpute, 2013; Smith and Lane, 2015; Smith et al., 2017). Several large-scale neural networks have been implicated in the emotion-related processes described above, with contributing regions within distinct prefrontal, cingulate and subcortical areas (Barrett and Satpute, 2013). As individuals with a history of mTBI have been found to exhibit problems with the experience, expression and control of anger, this suggests that such individuals may exhibit pathology in these emotion-related processes, and within the neural networks that appear to implement them (Bailie et al., 2015). However, the potential neural mechanisms that underlie the expression and regulation of anger/aggression, and the relationship between neuronal injury sustained during mTBI and affective dysregulation, have not yet been thoroughly examined.

Of the many interconnected large-scale neural networks embedded within association cortices, white matter pathways connecting the temporal lobe, amygdala and orbitofrontal, medial prefrontal, and cingulate cortices are believed to play especially important roles in the emotion-related processes mentioned above (Barrett and Satpute, 2013). One such pathway is the anterior thalamic radiation, a fiber bundle connecting the thalamus, orbitofrontal cortex and anterior cingulate cortex, which is believed to be involved in affective response generation/regulation. Damage to this pathway is associated with emotional dysfunction (e.g., depression) and reduced self-awareness of emotion in clinical populations (Sussmann et al., 2009; Kubota et al., 2012). Another important pathway is the uncinate fasciculus, which connects the anterior temporal lobe, amygdala and orbitofrontal cortex. This pathway may facilitate top-down prefrontal modulation of the amygdala, which is believed to be important for promoting context-appropriate affective responses (Gershman et al., 2013; Chan et al., 2016). Reductions in white matter integrity within the uncinate fasciculus have also been found in populations that exhibit patterns of aggression and/or deficits in emotional regulation, including adults with multiple concussions (Goswami et al., 2016) and specific psychiatric disorders (Sundram et al., 2012). Yet another relevant pathway is the cingulum, which contains fibers connecting medial prefrontal, cingulate, and medial parietal regions. These regions support a network often termed the "default network", and is thought to play an important role in the conceptualization of affective states through the integration of prior experiences (Binder et al., 2009). Finally, the corpus callosum connects left and right hemisphere components of a range of cortical systems, including those subserving motor, perceptual, and cognitive functions. Furthermore, there is some evidence that interhemispheric signal transfer through the corpus callosum may play an integral role in cognitive processes that contribute to aggressive behavior (Schutter and Harmon-Jones, 2013).

When considering acquired neural network pathology in mTBI, time since injury and injury severity are likely key factors for understanding affective symptomology. Neurobehavioral symptoms are often dynamic in the early stages of injury, with the majority of individuals recovering quickly from mTBI (Binder et al., 1997; McCrea et al., 2003). However, there is evidence to suggest that a significant proportion of individuals experience persistent and potentially disruptive symptoms months and years after their injury (see Ruff, 2005). Findings related to affective disruption are also inconsistent in the few studies that directly investigate mTBI-related aggression. For example, some studies report diminished irritability and/or anger with increased time since injury (Kim et al., 1999; Bailie et al., 2015), suggesting improvements in neurobehavioral symptoms over time. In contrast, Baguley et al. (2006) found that the prevalence of aggression was similar at 6, 24 and 60 months post-injury, while another study by Roy et al. (2017) documented elevated aggression 6 months to 1-year post-injury—suggesting aggression is a persistent symptom associated with brain injury. Moreover, individuals who experience persistent symptoms, including affective disruption, may be prime candidates for clinical intervention. Similar discrepancies have been found regarding injury severity. An inverse relationship between injury severity and aggression has been documented, where individuals with mild to moderate TBI were more likely to report post-injury irritability/aggression (Kim et al., 1999). However, other studies report no significant relationship between injury severity and aggression (Rao et al., 2009; Bailie et al., 2015). The use of mixed samples (e.g., time since injury and/or injury severity) may account for the discrepancies in the current literature and complicate the interpretations regarding mTBI-related aggression.

The manifestation and duration of mTBI-related aggression beyond the acute and subacute stages of recovery is not well understood, nor are the underlying neural mechanisms. Given the inconsistencies in the literature, the present study focused exclusively on individuals in the chronic phase of recovery (6-months and 12-months post-injury) and with a TBI that was classified as mild. The purpose of the present study was twofold: (1) to assess chronic post-concussive aggression in those with mTBI; and (2) to identify fiber pathways associated with aggression. We hypothesized that adults with mTBI would

exhibit elevated levels of aggression relative to healthy controls (HCs). Using neural models of emotion to guide the selection of targeted white matter pathways, white matter integrity of the corpus callosum, cingulate, anterior thalamic radiation and uncinate fasciculus was hypothesized to show reduced integrity in the mTBI population, and these white matter integrity reductions were predicted to show associations with aggression.

MATERIALS AND METHODS

Participants

Twenty-six age-matched young adults were enrolled in the present study, including 16 HCs and 10 individuals with mTBI; three at 6-months post-injury and seven at 12-months post-injury. Eligibility criteria required participants to be between 18 years and 45 years of age, native English speakers and right handed. For those in the chronic mTBI group, brain injury documentation from a doctor, physician, or other qualified witness to the injury was required prior to enrollment in the study. Severity was classified as mild based on the ACRM and the Department of Veterans Affairs, Department of Defense (2016), where mTBI was defined as a physiological disruption of brain function resulting in temporary loss of consciousness (<30 min), transient posttraumatic amnesia (<24 h), altered mental state (i.e., feeling dazed, disoriented, or confused), and/or focal neurological damage that may or may not be transient (American Congress of Rehabilitation Medicine, 1993). Exclusionary criteria included: (1) a history of psychiatric or neurological disease; (2) pregnancy; (3) previous or ongoing alcoholism or substance abuse; (4) more than three TBIs in a lifetime; or (5) contraindication to MRI. In the present sample, mTBI was the result of sports related injuries (70%), vehicular accidents (20%) and falls (10%). Participants in this study are part of a larger ongoing study, investigating neuropsychological function across multiple stages of recovery from mTBI. The current study was approved by the Institutional Review Board at the University of Arizona and the U.S. Army Human Research Protections Office (HRPO), and all participants provided written informed consent in accordance with the Declaration of Helsinki.

Neuropsychological Assessments

Participants completed a battery of neuropsychological assessments on the same day and prior to the collection of neuroimaging data. Paper and pencil assessments were administered by a trained full-time research technician in a quiet testing room located in the laboratory.

Wechsler Abbreviated Scale of Intelligence Test (WASI-II)

All participants completed the Wechsler Abbreviated Scale of Intelligence test (WASI-II; Wechsler, 1999). The WASI-II is highly correlated (r = 0.92) with the longer Wechsler Adult Intelligence Scale (WAIS; Wechsler, 2008) and was used to obtain a measure of general intellectual ability or "IQ". Full Scale IQ was used to assess overall intelligence and ensured participants enrolled in the study exhibited cognitive functioning within normal limits.

Buss-Perry Aggression Questionnaire

Aggression was measured using two different questionnaires. The Buss-Perry Aggression Questionnaire (BPAQ; Buss and Perry, 1992) consists of 29 items, rated on a 5-point scale from "extremely uncharacteristic" to "extremely characteristic". The BPAQ provides an overall measure of aggression (total aggression) and four subscales including physical aggression, verbal aggression, anger and hostility. BPAQ-Physical measures one's tendency to use threats, and/or physical harm towards others and objects. BPAQ-Verbal measures disagreements and argumentative behavior, while BPAQ-Anger assesses irritability and control over one's temper. Finally, BPAQ-Hostility refers to feelings of jealousy, suspicion and resentment. Moderate to high reliability has been established for the BPAQ (Harris, 1997) and participants were given as much time as needed to complete the assessment.

Personality Assessment Inventory

The personality assessment inventory (PAI; Morey, 1991) was the second self-report measure of aggression. The PAI was administered on the computer and required roughly 45 min to complete. This 344-item inventory uses a four-alternative scale ranging from "Totally False" to "Very True", to assess 22 non-overlapping scales, including aggression. Total aggression on the PAI measures characteristics and attitudes related to anger, assertiveness and hostility. The PAI has three subscales which include aggressive attitude (hostility and poor control over anger), verbal aggression (assertiveness and readiness to express anger to others), and physical aggression (tendency to be involved in physical altercations). The PAI has been found to be a valid and clinically useful measure of psychiatric and emotional disturbances in adults with TBI (Till et al., 2009). Due to time restrictions and computer error, PAI scores were incomplete for one HC and three mTBI participants.

Beck Depression Inventory

Given the strong association between depression and aggression (Rapoport et al., 2003), the Beck Depression Inventory (BDI-II; Beck et al., 1961) was used to assess post-injury depression. The BDI-II has been shown to discriminate well between clinical and non-clinical populations, where a score of 13 or greater is indicative of mild clinical depression (Lasa et al., 2000). Participants scored the 21-item inventory using a 4-point scale ranging in severity from 0 to 3 for each item. Clinical levels of depression have been shown to be a comorbid symptom of mTBI (Jorge et al., 2004; Baguley et al., 2006), therefore, BDI-II scores were used as a covariate in subsequent analyses, allowing for the comparison of aggressive tendencies while controlling for behaviors associated with depression.

Neuroimaging

Magnetic resonance imaging (MRI) data were collected at the University of Arizona, using a whole-body Siemens Skyra 3.0 Tesla with 32-channel head coil (MAGNETO Skyra Siemens

Healthcare). Diffusion weighted data were acquired using single-shot echo planar imaging (TR = 9600; TE = 88; acquisition matrix = 128 × 128; FOV: 256 × 256; slice thickness = 2 mm, no gap). Diffusion gradients were applied along 72 directions, with b = 1000 s/mm^2 and six non-diffusion weighted images (b_0). A preprocessing pipeline consisted of artifact and head motion correction using TOPUP eddy in the FMRIB Software Library (FSL; Andersson and Sotiropoulos, 2016). The FMRIB Diffusion Toolbox was used for brain extraction (Smith, 2002), and fitting of the diffusion tensor model (DTIFIT; Behrens et al., 2003). DTIFIT calculates fractional anisotropy (FA) and mean diffusivity (MD), while axial diffusivity (AD) and radial diffusivity (RD) were calculated from DTIFIT outputs using the following formulas:

$$AD = \lambda_1 \quad (1)$$

$$RD = (\lambda_2 + \lambda_3)/2 \quad (2)$$

Measured differences in anisotropy can result from axonal density and/or myelination, where AD and RD have been associated with axonal integrity and demyelination, respectively (Song et al., 2002, 2005). Thus, these metrics allow for the quantification of fiber pathway integrity, and may provide reliable biomarkers of mTBI-related symptoms. Tract-Based Spatial Statistics (TBSS; Smith et al., 2006) was used for nonlinear registration to a standard template (FMRIB-58) and affine-aligned to 1 × 1 × 1 mm Montreal Neurological Institute (MNI) space using FNIRT (de Groot et al., 2013). Individually aligned images were then merged to create a single 4D image for each DTI metric, resulting in a total of four separate 4D images. White matter was identified using whole-brain skeletonized masks with a threshold of 0.20, a process that reduces voxels in the periphery where inter-subject variability or partial volume effects tend to be high.

Targeted White Matter Tracts

Binary template masks were created to extract voxels from targeted pathways including the corpus callosum, and bilateral cingulate, uncinate fasciculus and anterior thalamic radiation. Template masks were based on the ICBM-DTI-81 white-matter labels atlas overlaid on a standard template in MNI space (MNI_152_T1 1 × 1 × 1 mm; see **Figure 1**). The population-based atlas includes 48 labeled tracts from hand-segmented white matter parcellation maps based on averaged tensor maps derived from 81 subjects (Mori et al., 2008). Voxels from the 4D skeletonized images which overlapped a given white matter mask were included in subsequent analyses for that tract (see **Figure 2**). White matter integrity was quantified using diffusion and anisotropy properties, resulting in FA, MD, RD and AD values for all targeted tracts. Mean values for a given tract were obtained by averaging all values from voxels extracted from the white matter mask. By extracting values from the skeletonized data and targeting specific tracts of interest, this DTI-approach eliminates superfluous comparisons and provides higher detection power of white matter differences between the two groups.

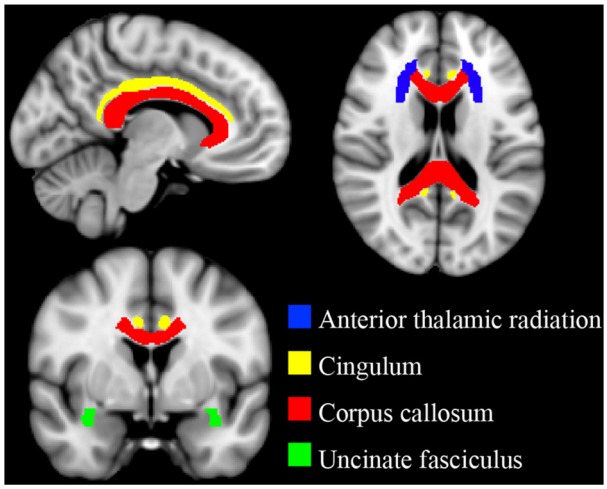

FIGURE 1 | Targeted white matter tracts. Binary template masks from the ICBM-DTI-81 atlas were used to delineate white matter pathways of interest. Anterior thalamic radiation (blue), cingulum (yellow), corpus callosum (red) and uncinate fasciculus (green). Template masks are overlaid on a standard T1 montreal neurological institute (MNI) template (1 × 1 × 1 mm).

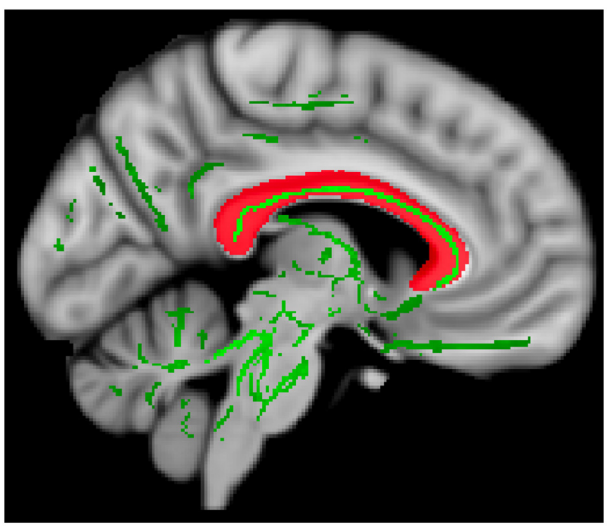

FIGURE 2 | Extracting diffusion values. Data from a representative participant showing whole-brain 4D skeletonized data (green) overlaid on the mask of the corpus callosum (red). Only voxels from 4D data (green) overlapping with white matter mask (red) were extracted and included in subsequent analyses.

Statistical Analysis

Analyses were conducted using IBM SPSS Statistics (version 24.0). Independent sample *t*-tests were performed to identify group differences on continuous demographic measures, and a chi-square was used to test that group and gender were independent. General linear models (GLMs) were used to test whether the two groups differed on measures of aggression and DTI metrics, while controlling for potential effects of age, gender and depression (i.e., covariates). Group was entered into each

GLM as a categorical independent variable, where the HCs was coded as "0" and individuals with mTBI were coded as "1".

To test our first hypothesis addressing aggression in chronic mTBI, we fit individual GLMs with group as a categorical independent variable and BPAQ and PAI total aggression as dependent variables. Age, gender and depression were entered into each model as covariates. Based on significant findings, *post hoc* analyses were conducted to determine which aggression subscales contributed significantly to the overall between-group effect. Separate GLMs were calculated, with group as the independent variable and BPAQ or PAI subscales as the dependent variables, controlling for age, gender and depression.

To test our second hypothesis addressing group differences in the microstructure of targeted fiber pathways, individual GLMs were fit for each tract in the left and right hemisphere separately, with group as a categorical independent variable and DTI metrics (FA, MD, AD and RD) as the dependent variables, while accounting for the effects of age, gender and depression. False discovery rate (FDR; $\alpha = 0.05$) was used to minimize Type I error associated with multiple comparisons (Benjamini and Yekutieli, 2001). For comparisons of microstructure integrity, pathways of interest were selected *a priori* and FDR-correction was adjusted within tract. Finally, Pearson's partial correlations were calculated to quantify the unique relationship between white matter integrity and aggression. Given our interest in determining whether a relationship exists between white matter integrity and aggression, we computed these partial correlations within our whole sample, without stratifying by group. Partial correlation covariates included age, gender and depression and the correlations were restricted to overall aggression measures and tracts which showed significant between-group differences in the previous analyses.

RESULTS

Neuropsychological

Demographic characteristics are summarized in **Table 1**. Adults with mTBI reported significantly higher levels of aggression on the BPAQ ($F_{(1,21)} = 13.22$, $p < 0.05$; $\eta^2 = 0.39$; FDR-corrected) and the PAI ($F_{(1,17)} = 10.86$, $p < 0.05$; $\eta^2 = 0.39$; FDR-corrected), as compared to HCs (see **Figure 3**). In addition, BPAQ scores differed based on gender ($F_{(1,21)} = 8.28$, $p < 0.01$; $\eta^2 = 0.28$).

To better understand the driving factors associated with elevated aggression, *post hoc* analyses were conducted separately for BPAQ and PAI subscales (see **Table 2**). *post hoc* results were FDR-corrected at $p < 0.05$, within test. Adults with mTBI reported significantly higher aggressive attitude on the PAI and significantly higher levels of physical aggression and anger on the BPAQ. In the GLM for the BPAQ, gender was significantly associated with physical aggression ($F_{(1,21)} = 9.28$, $p < 0.01$; $\eta^2 = 0.31$). Follow-up analyses were conducted to further explore these findings. An analysis of covariance was calculated with physical aggression as the dependent variable, group and gender as the independent variables, with age and depression as covariates. There was a significant main effect of group ($F_{(1,20)} = 19.08$, $p < 0.001$; $\eta^2 = 0.49$), a significant main effect of gender ($F_{(1,20)} = 15.64$, $p < 0.001$; $\eta^2 = 0.44$), and a significant group × gender interaction ($F_{(1,20)} = 5.49$, $p < 0.05$; $\eta^2 = 0.22$). **Figure 4** shows the *post hoc* results, in that males with mTBI reported significantly higher physical aggression ($M = 25.67$; $SD = 4.04$) than females with mTBI ($M = 15.86$; $SD = 3.13$), a result not observed in HCs.

Neuroanatomical

The microstructure of targeted fiber pathways was compared between mTBI and HCs. In the corpus callosum, individuals with mTBI exhibited higher RD compared to HCs ($F_{(1,21)} = 7.71$, $p < 0.05$; $\eta^2 = 0.27$; FDR-corrected), indicating reduced fiber integrity within the corpus callosum after an mTBI. Lower FA in the corpus callosum was also found in the mTBI group, however this finding did not survive FDR-correction. White matter integrity (FA, MD, RD and AD) within the anterior thalamic radiation, cingulum, and uncinate fasciculus showed no significant between-group differences (see Supplementary Table S1).

Neural Correlates of Aggression

Neural correlates of aggression were restricted to overall aggression measures and fiber pathways that showed significant between-group differences in the previous analyses. Therefore, we assessed the relationship between white matter integrity in the corpus callosum (RD) and aggression (BPAQ-total aggression and PAI-total aggression). A significant positive correlation was

TABLE 1 | Demographic characteristics by group.

	Healthy Controls ($n = 16$)	Chronic mTBI ($n = 10$)	Statistic	p-value
Age, in years	22.69 (3.40)	22.40 (6.38)	$t_{(24)} = 0.15$	0.88
Gender – %female	50%	70%	$\chi^2_{(1)} = 1.01$	0.43
Education, in years	14.19 (2.43)	12.80 (1.55)	$t_{(24)} = 1.61$	0.12
WASI-II Full-Scale IQ	111.31 (9.69)	111.90 (12.90)	$t_{(24)} = -0.12$	0.90
BDI	2.50 (3.08)	6.10 (7.64)	$t_{(24)} = -1.69$	0.10
Time Since Injury, in days				
6-months ($n = 3$)		184.67 (2.08)		
12-months ($n = 7$)		363.57 (2.99)		

Note: Values are Mean (Standard Deviation), unless otherwise noted. mTBI, mild traumatic brain injury; WASI-II, Wechsler Abbreviated Scale of Intelligence – 2nd Edition; BDI, Beck Depression Inventory.

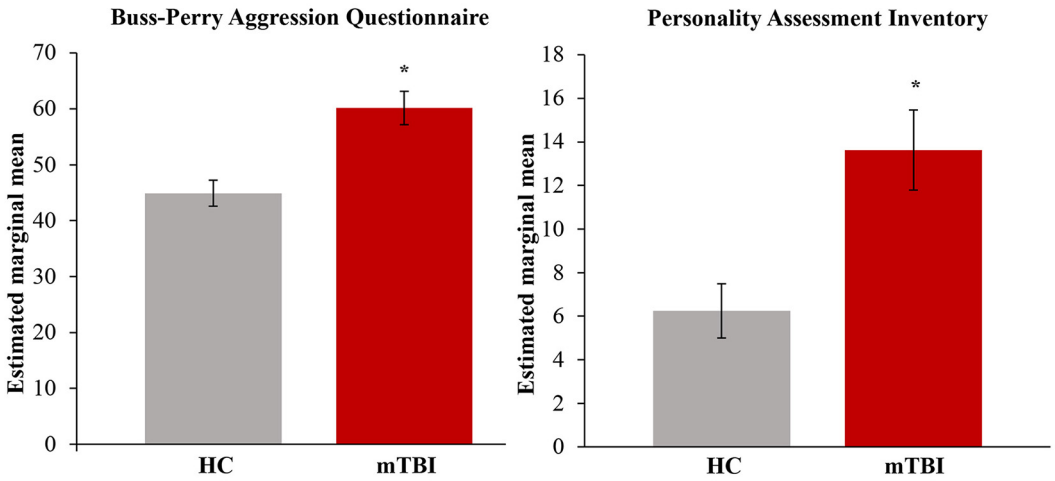

FIGURE 3 | Total aggression by group. Significantly higher aggression on the Buss-Perry Aggression Questionnaire (BPAQ) and Personality Assessment Inventory (PAI) was found in those with mild traumatic brain injury (mTBI). Estimated marginal means represent the group means after adjusting for covariates in the model (age, gender and depression). HC, healthy controls; mTBI, mild traumatic brain injury. Error bars represent standard error of the mean. *$p < 0.05$; FDR-corrected.

found between RD in the corpus callosum and BPAQ-total aggression ($r = 0.49$; $p < 0.05$; FDR-corrected; see **Figure 5**).

Post hoc analyses were conducted to determine whether findings related aggression in the corpus callosum were widespread, or restricted to specific regions. Therefore, the corpus callosum was subdivided into the genu, body and splenium and template masks were created using the procedures previously described in the Materials and Methods: "Targeted White Matter Tracts" section. Similar to previous GLMs, between-group comparisons of white matter integrity in the corpus callosum were calculated for the three subdivisions separately (controlling for age, gender, and depression). Results are summarized in **Table 3**. Significantly higher RD was found in the body and the splenium of the corpus callosum in adults with mTBI compared to HCs ($p < 0.05$, uncorrected). While not significant across the entire corpus callosum, FA was significantly lower in the splenium for those with mTBI ($p < 0.05$, uncorrected). Partial correlations (controlling for age, gender and depression) were then calculated to determine which aspects of aggression were associated with the body and the splenium of the corpus callosum. Given the exploratory nature of these analyses, uncorrected *p*-values are reported. Physical aggression was only associated with white matter integrity in the splenium, in that higher reports of physical aggression were significantly correlated with higher RD ($r = 0.42$, $p < 0.05$) and lower FA ($r = -0.43$, $p < 0.05$). In contrast, aggressive attitude was significantly correlated with higher RD in the body of the corpus callosum ($r = 0.64$, $p < 0.01$).

DISCUSSION

In this study, we investigated post-concussive aggression in individuals who were in the chronic stage of recovery from mTBI, as well as the neural correlates of aggression. We hypothesized that individuals with mTBI would exhibit higher aggression relative to HCs, and that white matter integrity in the corpus callosum, cingulum, anterior thalamic radiation and uncinate fasciculus would be reduced in the mTBI population. In addition, we hypothesized that white matter integrity in these tracts would

TABLE 2 | *Post hoc* group comparisons on aggression subscales.

	Healthy Controls ($n = 16$)	Chronic mTBI ($n = 10$)	*F-statistic*[a,b]	*p*-value	*Partial* η^2[‡]
BPAQ					
Physical Aggression	14.19 (3.73)	18.80 (5.71)	13.22[a]	0.01*	0.39
Verbal Aggression	10.69 (2.92)	12.40 (4.01)	2.39[a]	0.14	0.10
Anger	9.75 (1.98)	12.20 (2.97)	9.44[a]	0.01*	0.31
Hostility	11.63 (4.02)	14.60 (4.38)	0.25[a]	0.05	0.17
PAI					
Aggressive Attitude	1.27 (1.53)	4.14 (2.80)	15.94[b]	0.01*	0.48
Verbal Aggression	4.47 (3.09)	7.43 (2.64)	4.56[b]	0.05	0.21
Physical Aggression	0.80 (1.37)	1.43 (1.62)	2.06[b]	0.17	0.11

Note: Values are Mean (Standard Deviation). Statistics are from separate general linear models on the BPAQ and PAI, controlling for age, gender and depression. [a]*df(1,21);* [b]*df(1,17);* η^2 *= partial eta squared;* [‡]*Small effect size: 0.01 ≤* η^2 *< 0.05; medium effect size: 0.06 ≤* η^2 *< 0.13; large effect size:* $\eta^2 \geq 0.14$*. mTBI, mild traumatic brain injury; BPAQ, Buss-Perry Aggression Questionnaire; PAI, Personality Assessment Inventory. Unadjusted p-values reported. *Significant at FDR-corrected p < 0.05.*

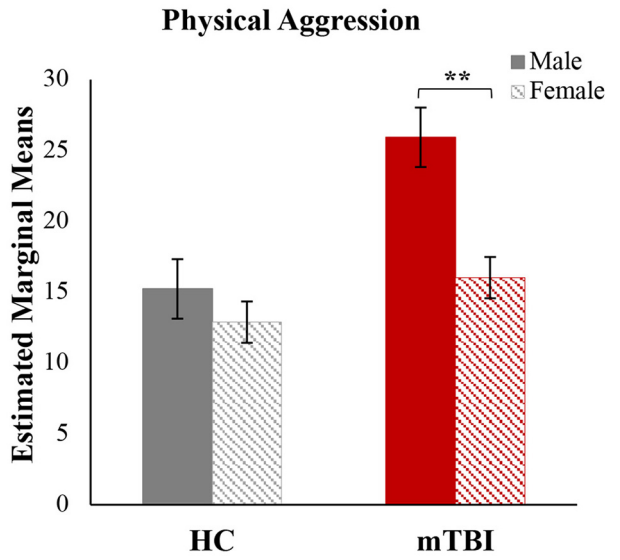

FIGURE 4 | Physical aggression by group and gender. A significant group by gender interaction was found for physical aggression. Estimated marginal means for the physical aggression subscale of the Buss-Perry Aggression Questionnaire, after adjusting for covariates (age and depression). HC, healthy controls; mTBI, mild traumatic brain injury. Error bars represent standard error of the mean. $^{**}p < 0.01$.

be associated with aggression. In support of our first hypothesis, we found significantly elevated levels of aggression in the mTBI group. Partial support was found for our second hypothesis, in that microstructure differed between the two groups, but only in the corpus callosum. We found significantly higher RD in the corpus callosum of adults with mTBI, which is indicative of reduced white matter integrity. Furthermore, a significant positive correlation was found between aggression and RD of the corpus callosum.

Numerous studies have reported increased aggression following traumatic brain injury (Kim et al., 1999; Bailie et al., 2015; Epstein et al., 2016; Roy et al., 2017), yet few have restricted participant samples to chronic mTBI to investigate the presence of persistent and potentially long-lasting symptoms associated with brain injury. Consistent with a recent study by Epstein et al. (2016), we found increased physical aggression, anger, and total aggression on the BPAQ following mTBI. Additionally, measures of aggressive attitude and total aggression on the PAI were elevated in those with mTBI. While not a focus of the present study, we found interesting gender differences following mTBI. In our sample, males with mTBI reported higher levels of physical aggression compared to females with mTBI. While some studies report no relationship between gender and aggression (Baguley et al., 2006; Johansson et al., 2008), our findings are consistent with a recent study focused exclusively on mild TBI. McGlade et al. (2015) investigated sex differences associated with functional connectivity following mTBI, and found that males exhibited increased physical aggression, which was associated with decreased left orbitofrontal functional connectivity. These findings may have important theoretical and clinical implications regarding the manifestation of aggression in the chronic recovery phase.

The BPAQ-anger and PAI-aggressive attitude subscales assess an individual's tendency to become easily frustrated or lose control of one's temper. High endorsement of these constructs by those with mTBI might be due to difficulties with the generation or subsequent understanding of affective responses (Lindquist et al., 2012; Smith et al., 2017). For example, it may be that individuals struggle to appropriately understand the causes and/or emotional meaning of felt somatovisceral changes during an affective response, which would be expected to hinder effective regulation of such responses. Thus, incomplete conceptualization of negative affect may manifest in initial frustration. On the other hand, increased levels of BPAQ-physical aggression suggest those with mTBI might struggle more with top-down control processes, which are important for appropriately adjusting behavioral responses within a particular context; if so, greater levels of dysregulated aggression would also be expected. In healthy adults, physical aggression is often higher in males than females (Archer, 2004; Cleverley et al., 2012). Although we did not observe this relationship exclusively in our healthy control group, we did find elevated physical aggression in males compared to females in those with mTBI. Based on our results, it may be that mTBI exacerbates a pre-existing gender difference, leaving males particularly prone to dysregulated emotional responses. Together, the current findings suggest persistent and variable manifestations of dysregulated aggression and frustration, perhaps related to impaired affect generation, conceptualization, and top-down control processes in chronic mTBI.

From this study, we provide preliminary findings regarding possible loci of pathology within neural networks that plausibly contribute to affective processing. Reduced integrity in the corpus callosum has previously been reported in mTBI (Lipton et al., 2008; Lo et al., 2009; Sugiyama et al., 2009). In line with these previous studies, we found increased RD in the corpus callosum in adults with chronic mTBI. The diffusivity pattern of increased RD is proposed to reflect a loss of structural integrity, resulting from myelination abnormalities and/or reduced axonal density (Beaulieu, 2002; Song et al., 2002; Concha et al., 2009). The lack of observed significant between-group differences for other diffusivity measures, particularly FA, is unclear. It is important to note that FA in the corpus callosum was reduced in the mTBI group compared to HCs. Although these findings did not survive correction for multiple comparisons, this was possibly the result of low power within our relatively small sample size. Overall, our findings provide preliminary evidence of persistent and/or dynamic loss of structural integrity within the corpus callosum in those who have experienced a mild TBI, and are in the chronic stage of recovery.

A major aim of our study was to evaluate the relationship between neuropsychological function and structural integrity of white matter pathways. The association between aggression and white matter integrity offers several potential implications regarding the underlying systems responsible for affective states. Cortical networks connected by the corpus callosum are known to play an integral role in the

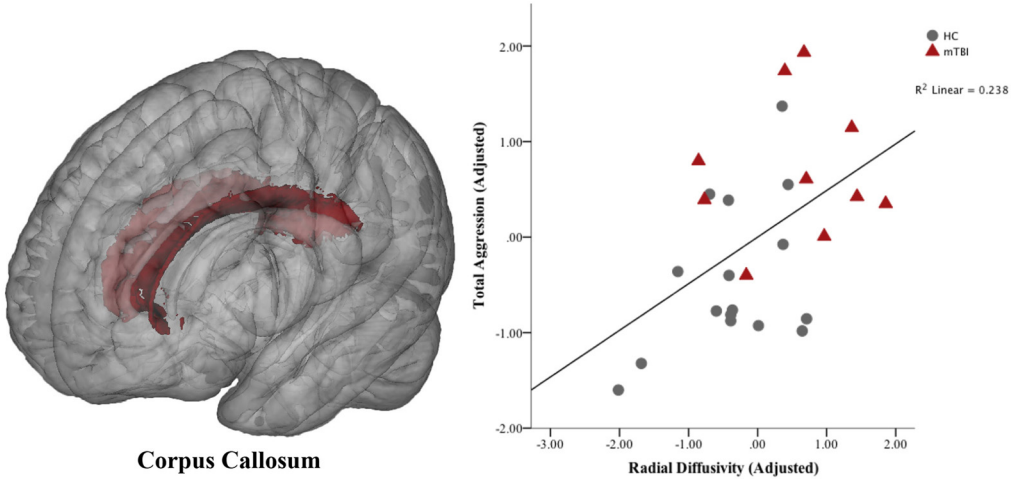

FIGURE 5 | Association between aggression and white matter in the corpus callosum. Voxels of the corpus callosum included in the analysis are shown in red overlaid on a standard brain. Means are the standardized residuals after adjusting for covariates (age, gender and depression). A significant partial correlation (controlling for age, gender and depression) was found between total aggression on the Buss-Perry Aggression Questionnaire and radial diffusivity (RD) in the corpus callosum ($p < 0.05$; FDR-corrected). HC, healthy controls; mTBI, mild traumatic brain injury.

generation, conceptualization/representation, and regulation of affective/emotional responses (Lindquist et al., 2012; Smith and Lane, 2015). For example, one interpretation could be that reduced white matter in the corpus callosum might disrupt one's ability to integrate exteroceptive and interoceptive percepts with conceptualization processes during an emotional episode, potentially contributing to situationally inappropriate aggressive responses and a poor conceptual understanding of those responses (i.e., low emotional awareness or alexithymia)—both of which would be expected to contribute to sustained dysregulation (Paul, 2004; Kubota et al., 2012). Considering previous findings implicating the corpus callosum (Kubota et al., 2012), as well as the interconnected cortical regions (Kalisch et al., 2006) in emotional awareness (or the related construct of alexithymia), our results suggest disruption in such cognitive-emotional processes might contribute to frustration or agitation in individuals with mTBI. This interpretation is also consistent with our *post hoc* analyses indicating reduced

TABLE 3 | Diffusion characteristics for the corpus callosum.

	Healthy Controls (n = 16)	Chronic mTBI (n = 10)	*F-statistic* df (1, 21)	*p*-value	*Partial* $\eta^{2‡}$
CC					
FA	0.80456 (0.01415)	0.79500 (0.01073)	4.32	0.05	0.17
MD	0.00072 (0.00002)	0.00074 (0.00002)	2.76	0.11	0.12
RD	0.00027 (0.00002)	0.00028 (0.00002)	7.71	0.01*	0.27
AD	0.00162 (0.00007)	0.00164 (0.00003)	0.16	0.69	0.01
CC Genu					
FA	0.80530 (0.02682)	0.79903 (0.01414)	0.13	0.72	0.01
MD	0.00071 (0.00002)	0.00072 (0.00003)	1.31	0.27	0.06
RD	0.00026 (0.00003)	0.00028 (0.00002)	0.53	0.48	0.02
AD	0.00159 (0.00008)	0.00162 (0.00007)	0.45	0.51	0.02
CC Body					
FA	0.78165 (0.01648)	0.77022 (0.02114)	3.60	0.07	0.15
MD	0.00074 (0.00003)	0.00076 (0.00002)	2.64	0.12	0.11
RD	0.00029 (0.00002)	0.00032 (0.00003)	5.68	0.03	0.21
AD	0.00163 (0.00007)	0.00165 (0.00003)	0.16	0.69	0.01
CC Splenium					
FA	0.83502 (0.01310)	0.82553 (0.01385)	4.94	0.04	0.19
MD	0.00070 (0.00003)	0.00071 (0.00002)	1.20	0.29	0.05
RD	0.00023 (0.00002)	0.00025 (0.00002)	4.95	0.04	0.19
AD	0.00164 (0.00008)	0.00164 (0.00003)	0.00	1.00	0.00

*Note: Mean (Standard Deviation) in mm²/s. Values extracted from overlapping voxels in the 4D skeletonized image and template mask, for each region of the corpus callosum. General linear models were calculated for each interhemispheric tract separately, controlling for age, gender and depression. df, degrees of freedom. ‡Small effect size: 0.01 ≤ η^2 < 0.05; medium effect size: 0.06 ≤ η^2 < 0.13; large effect size: η^2 ≥ 0.14. mTBI, mild traumatic brain injury; FA, fractional anisotropy; MD, mean diffusivity; RD, radial diffusivity; AD, axial diffusivity; CC, corpus callosum. Unadjusted p-values reported. *Significant at FDR-corrected p < 0.05.*

white matter integrity in the body and splenium of the corpus callosum, which have been associated with sensorimotor and perception/conceptualization processes, respectively (Paul, 2011).

An alternative interpretation of our findings could be that reduced white matter integrity in the corpus callosum results in decreased behavioral inhibition. Prior studies have documented increased aggression in patients with orbitofrontal damage (Coccaro et al., 2007; Epstein et al., 2016). Our findings indicate similar behavioral tendencies (increased aggression) associated with reduced structural integrity in the corpus callosum, which may disrupt interhemispheric signal transfer and impede cortically mediated inhibitory processes necessary for context-appropriate behavioral regulation. The different mechanistic interpretations we have proposed could also interact, such that difficulty integrating internal and external cues during conceptualization, combined with a lack of inhibitory control during the regulatory process, could result in the selection of inappropriate behaviors such as physical or verbal aggression. It should be mentioned, however, that disruptions within frontal (genu) subregions of the corpus callosum would be most consistent with deficits in inhibitory control; thus, the fact that alterations within posterior subregions of the corpus callosum appear to drive our findings, this is probably most consistent with deficits in recognizing and understanding one's own emotions. Regardless of the detailed mechanisms involved, our findings suggest that alterations in the corpus callosum may play an important role in promoting dysregulated affect, leading to the observed increases in aggressive tendencies.

Limitations and Future Directions

It is important to acknowledge methodological limitations of the current study. First, we assessed aggression at a single point in time (i.e., during the chronic stage of recovery). As such, we are unable to determine whether aggression manifests differently throughout various stages of recovery. For example, those in the acute phase might exhibit more outward aggression (i.e., physical or verbal aggression) as a result of reduced executive control, while those in the chronic phase might have relearned aspects of executive function, gaining more control over behavioral inhibition but continue to exhibit deficits with the context-appropriate generation or conceptualization of affective responses. While we are unable to answer this particular question about the role of different mechanistic contributions at different recovery stages, our current findings provide new insights into the manifestation of aggression in chronic mTBI.

We acknowledge the relatively small sample size of the present study. Although we implemented methodological approaches aimed at minimizing small sample effects (i.e., partial volume effects and targeted pathways), we may have lacked the statistical power necessary to detect group-differences in certain tracts. This is especially problematic for anatomical regions with a considerable number of crossing fibers (i.e., the uncinate fasciculus), as crossing fibers are another source of inherent noise in DTI studies (Jeurissen et al., 2013). Furthermore, the link between aggression and white matter integrity was calculated across all participants. As such, a disease-specific effect of brain structure on aggression cannot be inferred. Future studies with larger sample sizes are needed to confirm our preliminary findings and further examine the reliability of the reported relationship between aggression and fiber tracts in systems contributing to affective processing.

Limitations notwithstanding, the clinical implications of this study should not be overlooked. Aggressive behavior can have devastating impacts on the home environment, social and interpersonal functioning, and could result in the loss of employment or criminal violence. Therefore, therapeutic interventions aimed at ways to more effectively manage affective states may be particularly beneficial to individuals who experience persistent affective symptoms. Understanding the association between neural systems and behavior could potentially lead to interventions targeting the range of emotion-related processes that might be particularly affected by damage sustained from mTBI.

CONCLUSION

In conclusion, we found higher levels of aggression in adults with a chronic mTBI, when compared to HCs. Additionally, elevated aggression was associated with reduced white matter integrity in the corpus callosum, regardless of group. As this pathway is known to play an important role in multiple affective processes, our results suggest that alterations in this tract may play an important role in accounting for dysregulated aggression. This may be associated with the generation of situationally inappropriate affective responses and/or poor awareness/understanding of such responses (i.e., both linked to disrupted conceptualization processes). Alternatively, it could be directly associated with reduced top-down cognitive/behavioral regulatory processes. Future research should focus on disambiguating which of these processes, or what combination of them, best accounts for such mTBI symptoms. This may be especially important, given that our findings also highlight the potentially persistent nature of such post-concussive symptoms in mTBI.

AUTHOR CONTRIBUTIONS

ND assisted with MRI data acquisition, conducted MRI data processing, statistical analysis and drafted the initial manuscript. RS and SB assisted with data analysis and interpretations, and manuscript revisions. AA assisted with the statistical analysis and manuscript revisions. MG conducted participant recruitment, data acquisition, MRI preprocessing and assisted with manuscript revisions. AR assisted with data interpretation and manuscript revisions. BS assisted with manuscript revisions. WK designed the study, assisted with data interpretation and critique, as well as manuscript review and revisions.

FUNDING

This work was supported by the Office of the Assistant Secretary of Defense for Health Affairs and the Defense Health Agency J9, Research and Development Directorate, through the US

Army Medical Research and Materiel Command (USAMRMC) under Award No. (W81XWH-12-0386) to WK. Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the Department of Defense.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fnbeh.2018.00118/full#supplementary-material

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Resting-state functional connectivity as a biomarker of aggression in mild traumatic brain injury

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Mild traumatic brain injury (mTBI) can alter the structure of the brain and result in a range of symptoms, including elevated aggression. Neurological damage associated with mTBI is traditionally viewed as transient, yet a growing number of studies suggest long-lasting psychological and neurological changes following mTBI. However, research examining the neural basis of emotion processing in the chronic stage of mTBI recovery remains sparse. In the current study, we utilized resting state functional MRI to explore the association between default mode network connectivity and aggression in 17 healthy controls and 17 adults at least 6 months post-mTBI. The association between within-network connectivity and aggression was examined using general linear models, controlling for the effects of depression. Increased connectivity between the right hippocampus and midcingulate cortex was associated with elevated aggression in adults with mTBI, but not in healthy controls. The results provide evidence for a link between intrinsic functional network disruptions and the manifestation of postconcussive symptoms within chronic stages of recovery following mTBI. These findings expand upon the current research, providing evidence for the use of resting state functional connectivity as a potential biomarker of postconcussive aggression in chronic mTBI. *NeuroReport* **29:1413–1417** **Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.**

NeuroReport 2018, **29**:1413–1417

Keywords: aggression, default mode network, functional connectivity, mild traumatic brain injury, postconcussive symptoms, resting state functional magnetic resonance imaging

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Received 13 August 2018 **accepted** 21 August 2018

Introduction

Mild traumatic brain injury (mTBI) is exceedingly prevalent [1,2], yet the heterogeneous nature of mTBI, combined with a dynamic recovery process, presents challenges in accurate diagnosis and treatment. Neurological damage associated with mTBI is traditionally viewed as transient, followed by rapid symptom reduction in the days and weeks following injury [3]. Nonetheless, recent studies have documented a range of persistent symptoms in individuals at least 6 months after injury [4–6], alluding to potentially long-lasting psychological and neurological changes following mTBI. One persistent symptom is elevated aggressive tendencies, which is the focus of the present study.

Disruptions within the neural systems associated with aggression following mTBI, especially in the chronic stage of recovery, are not well understood. Specific large-scale networks are implicated in different aspects of emotion processing and can be explored through the use of resting state functional MRI (rs-fMRI). One particular network, the default mode network (DMN), consists of medial regions in prefrontal, parietal, and temporal cortices [7], and plays an important role in recognizing and understanding emotions [8–11]. Reduced understanding of one's own emotions promotes inefficient conceptualization [11], suggesting that DMN dysfunction could promote elevated aggression. Findings are mixed in terms of the influences of mTBI on DMN function, but, previous work suggests that functional connectivity in the DMN is disrupted in acute [12–14] and chronic stages [13,15,16] of mTBI, and that such disruption relates to impaired control of affective responses in mixed severity TBI [17].

Research examining the neural basis of recognizing/understanding emotion in the chronic stage of mTBI recovery remains sparse. The aim of the present study was to explore the association between DMN function and self-reported aggression in individuals at least 6 months post-mTBI. The metric of network function we chose to examine was within-network functional connectivity. On the basis of the critical role played by the DMN in understanding emotion, we hypothesized that connectivity within this network would be altered in individuals with mTBI, compared with healthy controls (HCs), and that connectivity within the DMN would be associated with differences in post-mTBI aggression.

Participants and methods

Participants

The present study included 17 individuals with mTBI and 17 HCs and is part of a larger, on-going study

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DOI: 10.1097/WNR.0000000000001127

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investigating neuropsychological function at various stages of mTBI recovery. Previous aggression findings from the larger study were previously published [6], yet this manuscript reports on novel connectivity findings. All participants were between 18 and 45 years of age, native English speakers, and right-handed. Exclusionary criteria included a history of psychiatric/neurological disease, alcohol/substance abuse, or contraindication for MRI. Individuals in the mTBI group presented at least 6 months after injury and provided brain injury documentation before study enrollment. Injury severity was based on the American Congress of Rehabilitation Medicine [18] and VA/DoD Guidelines [19], where mTBI was defined as a physiological disruption of brain function, a Glasgow Coma Scale between 13 and 15, temporary loss of consciousness less than 30 min, transient post-traumatic amnesia less than 24 h, and altered mental state that may be transient.

Participants underwent neuropsychological testing followed by rs-fMRI data acquisition. The Buss–Perry Aggression Questionnaire was used to measure aggression [20] and the Beck Depression Inventory [21] was used to measure depression. The study was approved by the Institutional Review Board at the University of Arizona and the US Army Human Research Protections Office, and participants provided prior written informed consent in accordance with the Declaration of Helsinki.

MRI data acquisition

Neuroimaging data were acquired on a 3.0-Tesla Siemens Skyra scanner (MAGNETOM Skyra; Siemens Healthcare, Malvern, Pennsylvania, USA) equipped with a 32-channel head coil. A high-resolution T1-weighted MPRAGE anatomical scan was collected first (repetition time = 2100 ms, echo time = 2.33 ms, field-of-view = 256 mm, matrix size = 256 × 256; flip angle = 12°, voxel size = 1 × 1 × 1 mm, 176 slices). During rs-fMRI, participants were instructed to relax and fixate on a cross in the middle of the screen. Functional scans were obtained using a T2*-weighted gradient-echo, echo-planar imaging sequence (repetition time = 2000 ms, echo time = 25 ms, field-of-view = 220 mm, flip angle = 90°, GRAPPA acceleration factor = 2). We collected 32 transverse slices (matrix = 88 × 84, voxel size = 2.5 × 2.5 × 2.5 mm, distance factor = 40%), allowing for 300 volumes.

Statistical analysis

The rs-fMRI data were preprocessed using Statistical Parametric Mapping (SPM12) running in Matlab (v. R2016a; Mathworks, Natick, Massachusetts, USA) and included motion correction with realignment, slice timing correction using the middle slice as the reference slice, coregistration of functional scans to anatomical scans, forward deformation normalization (isotropic voxel size = 3 × 3 × 3 mm), and smoothing using a Gaussian kernel (full-width at half maximum = 5 mm). Preprocessed structural and rs-fMRI data were loaded into the CONN Functional Connectivity Toolbox (v. 17.f; *http://www.nitrc.org/projects/conn/* [22]). Artifact Detection Toolbox (ART; SPM12) was used to identify outlier scans with a global mean signal threshold of 3 SD and movement threshold of 0.5 mm. Single-participant data were denoised using bandpass filters of 0.01–0.1 Hz. Three HCs and two mTBI participants were excluded from further analysis because of excessive head motion (i.e. <20% outlier scans), resulting in a final sample of 14 HCs and 15 with mTBI.

The dorsal DMN was comprised of nine functionally defined regions of interests (ROIs) on the basis of Shirer *et al.* [23] (*http://findlab.stanford.edu/functional_ROIs.html*). Network ROIs included the medial prefrontal cortex (mPFC), posterior cingulate cortex, midcingulate cortex (MCC), right superior frontal gyrus, left and right angular gyri, thalamus, and left and right hippocampi (lHPC, rHPC) (Table 1). A weighted general linear model was used to calculate functional connectivity measures for each participant. Weights for the model were defined as the block-convolved canonical hemodynamic response function and are appropriate for analyzing resting state data [22]. Time courses at each voxel in a ROI were averaged to generate a mean time course specific to that of ROI. Individual bivariate correlation maps (Fisher-transformed) were computed for resting state connectivity between each seed and target ROI time series within the DMN. A group-level approach was used to compare differences in DMN connectivity between the two groups and the association between within-network connectivity and aggression using general linear models, controlling for the effects of depression. Reported results were corrected for multiple comparisons ($P < 0.05$, seed-level false discovery rate correction).

Results

Neuropsychological data

Demographic information and neuropsychological results are presented in Table 2. Significant differences in depression and aggression were previously reported between mTBI and HC groups [6].

Table 1 Functionally defined regions of interest for the default mode network

ROI	Anatomical location	*x* (mm)	*y* (mm)	*z* (mm)	Voxels
1	Medial prefrontal cortex	−4	50	14	5257
2	Left angular gyrus	−48	−66	36	97
3	Superior frontal gyrus	18	40	48	137
4	Posterior cingulate cortex	0	−52	30	1555
5	Midcingulate cortex	2	−14	38	114
6	Right angular gyrus	48	−62	34	38
7	Thalamus	−2	−8	6	220
8	Left hippocampus	−24	−28	−12	393
9	Right hippocampus	26	−22	−16	142

Default mode network regions of interest from Shirer *et al.* [23].
x, *y*, *z*, coordinates correspond to Montreal Neurological Institute cluster centroid in millimeters (mm).
ROI, region of interest.

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Default mode network functional connectivity

Connectivity between ROIs comprising the DMN was calculated and compared between the two groups. No significant between-group differences in DMN connectivity were found in any of the ROI-to-ROI comparisons (Fig. 1).

Default mode network connectivity and aggression

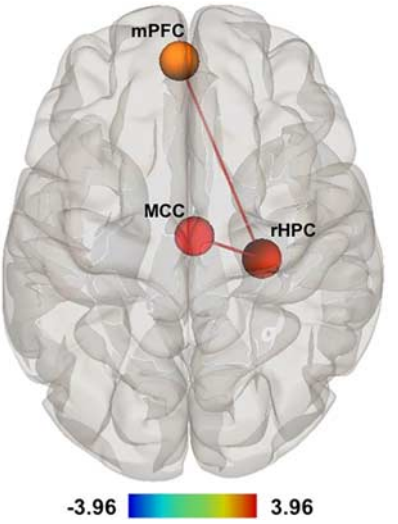
Despite the lack of differences in DMN connectivity between the two groups, we were interested in whether the association between connectivity and aggression differed between groups, given the significantly elevated levels of aggression in those with mTBI. A significant group × aggression interaction was found for functional connectivity [$F(6, 19) = 3.97$, $P = 0.01$]. The groups differed significantly in their association between aggression and ROI-to-ROI connectivity for the rHPC and MCC [$t(24) = 3.96$, $P_{corrected} = 0.01$] and the rHPC and mPFC [$t(24) = 2.89$, $P_{corrected} = 0.03$] (Fig. 2). In the mTBI group, elevated aggression was significantly correlated with increased rHPC–MCC connectivity ($r = 0.68$, $P = 0.01$), but not rHPC–mPFC connectivity ($r = 0.32$, $P = 0.27$). By contrast, in the HC group, aggression was negatively correlated with rHPC–MCC connectivity ($r = -0.58$, $P = 0.04$) and rHPC–mPFC connectivity ($r = -0.63$, $P = 0.02$) (Fig. 3).

Table 2 Demographic and neuropsychological measures by group

	HC	mTBI	*P* value[a]
Age [mean (SD)] (years)	23.88 (3.26)	21.86 (2.79)	0.08
Female/male	10/4	11/4	1.00[b]
BDI [mean (SD)]	1.29 (1.49)	8.47 (7.46)	0.002
BPAQ total [mean (SD)]	44.86 (9.68)	58.33 (10.61)	0.001
TSI (days) [mean (SD)]	NA	290.40 (91.87)	NA
Injury mechanism (%)			
Sport-related	NA	53.3	NA
MVA	NA	20.0	NA
Fall	NA	6.7	NA
Cycling	NA	13.3	NA
Other	NA	6.7	NA

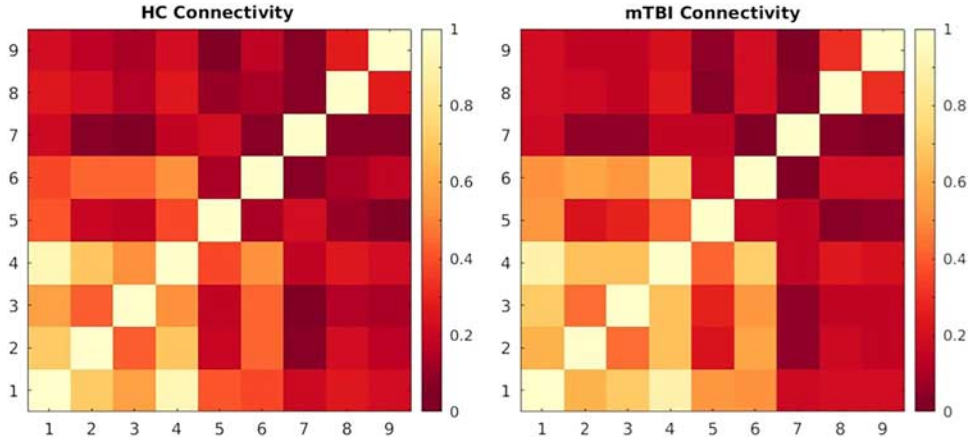
BDI, Beck Depression Inventory; BPAQ total, total aggression on the Buss–Perry Aggression Questionnaire; HC, healthy controls; mTBI, mild traumatic brain injury; MVA, motor vehicle accident; NA, not applicable; TSI, time since injury.
[a]Two-tailed independent-samples *t*-test.
[b]Pearson's χ^2-test.

Fig. 2



Significant between-group differences of ROI-to-ROI connectivity associated with aggression in the default mode network. Color bar indicates *t* scores for mTBI > HC contrast, adjusted for depression ($P < 0.05$, seed-level FDR correction). HC, healthy control; FDR, false discovery rate; MCC, midcingulate cortex; mPFC, medial prefrontal cortex; mTBI, mild traumatic brain injury; rHPC, right hippocampus; ROI, region of interest.

Fig. 1



Matrices showing within-network functional connectivity (mean correlation, *r*) between seed and target regions of the default mode network (DMN) for healthy control (HC) and mild traumatic brain injury (mTBI) groups. Color bars indicate *r* values. 1, medial prefrontal cortex; 2, left angular gyrus; 3, superior frontal gyrus; 4, posterior cingulate gyrus; 5, midcingulate cortex; 6, right angular gyrus; 7, thalamus; 8, left hippocampus; 9, right hippocampus.

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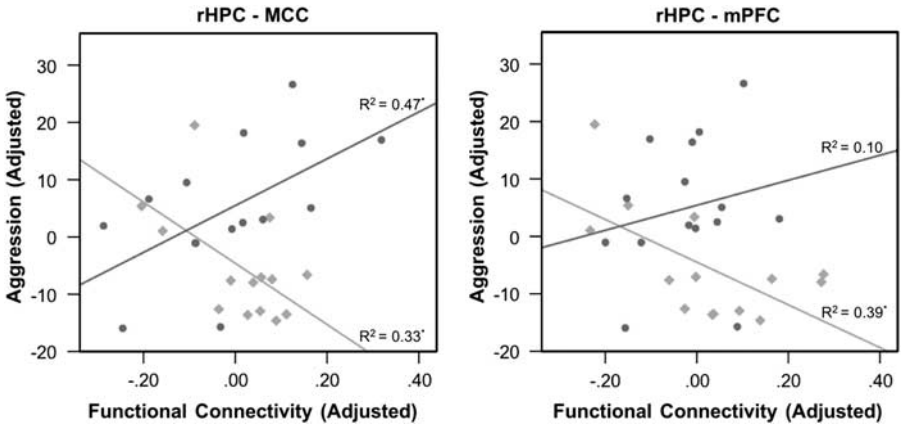
Fig. 3



Scatterplots show individual mean Fisher-transformed values for right hippocampal–midcingulate cortex connectivity (rHPC–MCC) and right hippocampal–medial prefrontal cortex connectivity (rHPC–mPFC) in relation to demeaned aggression scores, adjusted for depression. Mild traumatic brain injury group = circle; healthy controls = diamond, $*P < 0.05$.

Discussion

The present study utilized resting state fMRI to examine connectivity within the DMN in relation to long-term postconcussive aggression following mTBI. We found that those recovering from mTBI reported significantly greater aggression than the matched HC group. Moreover, while there were no group differences in overall DMN functional connectivity, increased connectivity between the rHPC and MCC was associated with higher levels of aggression in individuals with mTBI but not in healthy controls. These findings suggest that mTBI-related elevations in aggressive behavior may be associated with altered connectivity within the DMN.

Our results extend previous findings examining behavioral correlates of DMN connectivity following mTBI. In a study by van der Horn *et al.* [15], increased connectivity between posterior cingulate and precuneus regions and medial prefrontal and inferior parietal regions of the DMN positively correlated with persistent cognitive and/or affective complaints at 3 months post-mTBI. In addition to disruptions in connectivity, poor outcomes for individuals with mTBI during the first-year after injury have been associated with morphological alterations of the prefrontal cortex [24]. Our findings of elevated aggression and increased connectivity among regions of the DMN are consistent with the aforementioned studies, and suggest a potential neural mechanism underlying persistent post-mTBI symptomology.

The DMN contributes to recognizing and understanding one's own emotions [8–11], among many other domain-general conceptualization processes [25]. Furthermore, the hippocampus plays an important role in integrating past and present experiences through episodic memory, which is an essential part of the conceptualization process [7]. Differences in emotional awareness have previously been linked to DMN connectivity, and higher emotional awareness has in turn been linked to efficiency of emotion conceptualization [11]. This suggests that altered DMN function could promote aggression through reduced emotional awareness. However, it is important to note that we found increased DMN connectivity with higher aggression. In fact, the relationship we observed within the mTBI group more closely resembles the greater DMN engagement that has been previously associated with depressive rumination [25,26]. Yet, the present findings cannot adequately be explained by post-mTBI depression, as we controlled for depressive symptoms. Thus, another interpretation could be that mTBI promotes greater aggression by increasing the tendency to maladaptively ruminate over negative life events.

Limitations and conclusion

Our study has some limitations that warrant further discussion. First, the sample size of our study was relatively small, which could account for the unexpected absence of group difference in DMN connectivity because of reduced statistical power. Alternatively, these results may be attributable to partial recovery of functional connectivity, as observed in a recent longitudinal study [13]. Second, the analytic approach used a seed-level correction for false discovery rate of post-hoc comparisons. Therefore, type I error cannot be ruled out and ROI-to-ROI findings linking DMN connectivity and aggression should be interpreted with caution. Limitations notwithstanding, our findings align with previous reports of observed associations between DMN connectivity and disrupted emotion processing in mTBI [15].

In summary, higher self-reported aggression in individuals at least 6 months post-mTBI was associated with increased functional connectivity between the right

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hippocampus and midcingulate cortex. Our results expand current evidence suggesting a link between intrinsic functional network disruptions and the manifestation of postconcussive symptoms within chronic stages of mTBI recovery.

Acknowledgements

This work was supported by the Office of the Assistant Secretary of Defense for Health Affairs and the Defense Health Agency J9, Research and Development Directorate, through the US Army Medical Research and Materiel Command (USAMRMC) under Award No. W81XWH-12-0386, to W.D.S. Killgore. Opinions, interpretations, conclusions, and recommendations are those of the authors and are not necessarily endorsed by the Department of Defense.

Conflicts of interest

There are no conflicts of interest.

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frontiers in Neurology

ORIGINAL RESEARCH
published: 20 June 2018
doi: 10.3389/fneur.2018.00468

Diffusion Tensor Imaging (DTI) Correlates of Self-Reported Sleep Quality and Depression Following Mild Traumatic Brain Injury

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OPEN ACCESS

Edited by:
Denes V. Agoston, Karolinska Institutet (KI), Sweden

Reviewed by:
Ramon Diaz-Arrastia, University of Pennsylvania, United States
Ralph George Depalma, US Department of Veterans Affairs, United States

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Specialty section:
This article was submitted to Neurotrauma, a section of the journal Frontiers in Neurology

Received: *20 December 2017*
Accepted: *31 May 2018*
Published: *20 June 2018*

Citation:
Raikes AC, Bajaj S, Dailey NS, Smith RS, Alkozei A, Satterfield BC and Killgore WDS (2018) Diffusion Tensor Imaging (DTI) Correlates of Self-Reported Sleep Quality and Depression Following Mild Traumatic Brain Injury. Front. Neurol. 9:468. doi: 10.3389/fneur.2018.00468

Background: Mild traumatic brain injuries (mTBIs) are a significant social, sport, and military health issue. In spite of advances in the clinical management of these injuries, the underlying pathophysiology is not well-understood. There is a critical need to advance objective biomarkers, allowing the identification and tracking of the long-term evolution of changes resulting from mTBI. Diffusion-weighted imaging (DWI) allows for the assessment of white-matter properties in the brain and shows promise as a suitable biomarker of mTBI pathophysiology.

Methods: 34 individuals within a year of an mTBI (age: 24.4 ± 7.4) and 18 individuals with no history of mTBI (age: 23.2 ± 3.4) participated in this study. Participants completed self-report measures related to functional outcomes, psychological health, post-injury symptoms, and sleep, and underwent a neuroimaging session that included DWI. Whole-brain white matter was skeletonized using tract-based spatial statistics (TBSS) and compared between groups as well as correlated within-group with the self-report measures.

Results: There were no statistically significant anatomical differences between the two groups. After controlling for time since injury, fractional anisotropy (FA) demonstrated a negative correlation with sleep quality scores (higher FA was associated with better sleep quality) and increasing depressive symptoms in the mTBI participants. Conversely, mean (MD) and radial diffusivity (RD) demonstrated positive correlations with sleep quality scores (higher RD was associated with worse sleep quality) and increasing depressive symptoms. These correlations were observed bilaterally in the internal capsule (anterior and posterior limbs), corona radiata (anterior and superior), fornix, and superior fronto-occipital fasciculi.

Conclusion: The results of this study indicate that the clinical presentation of mTBI, particularly with respect to depression and sleep, is associated with reduced white-matter integrity in multiple areas of the brain, even after controlling for time since

injury. These areas are generally associated not only with sleep and emotion regulation but also cognition. Consequently, the onset of depression and sleep dysfunction as well as cognitive impairments following mTBI may be closely related to each other and to white-matter integrity throughout the brain.

Keywords: white matter integrity, Pittsburgh sleep quality index, beck depression inventory, fractional anisotropy, radial diffusivity, internal capsule, superior fronto-occipital fasciculus, corona radiata

INTRODUCTION

Concussions and mild traumatic brain injuries (mTBI) represent a significant public and military health crisis. 1.6 to 3.8 million sport-related concussions (SRCs) are reported annually (1, 2), and more than 300,000 mTBIs (hereafter referring to both mTBIs and SRCs) have been documented in military personnel since the year 2000 (3). The actual incidence of these injuries is likely much higher, as estimates reflect only those for which treatment is sought (4). Treatment costs for mTBIs top $22 billion annually in the United States (5). Individuals sustaining an mTBI may exhibit any number of clinical features, including changes in cognitive and motor function as well as post-injury depression, somatic symptoms, and sleep-wake cycle disruption (6). However, these clinical signs and symptoms are not generally associated with visible structural abnormalities when using traditional diagnostic/clinical neuroimaging techniques (e.g., structural magnetic resonance imaging (MRI) or computed tomography (CT) in the emergency department). Furthermore, although many of the clinical signs and symptoms resolve within the first month post-injury (6), many individuals continue to experience symptoms well beyond this clinical timeframe.

Among those persistent symptoms, sleep disruption and depression are among the most common. Estimates of the prevalence of sleep disruption following mTBI ranges from 30 to 80% (7–9), with complaints of insomnia, hypersomnia, and pleiosomnia all reported (8, 10–12). Individuals with prior mTBI also often report and exhibit depressive symptoms, with an estimated 6% per year being clinically diagnosed with depression (13) and many more exhibiting depressive symptoms (14). Notably, depression may additionally cause altered sleep patterns (15). Collectively, both sleep disruption and depression can impair cognitive and physical function (16–20) and may therefore exacerbate the symptoms of and delay the recovery from an mTBI. However, to date, there are have a limited number of studies that have identified the neural correlates of both sleep disruption (21) or depression (22, 23) following mTBI. Consequently, it is needful to identify objective biomarkers of both the pathophysiology and post-injury recovery that underpin the evolution of post-mTBI sleep disruption and depression.

One imaging methodology that is particularly sensitive to altered brain structure is diffusion tensor imaging (DTI). In DTI, water molecule diffusion properties in the brain are quantified, principally by fractional anisotropy (FA) and mean diffusivity (MD). FA quantifies molecular diffusion along three dimensions (FA = 0: diffusion is equally likely in any direction; FA = 1: diffusion occurs along one direction), while MD quantifies the average three-dimensional diffusion rate. Additionally, radial diffusivity (RD) and axial diffusivity (AD) reflect the rates of diffusion perpendicular and parallel to the underlying tissue, respectively. These diffusion metrics, and most prevalently FA, are thought to provide an index of white matter integrity. Mouse models of neural trauma have demonstrated decreased AD concomitant with axonal damage (24, 25) and negative correlations between RD and myelination [e.g., higher RD is associated with reduced myelination; (25, 26)]. MD, the average of AD and RD, is non-specific with respect to the direction of diffusion. Increases in MD and coincident decreases in FA are often associated with neural trauma and neurodegeneration (27, 28), including mTBI (29–31).

Mild traumatic brain injuries may reflect a model of diffuse axonal injury (DAI), characterized by damage to, and subsequently the loss of, axons, myelin, or both (32–34). Demyelination has been observed in animal models of mTBI (35) and may be secondary to axonal loss or loss of oligodendrocytes supplying undamaged axons (36–39). Regardless of mechanism, white matter integrity may be compromised following mTBI. Therefore, DTI metrics may provide a suitable biomarker of both microstructural changes following mTBI as well as clinical presentation.

With respect to mTBI, numerous publications have featured DTI-related findings in civilian, military, and sport populations, spanning timeframes from acute to remote (years) post-injury (40–42). Despite the density of publications, there is little consistency in the findings with respect to directional changes in DTI metrics. While some studies, for instance, report lower FA following mTBI (43–47), this is not always the case (48–51). Such inconsistent patterns are also present with respect to MD, AD, and RD (43, 46, 48, 52). Given the heterogeneous nature of mechanistic/neural changes in mTBI and generally small study sample sizes, such inconsistency is not unexpected and necessitates additional exploration.

Despite the inconsistency in directional findings for DTI diffusion metrics following mTBI, several affected white matter pathways do exhibit some consistency. Changes or differences in FA and MD in the corpus callosum, anterior and posterior corona radiata, anterior and posterior thalamic radiations, superior and inferior longitudinal fasciculi, corticospinal tracts, and internal capsule, are commonly reported (40, 41, 53). Such consistency of reporting suggests that these white matter tracts may be particularly susceptible to the multiple mechanisms (focal injuries, shearing) that may result in an mTBI (40, 41, 53).

Importantly, prior work related to major depressive disorder (54) and insomnia (55, 56), as well as sleep quality (57) and variability (58) in generally healthy populations, has consistently demonstrated correlations with FA, such that more negative outcomes (e.g., greater depressive symptoms, lower sleep quality, and increased variability) are associated with lower FA in these same tracts. Given the overlapping tracts identified on DTI following mTBI and those related to sleep quality and depression from other populations, it is likely that these tracts play an important role in post-mTBI symptom presentation. However, to date, there are no DTI-related findings specific to mTBI and sleep quality or depression.

The purpose of this study was to use DTI to correlate diffusion metrics with self-report indices of sleep quality and depression in individuals with a recent mTBI. This study is part of a larger, on-going project aimed at identifying structural and neural correlates of self-report, neurocognitive, and behavioral outcomes following mTBI. Here, we compared DTI metrics between individuals within a year of an mTBI and individuals with no self-reported history of mTBI. Additionally, we computed within-group correlations between diffusion metrics and self-report outcomes in the National Institute of Neurological Disorders and Stroke (NINDS) Common Data Elements (CDEs; http://www.commondataelements.ninds.nih.gov/) psychiatric and psychological status [e.g., depression; (59)] domain and self-reported sleep quality (60). We hypothesized, consistent with the view that mTBI reflects aspects of DAI (32–34), that FA would be lower, and MD, AD, and RD higher in the mTBI group than in the healthy controls. Further we hypothesized that this pattern would extend to symptom presentation, with greater post-mTBI depressive symptoms, and lower sleep quality associated with lower FA and greater MD, AD, and RD.

MATERIALS AND METHODS

Participants

A total of 52 individuals ($n = 34$ with a history of a recent (within 12 months) mTBI; $n = 18$ healthy control individuals with no documented history of head trauma) participated in the present study. Participants were recruited from the Tucson metropolitan area via multiple methods including Internet advertisements, posted flyers, and referral through local emergency departments. The presence of mTBI was defined in agreement with the American Congress of Rehabilitation Medicine guidelines including (1) alteration of mental status related to specific head trauma lasting up to 24 h; (2) loss of consciousness <30 min; (3) post-traumatic amnesia lasting <1 day; and (4) initial Glasgow Coma Scale between 13 and 15 (61). To be eligible, participants were required to provide written documentation from a medical provider or other professional who either witnessed the injury or provided immediate treatment or care as a result of the injury.

All participants were right-handed and reported English as their first language. Individuals were not eligible to participate in this study in the presence of (1) any contraindications for MRI, (2) education <9th grade, (3) history of alcoholism or substance abuse, (4) colorblindness, or (5) lifetime history of DSM-IV Axis I disorder. Healthy control participants were additionally ineligible with any lifetime history of TBI or sport participation in concussion high-risk sports (e.g., football, rugby, boxing, ice hockey, wrestling, soccer, or martial arts) for longer than 1 month. All participants were compensated for their time. All study procedures were approved by The University of Arizona Institutional Review Board and the US Army Human Research Protections Office. All participants provided written informed consent prior to participation. Participant demographics are further summarized in **Table 1.**

Materials and Procedure

As part of a larger, on-going study, individuals in the current sample were evaluated at one of six pre-specified time points relative to their injury date: 2-weeks, 4-weeks, 3-months, 6-months, or 12-months post-injury (see **Table 1**). The purpose of the larger study is to examine structural and neural correlates of neuropsychological, behavioral, and self-reported outcomes over the first year following an mTBI. Individuals are included at only one of six time points and treated as exemplars of recovery at that time. We report here on a subset of the outcomes.

All participants underwent a comprehensive neuropsychological evaluation, including several self-report measures (described below), followed by a neuroimaging session that included diffusion-weighted imaging (DWI). Only a subset of the outcome measures are presented here. In addition to indices of depressive symptoms and sleep quality, we included NINDS CDEs related to global outcomes, post-mTBI symptom presentation, and perceived health-related quality of life, all of which may be impacted by depression and/or lower sleep quality.

Self-Report Outcomes

Glasgow Outcome Scale - Extended (GOS-E)

The GOS-E is a structured interview commonly used to assess overall disability and recovery following TBI (62). It is a core element of the NINDS CDEs for all levels of severity of TBI, including sport-related concussion. Scores on subscales for the GOS-E quantify disability in cognition, independence, employability, and social or community participation. These subscales are cumulatively reported as a single overall outcome, ranging from 1 (death) to 8 (upper good recovery). Reliability for the GOS-E is high [$\kappa = 0.85$; (62)].

Beck Depression Inventory-II (BDI-II)

The BDI-II is a self-administered survey requiring self-appraisal of mood over the preceding 2 weeks (63, 64). Increasing scores on the BDI-II are associated with increasing levels of depression symptoms. The BDI-II has high test-retest reliability ($r > 0.9$), as well as construct (vs. the original BDI) and moderate concurrent (vs. the State-Trait Anxiety Inventory Anxiety and Depression factors) validity ($r > 0.68$; (65, 66)). Previous work has demonstrated that individuals with both recent mTBIs and a history of mTBI report higher levels of depression and increased likelihood for depression by comparison to individuals without mTBI (22, 67–71).

TABLE 1 | Participant demographics and self-report measures.

	Healthy Control Mean (*SD*)	mTBI Mean (*SD*)	Statistic[a]	*p*	Effect Size[b]
n	18	34			
DEMOGRAPHICS					
Age (years)	23.2 (3.4)	24.4 (7.4)	−0.795	0.430	−0.232
Height (in)	67.2 (4.3)	66.4 (4.2)	0.649	0.520	0.189
Weight (lb)	158.4 (41.5)	151.8 (38.1)	0.565	0.576	0.165
Total mTBIs[c]	0 [0]	2 [1]	−12.6	< 0.001	−3.673
Sex (n)			0.272[d]	0.602	0.144
Male	9	13			
Female	9	21			
Race/Ethnicity (n)			4.063[d]	0.540	0.577
Asian/Pacific Islander	2	3			
Black/African American	0	2			
Hispanic/Latino	1	0			
Native American/ American Indian	2	2			
Other	0	1			
White	12	25			
Weeks Post-Injury (n)					
2 weeks		6 (17.6%)			
4 weeks		8 (23.5%)			
12 weeks		7 (20.6%)			
24 weeks		6 (14.7%)			
52 weeks		9 (23.5%)			
Mechanism of Injury (n)					
Sports-related		13 (38.2%)			
Slip and/or fall		7 (20.6%)			
MVA		6 (17.6%)			
Bike related		4 (11.8%)			
Environmental[e]		3 (8.8%)			
Assault		1 (2.9%)			
SELF-REPORT MEASURES					
PSQI Total Score	3.7 (1.8)	6.8 (3.5)	−4.227	< 0.001	−1.232
BDI–II Total Score	2.4 (2.9)	9.6 (8.1)	−4.636	< 0.001	−1.351
RPQ-3	0.2 (0.6)	2.4 (2.5)	−4.771	< 0.001	−1.391
RPQ-13	0.3 (1.0)	10.7 (10.6)	−5.616	< 0.001	−1.637
SWLS Total Score	26.6 (6.0)	26.2 (4.9)	0.230	0.819	0.067
GOS-E Outcome[f] (n)					
Upper Good Recovery		10			
Lower Good Recovery		13			
Upper Moderate Disability		10			
Upper Severe Disability		1			

[a] *Tests are two-tailed t-tests unless otherwise indicated.*
[b] *Cohen's d effect sizes.*
[c] *Data presented as median [interquartile range].*
[d] χ^2 *test.*
[e] *Mechanism of injury is for the most recent mTBI. Environmental accidents include falls from ladders or unanticipated contact with environmental features (ground, structures) unrelated to sports or falls.*
[f] *No GOS-E data were collected on the healthy control participants.*
mTBI, mild traumatic brain injury; MVA, motor vehicle accident; PSQI, Pittsburgh Sleep Quality Index; BDI-II, Beck Depression Inventory – 2; RPQ, Rivermead Post-concussion Symptom Questionnaire; SWLS, Satisfaction with Life Survey; GOS-E, Glasgow Outcome Scale-Extended.

Pittsburgh Sleep Quality Index (PSQI)

The PSQI is an 18-item self-report questionnaire yielding information about overall sleep quality, latency, duration, efficiency, disturbances, medication use, and the effects on daytime function (60). Better sleep quality is associated with lower scores, with scores of >5 indicating poor sleep and >8 indicating insomnia. Prior work has indicated good test-retest reliability ($r > 0.80$; (60)) and sensitivity to sleep disruption following mTBI (72, 73).

Satisfaction With Life Survey (SWLS)

The SWLS is a self-administered survey in which individuals assess current life satisfaction based on five questions. Questions are scored "Strongly Disagree" (1) to "Strongly Agree" (7) and summed with a maximum value of 35 (74). Higher scores indicate greater life satisfaction. The SWLS has demonstrated test-retest reliability [$r > 0.80$; (75)]. It is a basic element of the NINDS CDEs for concussion and mTBI (59). Previous research has indicated that individuals with prior mTBIs report greater life dissatisfaction (76, 77).

Rivermead Post-Concussion Symptom Questionnaire (RPCSQ)

The RPCSQ is a common post-mTBI assessment of symptom presentation and is a basic element of the NINDS CDEs for concussion and mTBI (59). Participants self-report the extent to which 16 symptoms currently affect them compared to preinjury-levels. Ratings range from "Not experienced at all" (0) and "No more of a problem" (1) to "A severe problem (4) (78). Previous analyses of the RPCSQ have identified a two-factor structure, such that the first three questions (RPQ3) are sensitive to acute injury symptoms while the final 13 (RPQ13) are sensitive to chronic symptoms. These two scales have good test-retest reliability ($r > 0.70$) and external validity [$\rho > 0.60$; (79)], and the RPQ is a significant predictor of 3-month outcomes (80).

Diffusion-Weighted Imaging

We acquired DWI data using single-shot echo planar imaging (EPI) (TE = 88 ms; TR = 9600 ms; acquisition matrix = 128 × 128; FOV: 256 × 256; slice thickness = 2 mm with no gap) on a Siemens Skyra 3.0 Tesla MRI machine (32-channel head coil; MAGNETO Skyra Siemens Healthcare). Images were acquired following a within-lab standardized process, including cross checks on image acquisition parameters at the time of scanning, with a single MRI technician overseeing all scanning procedures. Diffusion gradients were applied along 72 directions, with b = 1000 s/mm^2 and six non-diffusion weighted images (b_0). Preprocessing followed the standard pipeline available through FMRIB Software Library's [FSL; (81)], including EPI distortion correction using *TOPUP* (82), motion and eddy current distortion correction using *eddy* (83), skull-stripping with the brain extraction tool [*BET*; (84)], and diffusion tensor model fitting using *DTIFIT* (85). Output from *DTIFIT* includes separate images for FA, MD and three eigenvalues (λ_1, λ_2, λ_3). λ_1 is the axial diffusivity and radial diffusivity is the average of λ_2 and λ_3.

The four DTI-metric images (FA, MD, AD, and RD) were then nonlinearly registered to a standard template (FMRIB-58) followed by affine-alignment to standard space (MNI, 1 × 1 × 1 mm) using Tract-Based Spatial Statistics [TBSS; (86)]. A study-specific, averaged whole-brain skeletonized FA mask was created through TBSS (threshold = 0.2). Skeletonizing in this way reduces the number of voxels considered in statistical modeling by only including voxels near the center of white matter tracts.

Whole-brain voxel-wise statistical analysis was conducted via FSL's *randomise* using threshold-free cluster enhancement (87) with 5000 permutations. Significant voxels were identified as those with $p < 0.05$ after family-wise error rate (FWER) adjustment for multiple comparison. We tested between-group differences using a two-sample *T*-test for each of the DTI metrics (FA, MD, AD, RD), controlling for age, sex, and days post-injury. For the self-report measures, we fit within-group GLMs for each combination of measure and metric, controlling for age, sex, and days since injury (mTBI only). Within-group correlations for the relationships between DTI metrics and self-report outcome measures were examined.

A mask of all significant voxels was created for each of the DTI metrics. These masks were then used to compute the mean DTI-metric value for each participant, which was then extracted for *post-hoc* analyses. Mean DTI-metric values and self-report measures were scatter-plotted and the partial correlation coefficient, after controlling for age, sex, and days post-injury, was computed. Significant white matter voxels were anatomically identified using the Johns Hopkins University (JHU) ICBM-DTI-81 White-Matter Labels atlas (88).

Statistical Analyses

Between-group comparisons for continuous demographic characteristics and self-report measures were analyzed using a two-tailed *T*-test in R [v. 3.4.2; (89)]. The between-group gender and ethnicity comparisons were computed using a Chi-square test. Average values over all significant voxels were plotted in R as scatterplots with the relevant self-report outcomes using ggplot2 (90). For the healthy control participants, taking an inverse transformation of the BDI scores [$y = \frac{1}{(x+1)}$)] and a square transformation ($y = x^2$) of the SWLS scores was necessary to reduce skewness. No GOS-E data were collected for the healthy control participants, as this measure is specific to brain injury.

RESULTS

Demographic and Self-Report Measures

Demographic characteristics and self-report outcomes are summarized in **Table 1**. No participants were active duty military; however, we did not query for Veteran status. The groups did not differ in age, height, weight, or gender. Brain injured participants reported a median number of mTBIs, including the one used for referral, of 2 (range: 1–4). Most individuals ($n = 13$) reported a sports-related mechanism of injury for the referring mTBI. The mTBI participants reported significantly more post-concussive symptoms, poorer sleep quality, and greater

depressive symptoms than the healthy control participants. The majority of the mTBI participants ($n = 23$, 68%) reported a good recovery as assessed via the GOS-E.

Given the dynamic nature of post-mTBI recovery and the role that time since injury may play, we additionally report the means and standard deviations for the self-reported outcomes for each of the six distinct time points in **Table 2.** Given the small sample sizes across all of the post-mTBI groups, we do not report any between-group statistical comparisons at this time.

Diffusion Metrics

Whole-Brain Group Differences

After correcting for multiple comparisons, there were no statistically significant differences observed between the healthy control participants and those with a history of mTBI for any of the diffusion metrics at the whole brain level (*a priori* $\alpha = 0.05$). However, there were voxels with a trend toward greater radial diffusivity in the mTBI participants than the healthy control participants (FWER $0.064 \leq p \leq 0.094$; **Supplementary Figures 1**, **5**, top row).

Correlation Between Diffusion Metrics and Self-Report Measures

There were no significant correlations within the healthy control group between any of the DTI metrics and any of the self-report outcomes. However, a positive trend association between AD and SWLS scores was observed ($0.068 \leq$ *corrected* $p \leq 0.099$, **Supplementary Figures 2**, **5,** second row). We found voxels with significant correlations in the mTBI participant group for the BDI-FA (*corrected* $p < 0.05$, **Figures 1**, **6A**), BDI-MD (*corrected* $p < 0.05$, **Figures 2**, **6B**), BDI-RD (*corrected* $p < 0.05$, **Figures 3**, **6C**), PSQI-FA (*corrected* $p < 0.05$, **Figures 4**, **6D**) and PSQI-RD (*corrected* $p < 0.05$, **Figures 5**, **6E**) relationships. Finally, trend associations were observed for RPQ3-AD ($0.093 \leq$ *corrected* $p \leq 0.1$, **Supplementary Figures 3**, **5**, third row) and PSQI-MD ($0.079 \leq$ *corrected* $p \leq 0.1$, **Supplementary Figures 4**, **5**, bottom row). No statistically significant correlations were present in the mTBI group between any diffusion metric and the GOS-E, RPQ13, or SWLS scores.

Anatomical locations of significant correlations were automatically determined using FSL's *atlasquery* function and the JHU ICBM-DTI-81 White-Matter Labels atlas (88). These

TABLE 2 | Participant demographics and self-report measures by weeks post-Mtbi.

n	Uninjured *n* = 18	2 weeks *n* = 6	4 weeks *n* = 8	3 months *n* = 7	6 months *n* = 5	1 year *n* = 8
DEMOGRAPHICS						
Age (years)	23.2 (3.4)	25.1 (10.1)	25.3 (6.7)	26.6 (9.3)	24.9 (8.6)	20.9 (1.4)
Height (in)	67.2 (4.3)	69.3 (6.1)	66.9 (3.5)	65.3 (3.9)	65.2 (2.6)	65.5 (4.3)
Weight (lb)	158.4 (41.5)	169.7 (43.9)	158.9 (36.5)	139.3 (34.6)	157.0 (49.2)	139.0 (32.1)
Total mTBIs[a]	0.0 [0.0]	2.0 [0.8]	2.0 [1.0]	2.0 [2.0]	2.0 [2.0]	2.0 [1.0]
Sex (*n*)						
Male	9 (50%)	4 (66.7%)	4 (50%)	2 (28.6%)	1 (20%)	2 (25%)
Race/Ethnicity (n)						
Asian/Pacific Islander	2	0	0	1	0	2
Black/African American	0	2	0	0	0	0
Hispanic/Latino	1	0	0	0	0	0
Native American/ American Indian	2	0	1	0	1	0
Other	0	0	1	0	0	0
White	12	4	5	6	4	6
SELF-REPORT MEASURES						
PSQI Total Score	3.7 (1.8)	6.7 (4.5)	7.0 (1.4)	6.0 (2.8)	7.2 (3.8)	7.1 (5.0)
BDI-II Total Score	2.1 (2.6)	9.3 (7.2)	9.8 (6.5)	12.6 (10.3)	9.2 (9.8)	5.1 (4.4)
RPQ-3	0.2 (0.6)	2.7 (3.7)	3.8 (2.3)	2.0 (2.3)	1.4 (1.9)	1.9 (2.2)
RPQ-13	0.3 (1.0)	11.7 (9.3)	12.4 (10.0)	9.0 (11.0)	13.2 (16.4)	8.1 (9.8)
SWLS Total Score	26.6 (6.0)	28.2 (2.8)	24.1 (6.2)	25.0 (6.5)	25.6 (4.4)	28.1 (2.8)
GOS-E Outcome[b] (*n*)						
Upper Good Recovery		2	2	3	1	2
Lower Good Recovery		2	1	2	3	5
Upper Moderate Disability		1	5	2	1	1
Upper Severe Disability		1	0	0	0	0

[a] *Data presented as median [interquartile range].*

[b] *No GOS-E data were collected on the healthy control participants. mTBI, mild traumatic brain injury; PSQI, Pittsburgh Sleep Quality Index; BDI-II Beck Depression Inventory – 2; RPQ, Rivermead Post-concussion Symptom Questionnaire; SWLS, Satisfaction with Life Survey; GOS-E, Glasgow Outcome Scale – Extended.*

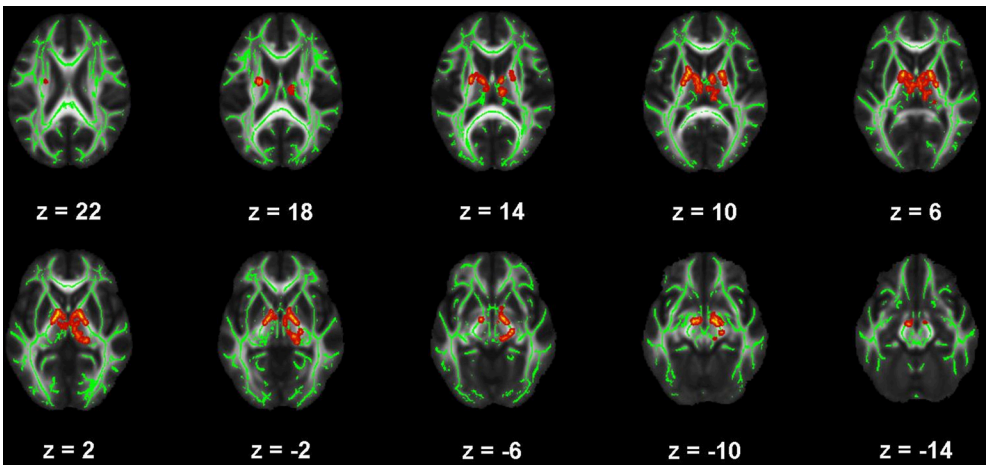

FIGURE 1 | Map of voxels with significant correlations between fractional anisotropy (FA) and Beck Depression Inventory – II (BDI) total scores in the mild traumatic brain injury (mTBI) participants. The average white-matter skeleton is presented in green. Yellow voxels indicate significant, negative correlations between FA and BDI total score (family-wise error rate corrected $p < 0.05$). Surrounding voxels are filled in red for visual purposes only. Images are in neurological orientation and Z-coordinates are presented in MNI standard space.

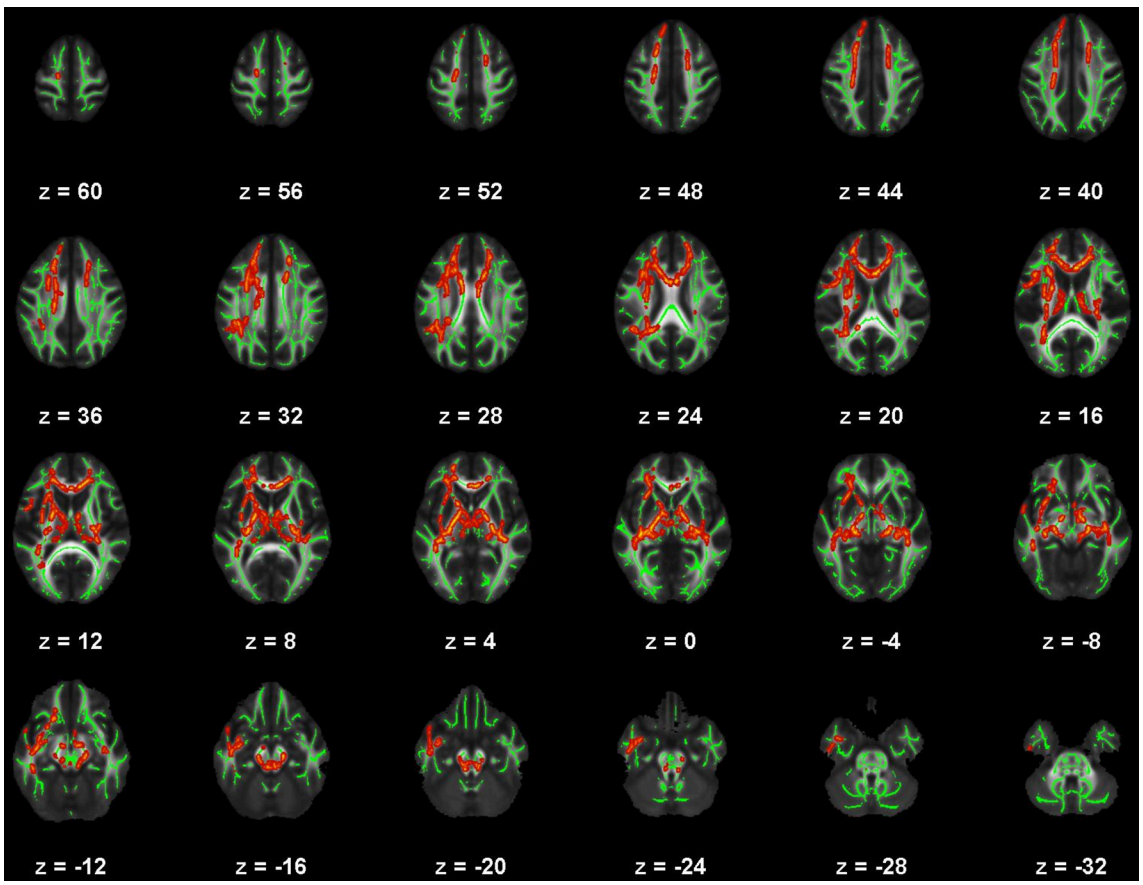

FIGURE 2 | Map of voxels with significant correlations between radial diffusivity (RD) and Beck Depression Inventory – II (BDI) total scores in the mild traumatic brain injury (mTBI) participants. The average white-matter skeleton is presented in green. Yellow voxels indicate significant, positive correlations between RD and BDI total score (family-wise error rate corrected $p < 0.05$). Surrounding voxels are filled in red for visual purposes only. Images are in neurological orientation and Z-coordinates are presented in MNI standard space.

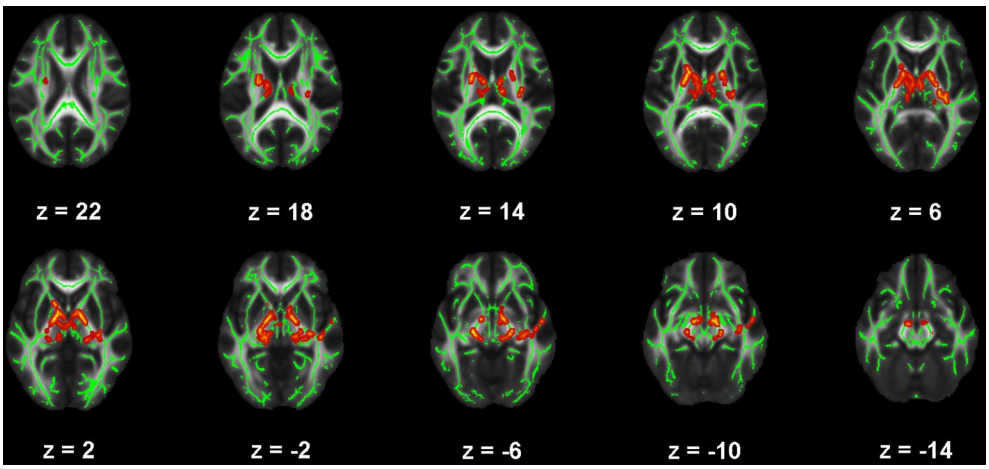

FIGURE 3 | Map of voxels with significant correlations between mean diffusivity (MD) and Beck Depression Inventory – II (BDI) total scores in the mild traumatic brain injury (mTBI) participants. The average white-matter skeleton is presented in green. Yellow voxels indicate significant, positive correlations between MD and BDI total score (family-wise error rate corrected $p < 0.05$). Surrounding voxels are filled in red for visual purposes only. Images are in neurological orientation and Z-coordinates are presented in MNI standard space.

locations are summarized in **Figure 7** and the abbreviations detailed in **Supplementary Table 1**. *Atlasquery* returns the probability (and, in the case of the JHU ICBM-DTI-81 atlas, the proportion) of voxels in a mask belonging to a region identified in a given atlas. The JHU ICBM-DTI-81 atlas does not encompass all white matter, and consequently some voxels remain unclassified. **Figure 7** has been rescaled to reflect only the classified voxels (e.g., 25% = 25% of the classified voxels). Across all five of the significant correlation pairs (BDI-FA, BDI-MD, BDI-RD, PSQI-FA, and PSQI-RD), correlations were consistently observed bilaterally within the internal capsules (anterior and posterior limbs), corona radiata (anterior and superior), fornix, and superior fronto-occipital fasciculi.

Confirmatory *Post-Hoc* Analyses

We performed two additional *post-hoc* analyses to further strengthen these findings. To confirm the lack of PSQI-DTI and BDI-DTI correlation in the healthy controls, we conducted an ROI analysis. Using the significant voxel masks created for the mTBI participants, the healthy control participants' mean DTI-metric values were extracted in the same manner as for the mTBI participants. *Post-hoc* partial correlations for the healthy controls were computed as described above, controlling for age and sex. None of these *post-hoc* correlations were statistically significant, as anticipated based on the results from *randomise*. Additionally, we compared the partial correlation coefficients between the healthy control and mTBI participants (91). These analyses confirmed that the observed correlations in the mTBI participants were significantly different from those in the healthy controls (see **Supplementary Table 2**).

Additionally, the BDI-II includes two questions that specifically address sleep. We observed significant correlations between sleep quality (PSQI) and DTI metrics, as well as depressive symptoms (BDI) and the same DTI metrics (FA and RD). Additionally, there was overlap in the structural areas exhibiting significance. Consequently, it was important to examine whether the BDI-DTI correlations for the mTBI participants depended upon perceived sleep quality. We computed a modified BDI total score that ignored items 16 (changes in sleeping pattern) and 20 (tiredness or fatigue) and re-calculated the partial correlations between BDI and the mean FA, MD, and RD over the previously identified significant voxels, while controlling for age, sex and time since injury. We then compared the two sets of correlation coefficients (91). There were no significant differences between the original and adjusted BDI correlations (see **Supplementary Table 2**), suggesting that the BDI-FA, BDI-MD, and BDI-RD correlations were not necessarily dependent on self-reported sleep characteristics.

DISCUSSION

The focus of this study was to identify neural correlates of clinically-relevant self-report outcomes related to global outcomes, psychiatric and psychological status, perceived health-related quality of life, and post-concussive related symptoms (59) as well as self-reported sleep quality (60). Specifically, the emphasis here was on metrics related to white-matter integrity, including FA as well as MD, AD, and RD. We hypothesized that individuals with a recent mTBI would exhibit lower FA and greater MD and RD than individuals with no prior history of mTBI. Additionally, we hypothesized that within-group correlations would be present such that poorer outcomes (e.g., poorer sleep quality, more depression symptoms) would be associated with lower FA and greater MD and RD. These hypotheses were partially confirmed.

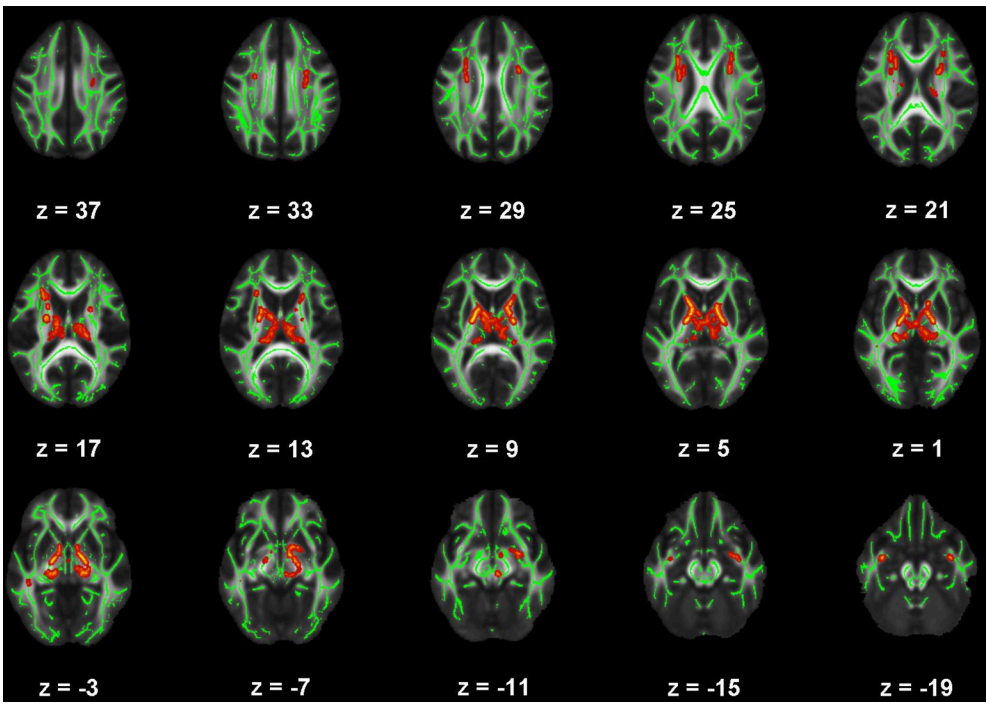

FIGURE 4 | Map of voxels with significant correlations between fractional anisotropy (FA) and Pittsburgh Sleep Quality Index (PSQI) total scores in the mild traumatic brain injury (mTBI) participants. The average white-matter skeleton is presented in green. Yellow voxels indicate significant, negative correlations between FA and PSQI total score (family-wise error rate corrected $p < 0.05$). Surrounding voxels are filled in red voxels for visual purposes only. Images are in neurological orientation and Z-coordinates are presented in MNI standard space.

DTI Sensitivity to mTBI

Contrary to our hypotheses, we did not observe any *statistically significant* differences between the healthy control and mTBI participants for any of the four diffusion metrics. This lack of difference occurred despite participants with mTBI reporting statistically greater sleep disturbances, depression symptoms, and post-concussive symptoms than the healthy controls. Recent systematic reviews and meta-analyses have generally highlighted the sensitivity of FA and MD to mTBI (40, 41, 53), however, the directional difference relative to non-mTBI participants is unclear, with lower, higher, and no differences reported (31, 43, 46, 48, 50–52). Our findings here are consistent with those of "no differences" at a whole brain corrected level, however it is important to note that generalization across DTI studies in mTBI is limited by cross-study heterogeneity in sample sizes, participant ages and populations, imaging protocols, and processing methods (40, 41). Please see **Exploratory trends** for a further discussion of group differences.

Correlations With Self-Report Outcomes

Consistent with our hypotheses, both sleep quality and depressive symptoms in the participants with mTBIs in the present study were correlated with DTI metrics. The relationships with depressive symptoms remained significant after removing sleep-related items from the BDI total score, suggesting that these were not driven by sleep issues *per se*. These measures exhibited negative correlations with FA and positive correlations with RD in projection and association tracts, including the internal capsule (IC), superior and anterior corona radiata (SCR, ACR), anterior and posterior thalamic radiations (ATR, PTR), and superior fronto-occipital fasciculus (SFO). Collectively, these white-matter tracts are integral aspects of neural circuits connecting deep brain structures, specifically the thalamus, parietal, and occipital cortical regions with frontal and prefrontal cortex areas. These connections not only play a critical role in sleep-wake regulation (thalamo-cortical circuits; (92–94), but also facilitate information processing, cognitive control, attention, executive function, and emotion regulation (95–97), all of which may be impaired following mTBI. Recent models of the neural basis of depression have further illustrated how alterations in the information processing supported by these prefrontal-posterior cortical/subcortical pathways (e.g., schema-guided attention, interpretation, and cognitive control processes) may bi-directionally interact with sleep quality to produce/maintain depressive symptoms (98). Consequently, damage in these pathways may precipitate the clinical presentation of mTBI, especially with respect to the correlated sleep and depression-related symptoms we observed in our sample.

There is substantial evidence that prior mTBI is associated with poor sleep quality, both self-reported (8, 12, 99, 100) as well as when measured via actigraphy (11, 101) and/or

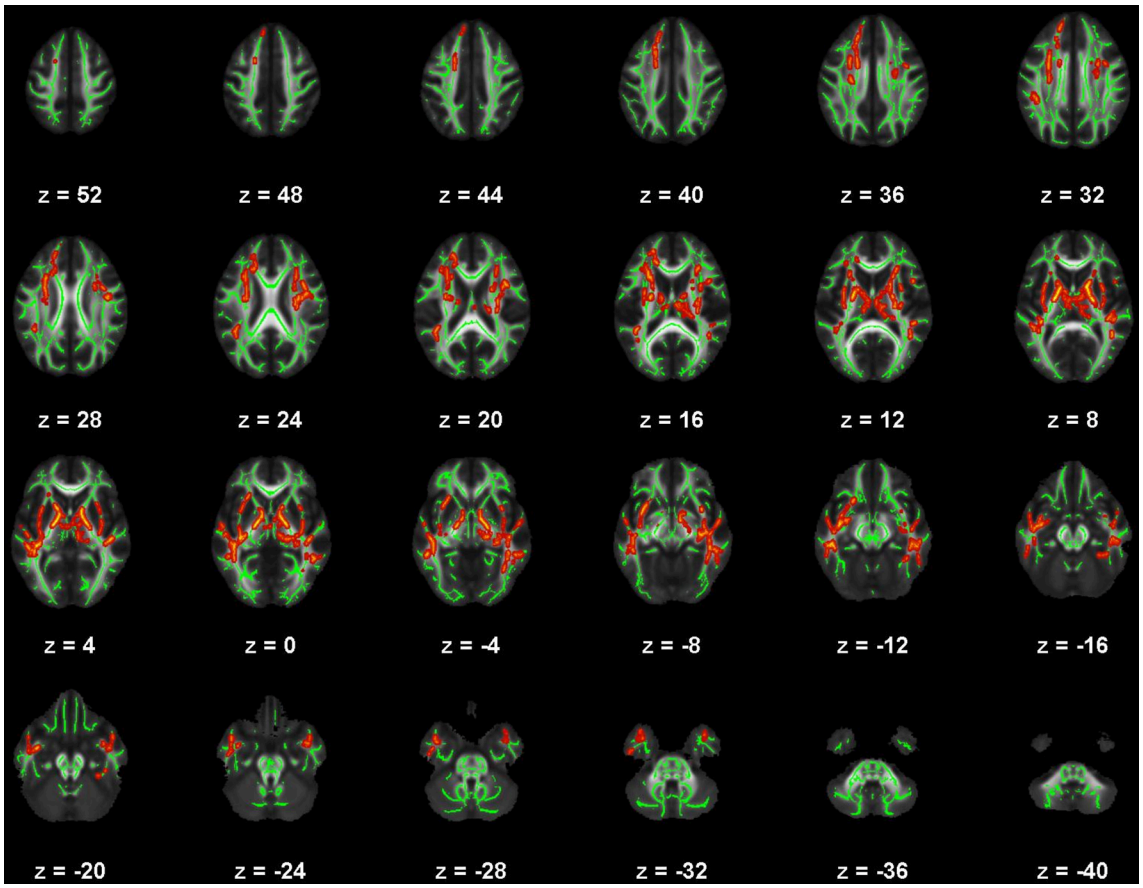

FIGURE 5 | Map of voxels with significant correlations between radial diffusivity (RD) and Pittsburgh Sleep Quality Index (PSQI) total scores in the mild traumatic brain injury (mTBI) participants. The average white-matter skeleton is presented in green. Yellow voxels indicate significant, positive correlations between RD and PSQI total score (family-wise error rate corrected $p < 0.05$). Surrounding voxels are filled in red for visual purposes only. Images are in neurological orientation and Z-coordinates are presented in MNI standard space.

polysomnography (102). Poor sleep quality may manifest in numerous ways, including insomnia (8, 12), hypersomnia (10), pleiosomnia (11), and increased night-to-night sleep variability (101). Proposed mechanisms for sleep-wake disturbances following mTBI include reduced sleep-wake regulation neurotransmitter availability, specifically low hypocretin/orexin, and lower counts of wake-promoting neurons in the hypothalamus (103–105). To our knowledge, the findings here are the first to link sleep quality with white-matter integrity following mTBI, and suggest that there are likely overlapping relationships between these mechanisms.

The results reported here are consistent with findings from both depression- and sleep-related studies apart from mTBI [i.e., where sleep disturbance is thought to both promote, and be promoted by, underlying neural processing abnormalities in depression; (98)]. Lower FA in the SLF, IC, and corpus callosum are frequently observed in major depressive disorder (54). Additionally, individuals with poor sleep quality (57), increased sleep variability (58), and insomnia (55, 56) all exhibit lower FA, particularly in the IC, SLF, and thalamic radiations. Importantly, previous work has indicated that poor sleep quality is associated with lower FA and increased RD even in healthy individuals and can cause reduced myelination and limit oligodendrocyte precursor proliferation (57, 58). In light of mouse models indicating that mTBI can directly result in loss of myelination (35–38), it is unclear to what extent post-mTBI sleep quality leads to white-matter damage vs. trauma-induced white-matter damage leading to poor sleep. Regardless, white-matter damage in these pathways may explain overlapping presentations of poor sleep quality, psychological distress, and cognitive impairment typically associated with mTBI. Identifying the independent contributions of traumatic insult vs. sleep loss-induced alterations in white-matter remains an open area of investigation in this population.

Exploratory Trends

Surprisingly, and generally contrary to the bulk of the literature on mTBI and DTI, there were no statistically significant differences (at a whole brain FWER *corrected* $p < 0.05$ level) between the mTBI participants and healthy controls. We did, however, observe a trend toward greater RD in the mTBI

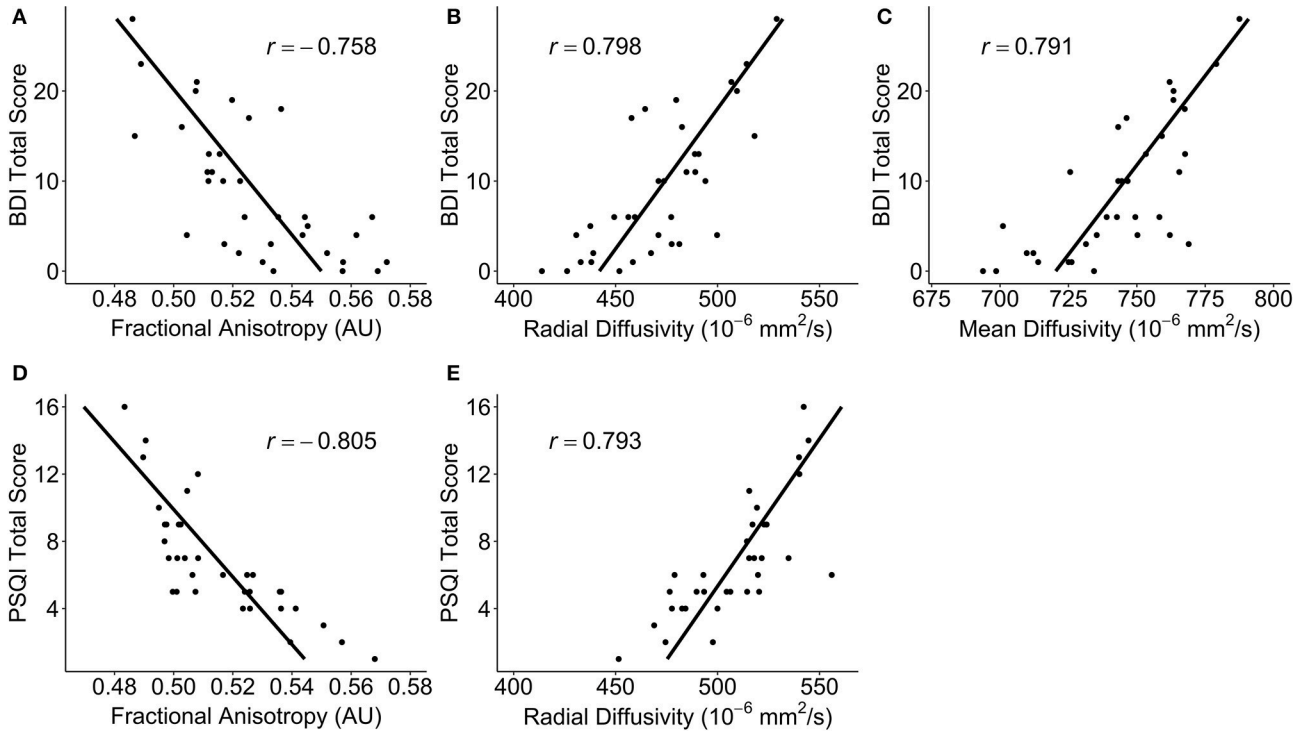

FIGURE 6 | Scatterplots of *post-hoc* partial correlations between diffusivity measures and self-reported outcomes for participants with a mild traumatic brain injury. The points in each plot are the average DTI measure over all of the significant voxels. The black line is a regression line predicting the self-report outcomes from the diffusivity measures, controlling for age, sex, and days post-injury. Correlation coefficients are noted as *r*. **(A)** The Beck Depression Inventory – II (BDI) total score vs. fractional anisotropy (FA); (**B)** BDI total score vs. radial diffusivity (RD); **(C)** BDI total score vs. mean diffusivity (MD); **(D)** Pittsburgh Sleep Quality Index (PSQI) total score vs. FA; **(E)** PSQI total score vs. RD.

participants (at a FWER *corrected* $p < 0.1$), primarily in the right hemisphere. While areas did not overlap exactly with the significant voxels from the mTBI group correlations, they do exist within the same pathways, particularly the corona radiata, longitudinal fasciculi, and the corpus callosum. While these differences do not meet the conventional level of significance, they do point to the possibility of myelin-related damage following mTBI.

Similarly, despite the observed relationships between FA/RD and both sleep quality and depressive symptoms, there were no statistically significant correlations (at a FWER *corrected* $p < 0.05$ level) between diffusion measures and post-concussive symptom presentation on the Rivermead Post-concussion Symptom Questionnaire. However, a negative *trend* did exist between AD and post-concussive symptoms on the RPQ3 (which identifies somatic symptoms; i.e., headaches, dizziness, nausea), such that lower AD was associated with greater symptom presentation. This result is in line with other recent findings (106), suggesting that somatic symptom presentation may be related to axonal damage.

Limitations

The present study indicates an association between diffusion metrics and self-report outcomes subsequent to mTBI, particularly with regard to sleep and depressive symptoms. However, a number of challenges remain. First, our overall sample was relatively small, which may contribute to the lack of statistically significant differences observed between healthy control participants and mTBI participants. Secondly, despite significant correlations between diffusion metrics and both sleep quality and depressive symptoms, the findings here present only a cross-sectional view of post-mTBI outcomes. Consequently, we cannot make any assertions about causation with respect to either the white matter integrity or self-report outcomes.

Third, our group had considerable heterogeneity of time since injury, ranging from 2-weeks to 12-months post injury. There is reasonable evidence that diffusion-related metrics may change over the weeks to months following an mTBI (40). Given the exclusively cross-sectional nature of our data, we addressed this potential limitation in the following ways. First, both our between-group and within-group models controlled for days since injury. Second, a *post-hoc* mTBI participant within-group correlation between the mean significant voxel values for PSQI and BDI-II scores reported earlier and time since injury revealed a non-significant correlation ($r = 0.026$, $p = 0.146$). Therefore, while intra-individual DTI-metrics may typically change over the course of mTBI recovery (40), the relationships between DTI measures, sleep quality, and depression we observed in the present sample appear independent of time since injury.

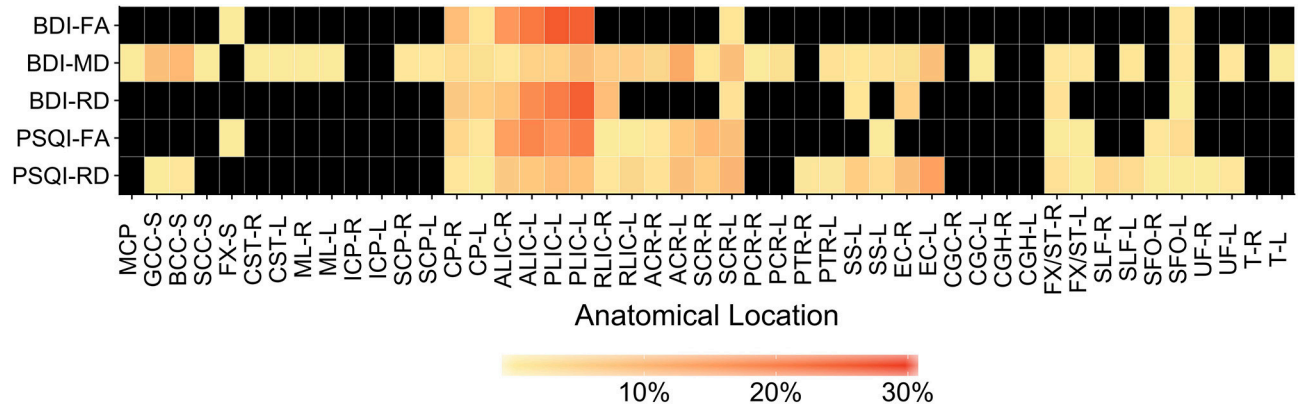

FIGURE 7 | Heatmap showing distribution of labeled, significantly correlated voxels (family-wise error rate corrected $p < 0.05$) for each correlation pair. Anatomical labels are drawn from the JHU ICBM-DTI-81 White-Matter Labels atlas and retrieved using the FMRIB Software Library (FSL) *atlasquery* function. *Atlasquery* returns the probability (and, in the case of the JHU ICBM-DTI-81 atlas, the proportion) of voxels in a mask belonging to a region identified in a given atlas. The JHU ICBM-DTI-81 atlas does not encompass all white matter, and consequently some voxels remain unclassified. Colors reflect the percentage of labeled voxels identified within each anatomical location ($\frac{localized\ voxels}{\sum(classified\ voxels)}$. Black boxes indicate no voxels with a significant correlation were present in that anatomical location. BDI, Beck Depression Inventory; PSQI, Pittsburgh Sleep Quality Index; FA, Fractional Anisotropy; MD, Mean Diffusivity; RD, Radial Diffusivity. Anatomical location abbreviations are summarized in **Supplementary Table 1**.

Finally, the white matter skeleton created during TBSS is based upon FA local maxima, generally near the midline of the white-matter tract (107). Thus, group differences between controls and mTBI participants may be present in non-maxima areas of the tracts, but these potential differences would not be detectable using the methods employed here. Finally, there are no established cutoffs, or reliable change indices, for DTI metrics after mTBI to identify whether the observed relationships reflect clinically meaningful changes in diffusion. Future work should address longitudinal outcomes, ideally with pre-injury DTI (though we recognize the inherent challenge in that), as well as machine-learning-based modeling methods (e.g., cross-validated logistic regression, classification trees) to identify discriminative post-mTBI changes in DTI metrics.

CONCLUSION

The results of this study contribute to a growing body of literature indicating that there are correlations between white-matter structure and clinical measures related to sleep quality and depression following mTBI. We have identified that the self-reported presentation of poor sleep quality and depressive symptoms following mTBI correlates with lower white-matter integrity in multiple areas of the brain involved in sleep-wake cycle and emotion regulation, in addition to information processing, cognitive control, attention, and executive function. Finally, trends in our data suggest that there may be alterations in white-matter structure that distinguish individuals with a history of mTBI from those without. Future work should emphasize identifying cutoff values in DTI metrics that provide clinically meaningful distinctions between individuals. Such findings will help not only to continue to increase what is known about mTBI pathophysiology and recovery, but will also help to guide best practices for the diagnosis and treatment of mTBI.

AUTHOR CONTRIBUTIONS

AR conducted the MRI data processing, statistical analyses, and drafted the initial manuscript. SB, ND, RS, and AA assisted with data interpretation and manuscript revisions. BS assisted with manuscript revisions. WK designed the study, assisted with data interpretation and critique, as well as manuscript review and revisions.

FUNDING

This work was supported by a grant to WK from the Office of the Assistant Secretary of Defense for Health Affairs and the Defense Health Agency J9, Research and Development Directorate, through the US Army Medical Research and Materiel Command (USAMRMC, Award #W81XWH-12-0386). The opinions, interpretations, conclusions and recommendations in this paper are solely those of the authors and are not necessarily endorsed by the Department of Defense or the U.S. Army Medical Research and Materiel Command.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fneur.2018.00468/full#supplementary-material

Supplementary Figure 1 | Map of voxels with greater radial diffusivity (RD; family-wise error rate corrected $0.064 \leq p \leq 0.094$) in mild traumatic brain injury (mTBI) participants compared to healthy control participants. The average white-matter skeleton is presented in green. Yellow voxels indicate voxels with a trend toward statistical significance. Surrounding voxels are filled with red for visual

purposes only. Images are in neurological orientation and Z-coordinates are presented in MNI standard space.

Supplementary Figure 2 | Map of voxels indicating a positive trend between axial diffusivity (AD) and Satisfaction with Life Scale (SWLS) total scores in the healthy control participants. The average white-matter skeleton is presented in green. Yellow voxels indicate positive correlations between AD and SWLS total score (family-wise error rate corrected $0.068 \leq p \leq 0.099$). Surrounding voxels are filled in red for visual purposes only. Images are in neurological orientation and Z-coordinates are presented in MNI standard space.

Supplementary Figure 3 | Map of voxels indicating a positive trend between mean diffusivity (MD) and Pittsburgh Sleep Quality Index (PSQI) total scores in the mild traumatic brain injury (mTBI) participants. The average white-matter skeleton is presented in green. Yellow voxels indicate positive correlations between MD and PSQI total score (family-wise error rate corrected $0.079 \leq p \leq 0.1$). Surrounding voxels are filled in red for visual purposes only. Images are in neurological orientation and Z-coordinates are presented in MNI standard space.

Supplementary Figure 4 | Map of voxels indicating a positive trend between axial diffusivity (AD) and Rivermead Post-concussion Symptom Questionnaire − 3 (RPQ3) scores in the mild traumatic brain injury (mTBI) participants. The average white-matter skeleton is presented in green. Yellow voxels indicate negative correlations between AD and RPQ3 total score (family-wise error rate corrected $0.093 \leq p \leq 0.1$). Surrounding voxels are filled in red for visual purposes only. Images are in neurological orientation and Z-coordinates are presented in MNI standard space.

Supplementary Figure 5 | Heatmap showing the distribution of labeled voxels (family-wise error rate corrected $0.05 < p \leq 0.1$). Anatomical labels are drawn from the JHU ICBM-DTI-81 White-Matter Labels atlas and retrieved using the FMRIB Software Library (FSL) *atlasquery* function. *Atlasquery* returns the probability (and, in the case of the JHU ICBM-DTI-81 atlas, the proportion) of voxels in a mask belonging to a region identified in a given atlas. The JHU ICBM-DTI-81 atlas does not encompass all white matter, and consequently some voxels remain unclassified. Colors reflect the percentage of labeled voxels identified within each anatomical location ($\frac{localized\ voxels}{\sum(classified\ voxels)}$. Black boxes indicate no voxels with a trend (family-wise error rate corrected $0.05 < p \leq 0.1$) were present in that anatomical location. BDI, Beck Depression Inventory; PSQI, Pittsburgh Sleep Quality Index; FA, Fractional Anisotropy; MD, Mean Diffusivity; RD, Radial Diffusivity. Anatomical location abbreviations are summarized in **Supplementary Table 1**.

Supplementary Table 1 | JHU ICBM-DTI-81 White-Matter Labels atlas abbreviations.

Supplementary Table 2 | Confirmatory *post-hoc* correlations.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Curriculum Vitae

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PLACE AND DATE OF BIRTH	
CITIZENSHIP	USA

CHRONOLOGY OF EDUCATION

8/83 - 5/85	A.A. (Liberal Arts), San Antonio College
8/83 - 5/85	A.A.S (Radio-TV-Film), San Antonio College
8/85 - 5/90	B.A. (Psychology), *Summa cum laude* with Distinction, University of New Mexico
8/90 - 5/92	M.A. (Clinical Psychology), Texas Tech University
8/92 - 8/96	Ph.D. (Clinical Psychology), Texas Tech University Dissertation Title: *Development and validation of a new instrument for the measurement of transient mood states: The facial analogue mood scale (FAMS)*. Lubbock, TX: Texas Tech University;1995. Advisor: Bill Locke, Ph.D.

POST-DOCTORAL TRAINING

8/95 - 7/96	Predoctoral Fellow, Clinical Psychology, Yale School of Medicine
8/96 - 7/97	Postdoctoral Fellow, Clinical Neuropsychology, University of OK Health Sciences Center
8/97 - 7/99	Postdoctoral Fellow, Clinical Neuropsychology, University of Pennsylvania Medical School
7/99 - 9/00	Research Fellow, Neuroimaging, McLean Hospital/ Harvard Medical School
9/13 - 5/14	Certificate in Applied Biostatistics, Harvard Medical School

LICENSURE/CERTIFICATION

2001 -	Licensed Psychologist, #966, State of New Hampshire

CHRONOLOGY OF EMPLOYMENT

Academic Appointments

10/00 - 8/02	Instructor in Psychology in the Department of Psychiatry Harvard Medical School, Boston, MA
9/02 - 7/07	Clinical Instructor in Psychology in the Department of Psychiatry Harvard Medical School, Boston, MA
8/07 - 10/10	Instructor in Psychology in the Department of Psychiatry Harvard Medical School, Boston, MA
4/08-	Faculty Affiliate, Division of Sleep Medicine Harvard Medical School, Boston, MA
10/10 - 10/12	Assistant Professor of Psychology in the Department of Psychiatry Harvard Medical School, Boston, MA
10/12 - 6/14	Associate Professor of Psychology in the Department of Psychiatry Harvard Medical School, Boston, MA
7/14-	Associate Professor of Psychology in the Department of Psychiatry (part-time) Harvard Medical School, Boston, MA
7/14-	Professor of Psychiatry—Tenured University of Arizona College of Medicine, Tucson, AZ
7/14-	Professor of Medical Imaging University of Arizona College of Medicine, Tucson, AZ
9/14-	Professor of Psychology University of Arizona College of Science, Tucson, AZ

Hospital/Clinical/Institutional Appointments

10/00 - 8/02	Assistant Research Psychologist, McLean Hospital, Belmont, MA
8/02 - 7/04	Research Psychologist, Department of Behavioral Biology, Walter Reed Army Institute of Research, Silver Spring, MD
7/04 - 10/07	Chief, Neurocognitive Performance Branch, Walter Reed Army Institute of Research, Silver Spring, MD
10/07 - 3/10	DoD Contractor, Chief Psychologist, GovSource, Inc., U.S. Department of Defense (DoD)
8/08	Consulting Psychologist, The Brain Institute, University of Utah
9/02 - 4/05	Special Volunteer, National Institute on Deafness and Other Communication Disorders (NIDCD), National Institutes of Health (NIH), Bethesda, MD
9/02 - 7/07	Research Consultant, McLean Hospital, Belmont, MA
8/05 - 5/06	Neuropsychology Postdocotoral Research Program Training Supervisor, Walter Reed Hospital, Washington, DC
8/07 -	Research Psychologist, McLean Hospital, Belmont, MA
7/10 - 6-11	DoD Contractor, Consulting Psychologist, Clinical Research Management (CRM)
7/11 - 6/14	Director, Social Cognitive, and Affective Neuroscience (SCAN) Laboratory, McLean Hospital, Belmont, MA
7/14-	Director, Social, Cognitive, and Affective Neuroscience (SCAN) Laboratory, University of Arizona, Tucson, AZ
3/16 -	ORISE Knowledge Preservation Fellow; Walter Reed Army Institute of Research, Silver Spring, MD

Military Positions

11/01 - 8/02	First Lieutenant, Medical Service Corps, United States Army Reserve (USAR)
8/02 - 7/05	Captain, Medical Service Corps, United States Army-Active Regular Army (RA)
8/05 - 10/07	Major, Medical Service Corps, United States Army-Active Regular Army (RA)
10/07 - 7/12	Major, Medical Service Corps, United States Army Reserve (USAR)
7/12 -	Lieutenant Colonel, Medical Service Corps, United States Army Reserve (USAR)
3/16 -	Deputy Consultant to the Surgeon General of the Army (SGA) for 71F Research Psychology, US Army Reserves

HONORS AND AWARDS

1990	Outstanding Senior Honors Thesis in Psychology, University of New Mexico
1990-1995	Maxey Scholarship in Psychology, Texas Tech University
2001	Rennick Research Award, Co-Author, International Neuropsychological Society
2002	Honor Graduate, AMEDD Officer Basic Course, U.S. Army Medical Department Center and School
2002	Lynch Leadership Award Nominee, AMEDD Officer Basic Course, U.S. Army Medical Department Center and School
2003	Outstanding Research Presentation Award, 2003 Force Health Protection Conference, U.S. Army Center for Health Promotion and Preventive Medicine
2003	Who's Who in America
2004	Who's Who in Medicine and Healthcare
2005	Edward L. Buescher Award for Excellence in Research by a Young Scientist, Walter Reed Army Institute of Research (WRAIR) Association
2009	Merit Poster Award, International Neuropsychological Society
2009	Outstanding Research Presentation Award, 2009 Force Health Protection Conference, U.S. Army Center for Health Promotion and Preventive Medicine
2010	Best Paper Award, Neuroscience, 27th U.S. Army Science Conference
2011	Published paper included in *Best of Sleep Medicine 2011*
2011	Blue Ribbon Finalist, 2011 Top Poster Award in Clinical and Translational Research, Society of Biological Psychiatry
2012	Defense Advance Research Projects Agency (DARPA) Young Faculty Award in Neuroscience
2014	Blue Ribbon Finalist, 2014 Top Poster Award in Basic Neuroscience, Society of Biological Psychiatry
2014	Harvard Medical School Excellence in Mentoring Award Nominee
2014	AASM Young Investigator Award (co-author), Honorable Mention, American Academy of Sleep Medicine
2018	Abstract Merit Award (co-author), Sleep Research Society.

SERVICE/OUTREACH

Local/State Service/Outreach

2003	Scientific Review Committee, Walter Reed Army Institute of Research (WRAIR), Silver Spring, MD

2005 Scientific Review Committee, Walter Reed Army Institute of Research (WRAIR), Silver Spring, MD
2012- McLean Hospital Research Committee, McLean Hospital, Belmont, MA
2016- House Ad Hoc Committee on Treatment of Traumatic Brain Injuries and Benefits of Hyperbaric Oxygen Therapy, Arizona House of Representatives

National/International Service/Outreach

2004 University of Alabama, Clinical Nutrition Research Center (UAB CNRC) Pilot/Feasibility Study Program Review Committee
2006 U.S. Small Business Administration, Small Business Technology Transfer (STTR) Program Review Committee
2006 Cognitive Performance Assessment Program Area Steering Committee, U.S. Army Military Operational Medicine Research Program Funding Panel
2006 External Member, Doctoral Thesis Committee, Belinda J. Liddle, Ph.D., University of Sydney, Australia
2007 Cognitive Performance Assessment Program Area Steering Committee, U.S. Army Military Operational Medicine Research Program Funding Panel
2008 United States Army Medical Research and Materiel Command (USAMRMC) Congressionally Directed Medical Research Programs (CDMRP) Extramural Grant Review Panel
2009 NIH-CSR Brain Disorders and Clinical Neuroscience N02 Member Study Conflict Section Review Panel
2009 Sleep Physiology and Fatigue Interventions Program Area Steering Committee, U.S. Army Military Operational Medicine Research Program
2009 Scotland, UK, Biomedical and Therapeutic Research Committee, Grant Reviewer
2010 Canada, Social Sciences and Humanities Research Council of Canada, Grant Reviewer
2011 National Science Foundation (NSF) Grant Reviewer
2011- National Network of Depression Centers (NNDC), Military Task Group
2011 Israel, Israel Science Foundation (ISF), Grant Reviewer
2011 Scientific Review Committee, US Army Institute of Environmental Medicine (USARIEM)
2012 National Science Foundation (NSF) Grant Reviewer
2012- American Academy of Sleep Medicine, Member
2013 Israel, Israel Science Foundation (ISF), Grant Reviewer
2014- Organization for Human Brain Mapping, Member
2015- Human Affectome Project Advisory Board Member
2016- Sleep Research Society Member
2017-2018 External Reviewer, Doctoral Thesis Reviewer, Kalina R. Rossa, Queensland University of Technology, Australia.
2018 Marsden Fund Council Grant Proposal Referee, Royal Society Te Aparangi, New Zealand.

Departmental Committees

2006 Chair, Undergraduate Honors Thesis Committee, Jessica Richards, Department of Psychology, University of Maryland, Baltimore County, MD
2012- Member, Research Committee, McLean Hospital, Belmont, MA
2014 Psychiatry Senior Research Manager Candidate Search Committee, Department of Psychiatry, University of Arizona, Tucson, AZ

2014-2015 Member, Faculty Search Committee, Department of Psychology, University of Arizona, Tucson, AZ.

2014-2016 Member, Comprehensive Examination Committee, Natalie Bryant, Department of Psychology, University of Arizona, Tucson, AZ

2014-2015 Chair/Research Faculty Mentor, Undergraduate Honors Thesis Committee, Haley Kent, Department of Biochemistry, University of Arizona, Tucson, AZ

2014- Member, Psychiatry Research Investigator Committee, Department of Psychiatry, University of Arizona, Tucson, AZ.

2015 Member, Dissertation Committee, Ryan S. Smith, Ph.D., Department of Psychology, University of Arizona, Tucson AZ.

2015 Imaging Excellence Cluster Hire Search Committee, Department of Medical Imaging, University of Arizona, Tucson, AZ

2015- Member, Mentoring Committee, Department of Psychiatry, University of Arizona, Tucson, AZ

2016- Member, Chief of Neuroradiology Faculty Search Committee, Department of Medical Imaging, University of Arizona, Tucson, AZ

2016-2017 Member, Dissertation Committee, Brian Arizmendi, Department of Psychology, University of Arizona, Tucson, AZ

2016-2017 Member, Masters Thesis Committee, Saren Seeley, Department of Psychology, University of Arizona, Tucson, AZ

2016-2017 Member, Masters Thesis Committee, Mairead McConnell, Department of Psychology, University of Arizona, Tucson, AZ

2016- Member, Masters Thesis Committee, John Vanuk, Department of Psychology, University of Arizona, Tucson, AZ

2016-2017 Faculty Advisor, Undergraduate Honor Thesis Committee, Matthew Nettles, Neuroscience/Cognitive Science, University of Arizona, Tucson, AZ

2016- Scientific Review Committee, Department of Psychiatry, University of Arizona, Tucson, AZ

2017- Faculty Advisor, Undergraduate Honors Thesis Committee, Debby Waugaman, Psychology, University of Arizona, Tucson, AZ

2017- Faculty Advisor, Undergraduate Honors Thesis Committee, Jun Lee, Department of Psychology, University of Arizona, Tucson, AZ

2017- Chair, Psychiatry Research Committee, Department of Psychiatry, University of Arizona, Tucson, AZ

2017- Member, Promotion and Tenure Committee, Department of Psychiatry, University of Arizona, Tucson, AZ

2017- Member, Mentoring Committee, Department of Psychiatry, University of Arizona, Tucson, AZ

University Committees/Service

2014 Ad Hoc Member, Interview Committee for Defense and Security Research Institute Director Position, University of Arizona, Tucson, AZ.

2014- Member, Mechanisms of Emotion, Social Relationships, and Health Interdisciplinary Developing Research Program, Clinical and Translational Science Institute, BIO5, University of Arizona, Tucson, AZ

2015 Vice President's Executive Committee for Defense and Security Strategic Planning, University of Arizona, Tucson, AZ

2015-	MRI Operations Committee, University of Arizona, Tucson, AZ
2016	Faculty Mentor, Undergraduate Biology Research Program (UBRP), University of Arizona, Tucson, AZ
2016	Faculty Mentor, Border Latino & American Indian Summer Exposure to Research (BLAISER) Program, University of Arizona, Tucson, AZ
2016	Faculty Mentor, Medical Student Research Committee (MSRC) Program, University of Arizona College of Medicine, Tucson, AZ
2018	Department Chair Administrative Review Committee.

Editorial Board Membership

2009-	Editorial Board Member, International Journal of Eating Disorders
2012-	Editorial Board Member, Dataset Papers in Neuroscience
2012-	Editorial Board Member, Dataset Papers in Psychiatry
2012-	Editor, Journal of Sleep Disorders: Treatment and Care

Ad Hoc Journal Reviewer (99 Journals)

2001-2012	Reviewer, Psychological Reports
2001-2012	Reviewer, Perceptual and Motor Skills
2002	Reviewer, American Journal of Psychiatry
2002-2013	Reviewer, Biological Psychiatry
2003	Reviewer, Clinical Neurology and Neurosurgery
2004-2016	Reviewer, NeuroImage
2004-2006	Reviewer, Neuropsychologia
2004-2016	Reviewer, Journal of Neuroscience
2004	Reviewer, Consciousness and Cognition
2005	Reviewer, Experimental Brain Research
2005	Reviewer, Schizophrenia Research
2005-2012	Reviewer, Archives of General Psychiatry
2005	Reviewer, Behavioral Brain Research
2005-2009	Reviewer, Human Brain Mapping
2005-2013	Reviewer, Psychiatry Research: Neuroimaging
2006	Reviewer, Journal of Abnormal Psychology
2006	Reviewer, Psychopharmacology
2006	Reviewer, Developmental Science
2006	Reviewer, Acta Psychologica
2006, 2015	Reviewer, Neuroscience Letters
2006-2018	Reviewer, Journal of Sleep Research
2006-2016	Reviewer, Physiology and Behavior
2006-2018	Reviewer, SLEEP
2007	Reviewer, Journal of Clinical and Experimental Neuropsychology
2008	Reviewer, European Journal of Child and Adolescent Psychiatry
2008	Reviewer, Judgment and Decision Making
2008-2010	Reviewer, Aviation, Space, & Environmental Medicine
2008	Reviewer, Journal of Psychophysiology

2008	Reviewer, Brazilian Journal of Medical and Biological Research
2008	Reviewer, The Harvard Undergraduate Research Journal
2008	Reviewer, Bipolar Disorders
2008-2013	Reviewer, Chronobiology International
2008	Reviewer, International Journal of Obesity
2009	Reviewer, European Journal of Neuroscience
2009-2018	Reviewer, International Journal of Eating Disorders
2009	Reviewer, Psychophysiology
2009	Reviewer, Traumatology
2009	Reviewer, Clinical Medicine: Therapeutics
2009	Reviewer, Acta Pharmacologica Sinica
2009	Reviewer, Collegium Antropologicum
2009	Reviewer, Journal of Psychopharmacology
2009-2014	Reviewer, Obesity
2009	Reviewer, Scientific Research and Essays
2009	Reviewer, Child Development Perspectives
2009-2010	Reviewer, Personality and Individual Differences
2009-2010	Reviewer, Noise and Health
2009-2010	Reviewer, Sleep Medicine
2010	Reviewer, Nature and Science of Sleep
2010	Reviewer, Psychiatry and Clinical Neurosciences
2010	Reviewer, Learning and Individual Differences
2010	Reviewer, Cognitive, Affective, and Behavioral Neuroscience
2010	Reviewer, BMC Medical Research Methodology
2010-2011	Reviewer, Journal of Adolescence
2010-2012	Reviewer, Brain Research
2011	Reviewer, Brain
2011	Reviewer, Social Cognitive and Affective Neuroscience
2011	Reviewer, Journal of Traumatic Stress
2011	Reviewer, Social Neuroscience
2011-2014	Reviewer, Brain and Cognition
2011	Reviewer, Frontiers in Neuroscience
2011-2012	Reviewer, Sleep Medicine Reviews
2012	Reviewer, Journal of Experimental Psychology: General
2012	Reviewer, Ergonomics
2012-2017	Reviewer, Behavioral Sleep Medicine
2012	Reviewer, Neuropsychology
2012	Reviewer, Emotion
2012	Reviewer, JAMA
2012	Reviewer, BMC Neuroscience
2012-2015	Reviewer, Cognition and Emotion
2012	Reviewer, Journal of Behavioral Decision Making
2012	Reviewer, Psychosomatic Medicine
2012-2014	Reviewer, PLoS One
2012	Reviewer, American Journal of Critical Care
2012-2014	Reviewer, Journal of Sleep Disorders: Treatment and Care
2013	Reviewer, Experimental Psychology
2013	Reviewer, Clinical Interventions in Aging

2013	Reviewer, Frontiers in Psychology
2013	Reviewer, Brain Structure and Function
2013	Reviewer, Appetite
2013-2018	Reviewer, JAMA Psychiatry
2014	Reviewer, Acta Psychologica
2014	Reviewer, Neurology
2014	Reviewer, Applied Neuropsychology: Child
2014-2016	Reviewer, Journal of Applied Psychology
2015	Reviewer, Early Childhood Research Quarterly
2015	Reviewer, Behavioral Neuroscience
2015-2018	Reviewer, Scientific Reports
2016-2018	Reviewer, Neuroscience & Biobehavioral Reviews
2016	Reviewer, Psychological Science
2016	Reviewer, Medicine & Science in Sports and Exercise
2016	Reviewer, Archives of Clinical Neuropsychology
2016	Reviewer, Advances in Cognitive Psychology
2017	Reviewer, Data in Brief
2017	Reviewer, Neuroscience
2017-2018	Reviewer, Sleep Health
2017	Reviewer, Journal of Experimental Social Psychology
2017-2018	Reviewer, Neural Plasticity
2018	Reviewer, NeuroImage: Clinical
2018	Reviewer, Journal of Psychiatric Research

PUBLICATIONS/CREATIVE ACTIVITY

Refereed Journal Articles

1. **Killgore WD**. The Affect Grid: a moderately valid, nonspecific measure of pleasure and arousal. Psychol Rep. 83(2):639-42, 1998.

2. **Killgore WD**. Empirically derived factor indices for the Beck Depression Inventory. Psychol Rep. 84(3 Pt 1):1005-13, 1999.

3. **Killgore WD**. Affective valence and arousal in self-rated depression and anxiety. Percept Mot Skills. 89(1):301-4, 1999.

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137. **Killgore, WD**, Balkin, TJ, Yarnell, AM, & Capaldi, VF. Sleep deprivation impairs recognition of specific emotions. Neurobiology of Sleep and Circadian Rhythms, 3, 10-16, 2017.

138. Smith, R, Lane, R, Alkozei, A, Bao, J, Smith, C, Sanova, A, Nettles, M, & **Killgore, WD**. Maintaining the feelings of others in working memory is associated with activation of the left anterior insula and left frontal-parietal control networks. Social, Cognitive, and Affective Neuroscience, 12, 848-860, 2017.

139. Marin, MF, Zsido, RG, Song, H, Lasko, NB, **Killgore, WD**, Rauch SL, Simon, NM, & Milad, MR. Skin conductance responses and neural activations during fear conditioning and extinction recall across anxiety disorders. JAMA Psychiatry, 74, 622-631, 2017.

140. Alkozei, A, Smith, R, & **Killgore, WD**. Gratitude and subjective wellbeing: A Proposal of two causal frameworks. Journal of Happiness Studies, 5, 1519-1542, 2018.

141. Smith, R, Alkozei, A, & **Killgore, WD**. Conflict-Related Dorsomedial Frontal Cortex Activation During Healthy Food Decisions is Associated with Increased Cravings for High-Fat Foods. Brain Imaging and Behavior, 12, 685-696, 2018.

142. Alkozei, A*, **Killgore, WD***, Smith, R, Dailey, NS, Bajaj, S, & Haack M. Chronic sleep restriction increases negative implicit attitudes toward Arab Muslims. Scientific Reports, 7: 4285, 1-6, 2017. (*authors contributed equally).

143. **Killgore, WD**, Smith, R, Olson EA, Weber, M, Rauch, SL, & Nickerson, LD. Emotional intelligence is associated with connectivity within and between resting state networks. Social Cognitive and Affective Neuroscience, 12, 1624-1636, 2017.

144. Smith, R, Alkozei, A, Bao, J, & **Killgore WD**. Successful goal-directed memory suppression is associated with increased inter-hemispheric coordination between right and left fronto-parietal control networks. Psychological Reports, 121, 93-111, 2018.

145. Smith, R, Alkozei, A, Bao, J, Lane, RD, & **Killgore, WD**. Resting state functional connectivity correlates of emotional awareness. NeuroImage, 159, 99-106, 2017.

146. Webb, CA, Olson, EA, **Killgore, WD**, Pizzagalli, DA, Rauch, SL, & Rosso, IM. Rostral anterior cingulate cortex morphology predicts treatment response to internet-based CBT for depression. Biological Psychiatry: Cognitive Neuroscience and Neuroimaging, 3, 255-262, 2018.

147. Smith, R, **Killgore, WD**, & Lane, RD. The structure of emotional experience and its relation to trait emotional awareness: A theoretical review. Emotion, 18, 670-692, 2018.

148. Alkozei, A, Smith, R, Dailey, NS, Bajaj, S, & **Killgore, WD**. Acute exposure to blue wavelength light during memory consolidation improves verbal memory performance. PLoS One, 12, e0184884, 2017.

149. Smith, R, Alkozei, A, **Killgore, WD**, & Lane, RD. Nested positive feedback loops in the maintenance of major depression: An integration and extension of previous models. Brain, Behavior, and Immunity, 67, 374-397, 2018.

150. Alkozei, A, **Killgore, WD**, Smith, R, Dailey, N.S., Bajaj, S, Raikes, A, & Haack, M. Chronic sleep restriction differentially affects implicit biased toward food among men and women:

Preliminary evidence. Journal of Sleep Research, 27, e12629, 2018.

151. Bajaj, S, Vanuk, JR, Smith, R, Sailey, NS, & **Killgore, WD**. Blue light therapy following mild traumatic brain injury: Effects on white mater water diffusion in the brain. Frontiers in Neurology, 8, 616, 2017.

152. Smith, R, Bajaj, S, Dailey, NS, Alkozei, A, Smith, C, Sanova, A, Lane, RD, & **Killgore, WD**. Greater cortical thickness within the limbic visceromotor network predicts higher levels of trait emotional awareness. Consciousness and Cognition, 57, 54-61, 2018.

153. Bajaj, S, Alkozei, A, Dailey, NS, & **Killgore, WD**. Brain aging: Uncovering cortical characteristics of healthy aging in you adults. Frontiers in Aging Neuroscience, 9, 412, 2017.

154. Bajaj, S, Dailey, NS, Rosso, IM, Rauch, SL, & **Killgore, WD**. Time-dependent differences in cortical measures and their associations with behavioral measures following mild traumatic brain injury. Human Brain Mapping, 39, 1886-1897, 2018.

155. Smith, R, Lane, RD, Alkozei, A, Bao, J, Smith, C, Sanova, A, Nettles, M, & **Killgore, WD**. The role of medial prefrontal cortex in the working memory maintenance of one's own emotional responses. Scientific Reports, 8, 3460, 2018.

156. **Killgore, WD**, Kent, HC, Knight, SA, & Alkozei, A. Changes in morning salivary melatonin correlate with prefrontal responses during working memory performance. NeuroReport, 29, 488-494, 2018.

157. Alkozei, A, Smith, R, Demers, LA, Divatia, S, Weber, M, Berryhill, SM, & **Killgore, WD**. Increases in emotional intelligence after an online training program are associated with better decision-making in the Iowa Gambling Task. Psychological Reports, 33294118771705, 2018.

158. Dailey, NS, Smith, R, Bajaj, S, Alkozei, A, Gottschlisch, MK, Raikes, AC, Satterfield, BC, & **Killgore, WD**. Elevated aggression and reduced white matter integrity in mild traumatic brain injury: A DTI study. Frontiers in Behavioral Neuroscience, 12, 118, 2018.

159. Raikes, AC, Bajaj, S, Dailey, NS, Smith, R, Alkozei, A, Satterfield, BC, & **Killgore, WD**. Diffusion tensor imaging (DTI) correlates of self-reported sleep quality and depression following mild traumatic brain injury. Frontiers in Neurology, 9, 468, 2018.

160. Smith, R, Sanova, A, Alkozei, A, Lane, RD, & **Killgore, WD**. Higher levels of trait emotional awareness are associatd with more efficient global information integration throughout the brain: A graph-theoretic analysis of resting state functional connectivity. Social Cognitive and Affective Neuroscience (in press).

161. Alkozei, A, Smith, R, & **Killgore, WD**. Implicit self-esteem is associated with higher levels of trait gratitude in women but not men. Journal of Positive Psychology (in press).

162. Bajaj, S, Raikes, A, Smith, R, Dailey, NS, Alkozei, A, Vanuk, JR, & **Killgore, WD**. The relationship between general intelligence and cortical structure in healthy individuals.

Neuroscience, 388, 36-44, 2018.

163. Alkozei, A, Haack, M, Skalamera, J, Smith, R, Satterfield, BC, Raikes, A, & **Killgore, WD**. Chronic sleep restriction affects the associations between implicit bias and explicit social decision-making. Sleep Health (in press).

164. Raikes, A, & **Killgore, WD**. Potential for the development of light therapies in mild traumatic brain injury. Concussion (in press).

165. Smith, R, Lane, RD, Sanova, A, Smith, C, & **Killgore, WD**. Common and unique neural systems underlying the working memory maintenance of emotional vs. bodily reactions to affective stimuli: The moderating role of trait emotional awareness. Frontiers in Human Neuroscience (in press).

166. Dailey, NS, Smith, R, Vanuk, JR, Raikes, AC, & **Killgore, WD**. Resting-state functional connectivity as a biomarker of aggression in mild traumatic brain injury. NeuroReport (in press).

167. Raikes, AC, Satterfield, BC, & **Killgore, WD**. Evidence of actigraphic and subjective sleep disruption following mild traumatic brain injury. Sleep Medicine (in press).

168. McConnell, MH, **Killgore, WD**, & O'Connor, MF. Yearning predicts subgenual anterior cingulate activity in bereaved individuals. Heliyon (in press).

169. Smith, R, Weihs, KL, Alkozei, A, **Killgore, WD**, & Lane RD. An embodied neurocomputational framework for organically integrating biopsychosocial processes: An application to the role of social support in health and disease. Psychosomatic Medicine (accepted).

Book Chapters/Editorials/Other Published Articles

1. **Killgore, WD.** Cortical and limbic activation during visual perception of food. In Dube, L, Bechara, A, Dagher, A, Drewnowski, A, Lebel, J, James, P, & Yada, R. (Eds), Obesity Prevention: The Role of Brain and Society on Individual Behavior. Elsevier, Boston, 2010, pp. 57-71.

2. **Killgore, WD.** Asleep at the trigger: Warfighter judgment and decision-making during prolonged wakefulness. In Bartone, P. (Ed), Applying Research Psychology to Improve Performance and Policy. 2010, pp. 59-77.

3. **Killgore, WD.** Effects of Sleep Deprivation on Cognition. In Kerkhof, G. & Van Dongen, H. Progress in Brain Research: Sleep and Cognition. Elsevier, B.V. New York, 2010, pp. 105-129.

4. **Killgore, WD.** Caffeine and other alerting agents. In Thorpy, M. & Billiard, M. (Eds), Sleepiness: Causes, Consequences, Disorders and Treatment. Cambridge University Press, UK, 2011, pp. 430-443.

5. **Killgore WD.** Priorities and challenges for caffeine research: Energy drinks, PTSD, and

withdrawal reversal. The Experts Speak Column, J Caffeine Res, 1, 11-12, 2011.

6. **Killgore, WD.** Odor identification ability predicts executive function deficits following sleep deprivation. In Lee-Chiong, T (Ed), Best of Sleep Medicine 2011. National Jewish Health, Denver CO, 2011, pp. 31-33.

7. **Killgore, WD.** Socio-emotional and neurocognitive effects of sleep loss. In Matthews, G. (Ed), Handbook of Operator Fatigue. Ashgate, London UK, 2012, pp. 227-243.

8. **Killgore, WD.** Sleepless nights and bulging waistlines (Editorial). Journal of Sleep Disorders: Treatment and Care, 1(1), doi: 10.4172/jsdtc.1000e101, 2012.

9. **Killgore, WD**, & Penetar, DM. Sleep and Military Operational Effectiveness. In Kushida, CA (Ed), The Encyclopedia of Sleep, 2013, vol. 1, pp. 311-319. Academic Press, Waltham, MA.

10. **Killgore, WD**, Weiner, MR, & Schwab, ZJ. Sleep deprivation, personality, and psychopathic changes. In Kushida, CA (Ed), The Encyclopedia of Sleep, 2013, vol. 1, pp. 264-271. Academic Press, Waltham, MA.

11. Schoenberg, MR, & **Killgore, WD**. Psychologic and Psychiatric Assessment. In Kushida, CA (Ed), The Encyclopedia of Sleep, 2013, vol. 2, pp. 23-26. Academic Press, Waltham, MA.

12. **Killgore, WD.** Sleep loss and performance. In Moore, BA, & Barnett, JE (Eds), Military Psychologists' Desk Reference, 2013, pp. 241-246. Oxford University Press, New York.

13. Weber, M., & **Killgore, WD**. What are the emerging therapeutic uses of bright light therapy for neurological disorders? (Editorial). Future Neurology, 8, 495-497, 2013.

14. **Killgore WD** & Weber, M. Sleep deprivation and cognitive performance. In Bianchi, M (Ed), Sleep Deprivation and Disease: Effects on the Body, Brain and Behavior, 2014, pp. 209-229. Springer, New York.

15. **Killgore, WD**. Sleep deprivation and behavioral risk taking. In Watson, RR, Sleep Modulation by Obesity, Diabetes, Age and Diet, 2015, pp. 279-287. Elsevier, San Diego, CA.

16. **Killgore, WD**. Lighting the way to better sleep and health (Editorial). Journal of Sleep Disorders: Treatment and Care, 5:1, 2016.

17. Singh, P, & **Killgore WD**. Time dependent differences in gray matter volume post mild traumatic brain injury. Neural Regeneration Research, 11, 920-921, 2016.

18. Klimova, A, Singh, P, & **Killgore WD**. White matter abnormalities in MS: Advances in diffusion tensor imaging/tractography. In Watson, RR & Killgore, WD (Eds), Nutrition and Lifestyle in Neurological Autoimmune Diseases: Multiple Sclerosis. Elsevier, San Diego, CA, pp. 21-28, 2017.

19. Alkozei, A, Smith, R, & **Killgore, WD**. Grateful people are happy and healthy—But why? Frontiers for Young Minds (in press).

20. Smith, R, Alkozei, A, & **Killgore WD**. How do emotions work? Frontiers for Young Minds (in press).

21. Satterfield, B. C., & **Killgore, WD**. Sleep loss, executive function, and decision-making. In Grandner, MG (Ed), Sleep and Health. Elsevier, San Diego (in press).

Books

1. Watson, RR, **& Killgore, WD** (Eds.). Nutrition and lifestyle in neurological autoimmune diseases: Multiple Sclerosis. Elsevier, San Diego, CA, 2017.

Published U.S. Government Technical Reports

1. **Killgore, WD**, Estrada, A, Rouse, T, Wildzunas, RM, Balkin, TJ. Sleep and performance measures in soldiers undergoing military relevant training. USAARL Report No. 2009-13. June, 2009.

2. Kelley, AM, **Killgore, WD**, Athy, JR, Dretsch, M. Risk propensity, risk perception, and sensation seeking in U.S. Army Soldiers: A preliminary study of a risk assessment battery. USAARL Report No. 2010-02. DTIC #: ADA511524. October, 2009.

CONFERENCES/SCHOLARLY PRESENTATIONS

Colloquia

2000 *The Neurobiology of Emotion in Children*, McLean Hospital, Belmont, MA *[Invited Lecture]*

2001 *The Neurobiology of Emotion in Children and Adolescents*, McLean Hospital, Belmont, MA *[Invited Lecture]*

2002 Cortico-Limbic Activation in Adolescence and Adulthood, Youth Advocacy Project, Cape Cod, MA [Invited Lecture]

2008 Lecture on *Sleep Deprivation, Executive Function, and Resilience to Sleep Loss*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2008 Lecture on *The Role of Research Psychology in the Army*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2008 Lecture on *Combat Stress Control: Basic Battlemind Training*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2009 Lecture entitled *Evaluate a Casualty, Prevent Shock, and Prevent Cold Weather injuries*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA*[Invited Lecture]*

2009 Lecture on *Combat Exposure and Sleep Deprivation Effects on Risky Decision-Making*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2009 Lecture on the *Sleep History and Readiness Predictor (SHARP)*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2009 Lecture on *The Use of Actigraphy for Measuring Sleep in Combat and Military Training*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2010 Lecture entitled *Casualty Evaluation*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2010 Lecture entitled *Combat Stress and Risk-Taking Behavior Following Deployment*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2010 Lecture entitled *Historical Perspectives on Combat Medicine at the Battle of Gettysburg*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2010 Lecture entitled *Sleep Loss, Stimulants, and Decision-Making*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2010 Lecture entitled *PTSD: New Insights from Brain Imaging*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2011 Lecture entitled *Effects of bright light therapy on sleep, cognition and brain function after mild traumatic brain injury*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2011 Lecture entitled *Laboratory Sciences and Research Psychology in the Army*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2011 Lecture entitled *Tools for Assessing Sleep in Military Settings*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2011 Lecture entitled *The Brain Basis of Emotional Trauma and Practical Issues in Supporting Victims of Trauma*, U.S. Department of Justice, United States Attorneys Office, Serving Victims of Crime Training Program, Holyoke, MA *[Invited Lecture]*

2011 Lecture entitled *The Brain Altering Effects of Traumatic Experiences*; 105th Reinforcement Training Unit (RTU), U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2012 Lecture entitled *Sleep Loss, Caffeine, and Military Performance*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2012 Lecture entitled *Using Light Therapy to Treat Sleep Disturbance Following Concussion*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2013 Lecture entitled *Brain Responses to Food: What you See Could Make you Fat*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2013 Lecture entitled *Predicting Resilience Against Sleep Loss*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2014 Lecture entitled *Get Some Shut-Eye or Get Fat: Sleep Loss Affects Brain Responses to Food*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2014 Lecture entitled *Emotional Intelligence: Developing a Training Program*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2014 Lecture entitled *Supporting Cognitive and Emotional Health in Warfighters*. Presented to the Senior Vice President for the Senior Vice President for Health Sciences and Dean of the Medical School, University of Arizona, Tucson, AZ *[Invited Lecture]*

2015 Lecture entitled *Understanding the Effects of Mild TBI (Concussion) on the Brain*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2015 Presentation entitled Superhuman Brains: The Neurocircuitry that Underlies the Ability to Resist Sleep Deprivation. Presented at the Neuroscience Datablitz, University of Arizona, Tucson, AZ *[Invited Lecture]*

2015 Presentation entitled: SCAN Lab Traumatic Stress Study. Presented at the Tucson Veteran Center, Tucson AZ *[Invited Lecture]*

2016 Presentation entitled: SCAN Lab Overview. Presented at the University of Arizona 2016 Sleep workshop, Tucson, AZ *[Invited Lecture]*

2016 Lecture entitled *Trauma Exposure and the Brain*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2016 Presentation entitled *Supporting Cognitive and Emotional Health in Warfighters*. UAHS Development Team, University of Arizona Health Sciences Center, Tucson, AZ *[Invited Lecture]*

2016 Lecture entitled Novel Approaches for Reducing Depression in the Military; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2016 Presentation entitled: SCAN Lab Traumatic Stress and TBI Studies. Presented at the Tucson Veteran Center, Tucson AZ *[Invited Lecture]*

2016 Lecture entitled The Battle for Mosul: An S2 Brief; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2017 Lecture entitled *A New Experimental Treatment for Sleep Problems Following Mild TBI*; 105th IMA Detachment, U.S. Army Reserve Center, Boston, MA *[Invited Lecture]*

2017 Lecture entitled *Basics of Neuroimaging Research*; UA Psychiatry Resident Neuroscience Course, University of Arizona Department of Psychiatry, Tucson, AZ *[Invited Lecture]*

Seminars

2001 *Using Functional MRI to Study the Developing Brain*, Judge Baker Children's Center, Harvard Medical School, Boston, MA *[Invited Lecture]*

2002 Lecture on the *Changes in the Lateralized Structure and Function of the Brain during Adolescent Development*, Walter Reed Army Institute of Research, Washington, DC *[Invited Lecture]*

2005 Lecture on *Functional Neuroimaging, Cognitive Assessment, and the Enhancement of Soldier Performance*, Walter Reed Army Institute of Research, Washington, DC *[Invited Lecture]*

2005 Lecture on *The Sleep History and Readiness Predictor*: Presented to the Medical Research and Materiel Command, Ft. Detrick, MD *[Invited Lecture]*

2006 Lecture on *Optimization of Judgment and Decision Making Capacities in Soldiers Following Sleep Deprivation*, Brain Imaging Center, McLean Hospital, Belmont MA *[Invited Lecture]*

2006 Briefing to the Chairman of the Cognitive Performance Assessment Program Area Steering Committee, U.S. Army Military Operational Medicine Research Program, entitled *Optimization of Judgment and Decision Making Capacities in Soldiers Following Sleep Deprivation*, Walter Reed Army Institute of Research *[Invited Lecture]*

2005 Briefing to the Chairman of the National Research Council (NRC) Committee on Strategies to Protect the Health of Deployed U.S. Forces, John H. Moxley III, on the *Optimization of Judgment and Decision Making Capacities in Soldiers Following Sleep Deprivation*, Walter Reed Army Institute of Research, Washington, DC *[Invited Lecture]*

2006 Lecture on *Norming a Battery of Tasks to Measure the Cognitive Effects of Operationally Relevant Stressors*, Cognitive Performance Assessment Program Area Steering Committee, U.S. Army Military Operational Medicine Research Program, Washington, DC *[Invited Lecture]*

2007 Lecture on *Cerebral Responses During Visual Processing of Food*, U.S. Army Institute of Environmental Medicine, Natick, MA *[Invited Lecture]*

2007 Briefing on the *Measurement of Sleep-Wake Cycles and Cognitive Performance in Combat Aviators*, U.S. Department of Defense, Defense Advanced Research Projects Agency (DARPA), Washington, DC *[Invited Lecture]*

2007 Lecture on *The Effects of Fatigue and Pharmacological Countermeasures on Judgment and Decision-Making*, U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL *[Invited Lecture]*

2008 Lecture on the *Validation of Actigraphy and the SHARP as Methods of Measuring Sleep and Performance in Soldiers*, U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL *[Seminar]*

2009 Lecture on Sleep Deprivation, *Executive Function, and Resilience to Sleep Loss*: Walter Reed Army Institute of Research AIBS Review, Washington DC *[Invited Lecture]*

2009 Lecture Entitled *Influences of Combat Exposure and Sleep Deprivation on Risky Decision-Making*, Evans U.S. Army Hospital, Fort Carson, CO *[Invited Lecture]*

2009 Lecture on *Making Bad Choices: The Effects of Combat Exposure and Sleep Deprivation on Risky Decision-Making*, 4th Army, Division West, Quarterly Safety Briefing to the Commanding General and Staff, Fort Carson, CO*[Invited Lecture]*

2010 Lecture on *Patterns of Cortico-Limbic Activation Across Anxiety Disorders*, Center for Anxiety, Depression, and Stress, McLean Hospital, Belmont, MA *[Invited Lecture]*

2010 Lecture on *Cortico-Limbic Activation Among Anxiety Disorders*, Neuroimaging Center, McLean Hospital, Belmont, MA *[Invited Lecture]*

2011 Lecture on *Shared and Differential Patterns of Cortico-Limbic Activation Across Anxiety Disorders*, McLean Research Day Brief Communications, McLean Hospital, Belmont, MA *[Invited Lecture]*

2011 Lecture Entitled *The effects of emotional intelligence on judgment and decision making, Military Operational Medicine Research Program Task Area C*, R & A Briefing, Walter Reed Army Institute of Research, Silver Spring, MD *[Invited Lecture]*

2011 Lecture Entitled *Effects of bright light therapy on sleep, cognition, brain function, and neurochemistry following mild traumatic brain injury*, Military Operational Medicine Research Program Task Area C, R & A Briefing, Walter Reed Army Institute of Research, Silver Spring, MD *[Invited Lecture]*

2012 Briefing to GEN (Ret) George Casey Jr., former Chief of Staff of the U.S. Army, entitled *Research for the Soldier*. McLean Hospital, Belmont, MA. *[Invited Lecture]*

2012 Lecture Entitled *Effects of bright light therapy on sleep, cognition, brain function, and neurochemistry following mild traumatic brain injury*, Military Operational Medicine Research Program In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

2013 Lecture Entitled *Update on the Effects of Bright light therapy on sleep, cognition, brain function, and neurochemistry following mild traumatic brain injury*, Military Operational Medicine Research Program In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

2013 Lecture Entitled *Internet Based Cognitive Behavioral Therapy: Effects on Depressive Cognitions and Brain Function*, Military Operational Medicine Research Program In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD [*Invited Lecture*]

2013 Seminar Entitled *Predicting Resilience Against Sleep Loss*, United States Military Academy at West Point, West Point, NY [*Invited Symposium*].

2014 Lecture entitled *Sleep Loss, Brain Function, and Cognitive Performance*, presented to the Psychiatric Genetics and Translational Research Seminar, Massachusetts General Hospital/Harvard Medical School, Boston, MA *[Invited Lecture]*

2014 Grand Rounds Lecture entitled *Sleep Loss, Brain Function, and Performance of the Emotional-Executive System*. University of Arizona Psychiatry Grand Rounds, Tucson, AZ *[Invited Lecture]*

2014 Psychology Department Colloquium entitled *Sleep Loss, Brain Function, and Performance of the Emotional-Executive System*. University of Arizona Department of Psychology, Tucson, AZ *[Invited Lecture]*

2014 Lecture Entitled *Internet Based Cognitive Behavioral Therapy: Effects on Depressive Cognitions and Brain Function*, Military Operational Medicine Research Program In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

2014 Lecture Entitled *The Neurobiological Basis and Potential Modification of Emotional Intelligence Through Affective/Behavioral Training*, Military Operational Medicine Research Program In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

2014 Lecture entitled *Supporting Cognitive and Emotional Health in Warfighters*. Presented to the Senior Vice President for t for Health Sciences and Dean of the Medical School, University of Arizona, Tucson, AZ *[Invited Lecture]*

2015 Lecture entitled *Sleep Loss and Brain Responses to Food*. Presented for the Sleep Medicine Lecture Series, University of Arizona Medical Center, Tucson, AZ *[Invited Lecture]*

2015 Presentation entitled *Superhuman Brains: The Neurocircuitry that Underlies the Ability to Resist Sleep Deprivation*. Presented at the Neuroscience Datablitz, University of Arizona, Tucson, AZ *[Invited Lecture]*

2015 Lecture entitled *Sleep Deprivation Selectively Impairs Emotional Aspects of Cognition*. Presented at the Pamela Turbeville Speaker Series, McClelland Institute for Children, Youth, and Families, Tucson, AZ, *[Invited Lecture]*

2015 Lecture Entitled Multimodal Neuroimaging to Predict Resistance to Sleep Deprivation, presented at the Pulmonary Research Conference, Department of Medicine, Sleep Medicine Sleep Lecture Series, University of Arizona College of Medicine, Tucson, AZ *[Invited Lecture]*.

2015 Lecture entitled Sleep Deprivation Selectively Impairs Emotional Aspects of Cognition. Presented at the Pamela Turbeville Speaker Series, McClelland Institute for Children, Youth, and Families, Tucson, AZ, *[Invited Lecture]*

2015 Lecture Entitled *Effects of bright light therapy on sleep, cognition, brain function, and neurochemistry following mild traumatic brain injury*, Military Operational Medicine Research Program In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

2015 Lecture Entitled *A Non-Pharmacologic Method for Enhancing Sleep in PTSD*, Military Operational Medicine Research Program In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

2015 Lecture Entitled *Internet Based Cognitive Behavioral Therapy: Effects on Depressive Cognitions and Brain Function*, Military Operational Medicine Research Program In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

2015 Lecture Entitled *Operating Under the Influence: The Effects of Sleep Loss and Stimulants on Decision-Making and Performance.* Presented at the annual SAFER training for interns and residents, University of Arizona Department of Psychiatry, Tucson AZ *[Invited Lecture]*

2016 Lecture entitled *Translational Neuroimaging: Using MRI Techniques to Promote Recovery and Resilience*. Functional Neuroimaging Course, Spring 2016, Psychology Department, University of Arizona, Tucson, AZ *[Invited Lecture]*

2016 Lecture entitled *Supporting Cognitive and Emotional Health in Warfighters*. Presented at the Department of Behavioral Biology, Walter Reed Army Institute of Research, Silver Spring, MD *[Invited Lecture]*

2016 Lecture Entitled *Internet Based Cognitive Behavioral Therapy: Effects on Depressive Cognitions and Brain Function*, Military Operational Medicine Research Program In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

2016 Lecture Entitled *A Model for Predicting Cognitive and Emotional Health from Structural and Functional Neurocircuitry following TBI*, Military Operational

Medicine Research Program In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

2016 Lecture Entitled *Refinement and Validation of a Military Emotional Intelligence Training Program*, Military Operational Medicine Research Program 2016 Resilience In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

2017 Lecture Entitled *Bright Light Therapy for Treatment of Sleep Problems following Mild TBI*, Military Operational Medicine Research Program Combat Casualty Care In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

2017 Lecture Entitled *Refinement and Validation of a Military Emotional Intelligence Training Program*, Military Operational Medicine Research Program 2017 Resilience In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

2018 Lecture Entitled *Introduction to Chronobiology (Part 1)*, Sleep Research Seminar Series, Walter Reed Army Institute of Research, Silver Spring, MD *[Invited Lecture]*

2018 Lecture Entitled *Introduction to Chronobiology (Part 2)*, Sleep Research Seminar Series, Walter Reed Army Institute of Research, Silver Spring, MD *[Invited Lecture]*

2018 Lecture Entitled *A Non-Pharmacologic Method for Enhancing Sleep in PTSD*, Military Operational Medicine Research Program In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

2018 Lecture Entitled *Refinement and Validation of a Military Emotional Intelligence Training Program*, Military Operational Medicine Research Program In Progress Review (IPR) Briefing, U.S. Army Medical Research and Materiel Command, Fort Detrick, MD *[Invited Lecture]*

Symposia/Conferences

1999 Oral Platform Presentation entitled *Functional MRI lateralization during memory encoding predicts seizure outcome following anterior temporal lobectomy*, 27th Annual Meeting of the International Neuropsychological Society, Boston, MA. *[Submitted Presentation]*

2000 Lecture on the *Neurobiology of Emotional Development in Children*, 9th Annual Parents as Teachers Born to Learn Conference, St. Louis, MO *[Invited Lecture]*

2001 Oral Platform Presentation entitled *Sex differences in functional activation of the amygdala during the perception of happy faces*, 29th Annual Meeting of the International Neuropsychological Society, Chicago, IL. *[Submitted Presentation]*

2002 Oral Platform Presentation entitled *Developmental changes in the lateralized activation of the prefrontal cortex and amygdala during the processing of facial affect*, 30th Annual Meeting of the International Neuropsychological Society, Toronto, Ontario, Canada. *[Submitted Presentation]*

2002 Oral Platform Presentation *Gray and white matter volume during adolescence correlates with cognitive performance: A morphometric MRI study*, 30th Annual Meeting of the International Neuropsychological Society, Toronto, Ontario, Canada. *[Submitted Presentation]*

2004 Lecture on *Sleep Deprivation, Cognition, and Stimulant Countermeasures*: Seminar Presented at the Bi-Annual 71F Research Psychology Short Course, Ft. Detrick, MD, U.S. Army Medical Research and Materiel Command *[Invited Lecture]*

2004 Lecture on the *Regional Cerebral Blood Flow Correlates of Electroencephalographic Activity During Stage 2 and Slow Wave Sleep: An H215O PET Study*: Presented at the Bi-Annual 71F Research Psychology Short Course, Ft. Detrick, MD, U.S. Army Medical Research and Materiel Command *[Invited Lecture]*

2004 Oral Platform Presentation entitled *Regional cerebral metabolic correlates of electroencephalographic activity during stage-2 and slow-wave sleep: An H215O PET Study*, 18th Associated Professional Sleep Societies Annual Meeting, Philadelphia, PA. *[Submitted Presentation]*

2006 Lecture on *The Sleep History and Readiness Predictor*: Presented at the Bi-Annual 71F Research Psychology Short Course, Ft. Rucker, AL, U.S. Army Medical Research and Materiel Command *[Invited Lecture]*

2007 Symposium on *Cortical and Limbic Activation in Response to Visual Images of Low and High-Caloric Foods*, 6th Annual Meeting of the International Society for Behavioral Nutrition and Physical Activity (ISBNPA), Oslo, Norway *[Invited Lecture]*

2008 Lecture on *Sleep Deprivation, Executive Function, & Resilience to Sleep Loss*, First Franco-American Workshop on War Traumatism, IMNSSA, Toulon, France *[Invited Lecture]*

2009 Symposium Entitled *Sleep Deprivation, Judgment, and Decision-Making*, 23rd Annual Meeting of the Associated Professional Sleep Societies, Seattle, WA *[Invited Symposium]*

2009 Symposium Session Moderator for *Workshop on Components of Cognition and Fatigue: From Laboratory Experiments to Mathematical Modeling and Operational Applications*, Washington State University, Spokane, WA *[Invited Speaker]*

2009 Lecture on *Comparative Studies of Stimulant Action as Countermeasures for Higher Order Cognition and Executive Function Impairment that Results from Disrupted Sleep*

Patterns, Presented at the NIDA-ODS Symposium entitled: Caffeine: Is the Next Problem Already Brewing, Rockville, MD *[Invited Lecture]*

2010 Oral Platform Presentation entitled *Sleep deprivation selectively impairs emotional aspects of cognitive functioning*, 27th Army Science Conference, Orlando, FL. *[Submitted Presentation]*

2010 Oral Platform Presentation entitled *Exaggerated amygdala responses to masked fearful faces are specific to PTSD versus simple phobia*, 27th Army Science Conference, Orlando, FL. *[Submitted Presentation]*

2012 Oral Symposium Presentation entitled *Shared and distinctive patterns of cortico-limbic activation across anxiety disorders*, 32nd Annual Conference of the Anxiety Disorders Association of America, Arlington, VA. *[Invited Symposium]*

2012 Oral Platform Presentation entitled *Shared and unique patterns of cortico-limbic activation across anxiety disorders*. 40th Meeting of the International Neuropsychological Society, Montreal, Canada. *[Submitted Presentation]*

2013 Lecture entitled *Brain responses to visual images of food: Could your eyes be the gateway to excess?* Presented to the NIH Nutrition Coordinating Committee and the Assistant Surgeon General of the United States, Bethesda, MD *[Invited Lecture]*

2014 Symposium Entitled *Operating Under the Influence: The Effects of Sleep Loss and Stimulants on Decision-Making and Performance*, Invited Faculty Presenter at the 34th Annual Cardiothoracic Surgery Symposium (CREF), San Diego, CA [*Invited Symposium*].

2014 Symposium Entitled *The Effects of Sleep Loss on Food Preference*, SLEEP 2014, Minneapolis, MN *[Invited Symposium]*

2015 Symposium Entitled *The Neurobiological Basis and Potential Modification of Emotional Intelligence in Military Personnel*. Invited presentation at the Yale Center for Emotional Intelligence, New Haven, CT *[Invited Lecture]*

2015 Lecture Entitled *Predicting Resilience to Sleep Loss with Multi-Modal Neuroimaging*. Invited presentation at the DARPA Sleep Workshop 2015, Arlington, VA *[Invited Lecture]*

2015 Symposium Entitled: *The Brain and Food: How your (sleepy) Eyes Might be the Gateway to Excess*, Invited Faculty Presenter at the 2015 University of Arizona Update on Psychiatry, Tucson, AZ [*Invited Symposium*].

2015 Oral Platform presentation entitled *Multimodal Neuroimaging to Predict Resistance to Sleep Deprivation*, Associated Professional Sleep Societies (APSS) SLEEP meeting, Seattle, WA *[Invited Lecture]*

2015 Symposium Entitled presentation entitled *Sleep Deprivation and Emotional Decision Making*, Virginia Tech Sleep Workshop, Arlington, VA *[Invited Symposium]*

2016 Oral Platform presentation entitled *Default Mode Activation Predicts Vulnerability to Sleep Deprivation in the Domains of Mood, Sleepiness, and Vigilance*. Presentation given at the Associated Professional Sleep Societies (APSS) SLEEP meeting, Denver, CO *[Invited Lecture]*

2016 Symposium presentation entitled *Short Wavelength Light Therapy Facilitates Recovery from Mild Traumatic Brain Injury*, 2016 Military Health Systems Research Symposium (MHSRS), Orlando, FL *[Invited Lecture]*

2017 Lecture Entitled: *Military Update on Blue Light Therapy for mTBI*. Lecture presented at the DoD Sleep Research Meeting breakout session at the Associated Professional Sleep Societies (APSS) SLEEP meeting, Boston, MA *[Invited Lecture]*

2017 Symposium entitled: *Judgment and Decision Making During Sleep Loss*. Invited symposium presentation at the SLEEP 2017 Trainee Symposium Series, Associated Professional Sleep Societies (APSS) SLEEP meeting, Boston, MA *[Invited Lecture]*

2017 Oral Platform presentation entitled *Short Wavelength Light Therapy Facilitates Recovery from Mild Traumatic Brain Injury*. Presentation given at the Associated Professional Sleep Societies (APSS) SLEEP meeting, Boston, MA *[Invited Lecture]*

2017 Symposium entitled: What makes a super-soldier: Identifying the neural correlates of individual differences in resilience against sleep deprivation. Invited symposium presentation at the 2017 Military Health Systems Research Symposium (MHSRS), Orlando, FL *[Invited Lecture]*

2018 Oral Platform presentation entitled: Short Wavelength Light Therapy Enhances Brain and Cognitive Recovery Following Mild Traumatic Brain Injury. Presentation given at the Arizona Research Institute for Biomedical Imaging (ARIBI) Workshop, Tucson, AZ *[Invited Lecture]*

2018 Session Chair: Healthy Shiftwork? Measures, Mitigation and Functional Outcomes. Session presented at the Associated Professional Sleep Societies (APSS) SLEEP Conference (Session O02), Baltimore, MD *[Session Chair]*

2018 Lecture Entitled: *Lapses During Sleep Loss are Predicted by Gray Matter Volume of the Ascending Reticular Activating Systems*. Lecture presented at the 2nd Annual DoD Sleep Research Meeting breakout session at the Associated Professional Sleep Societies (APSS) SLEEP meeting, Baltimore, MD *[Invited Lecture]*

2018 Oral Platform presentation entitled *Resistance to Sleep Deprivation is Predicted by Gray Matter Volume in the Posterior Brain Stem*. Presentation given at the Associated Professional Sleep Societies (APSS) SLEEP meeting, Baltimore, MD *[Invited Lecture]*

2018 Oral Platform presentation entitled *Why Can't You Just Stay Awake? Resistance to Sleep Deprivation is Associated with Measurable Differences in Brainstem Gray Matter*. Presentation given at the Military Health Systems Research Symposium (MHSRS), Orlando, FL *[Invited Lecture]*

Peer Reviewed Published Abstracts

1. **Killgore, WD.** Development and validation of a new instrument for the measurement of transient mood states: The facial analogue mood scale (FAMS) [Abstract]. Dissertation Abstracts International: Section B: The Sciences & Engineering 1995; 56 (6-B): 3500.

2. **Killgore, WD,** & Locke, B. A nonverbal instrument for the measurement of transient mood states: The Facial Analogue Mood Scale (FAMS) [Abstract]. Proceedings of the Annual Conference of the Oklahoma Center for Neurosciences 1996, Oklahoma City, OK.

3. **Killgore, WD,** Scott, JG, Oommen, KJ, & Jones, H. Lateralization of seizure focus and performance on the MMPI-2 [Abstract]. Proceedings of the Annual Conference of the Oklahoma Center for Neurosciences 1996, Oklahoma City, OK.

4. **Killgore, WD,** & Adams, RL. Vocabulary ability and Boston Naming Test performance: Preliminary guidelines for interpretation [Abstract]. Archives of Clinical Neuropsychology 1997; 13(1).

5. **Killgore, WD**, Glosser, G, Cooke, AN, Grossman, M, Maldjian, J, Judy, K, Baltuch, G, King, D, Alsop, D, & Detre, JA. Functional activation during verbal memory encoding in patients with lateralized focal lesions [Abstract]. Epilepsia 1998; 39(Suppl. 6): 99.

6. **Killgore, WD.** A new method for assessing subtle cognitive deficits: The Clock Trail Making Test [Abstract]. Archives of Clinical Neuropsychology 1998; 14(1): 92.

7. **Killgore, WD,** & DellaPietra, L. Item response biases on the WMS-III Auditory Delayed Recognition Subtests [Abstract]. Archives of Clinical Neuropsychology 1998; 14(1): 92.

8. **Killgore, WD,** Glosser, G, Alsop, DC, Cooke, AN, McSorley, C, Grossman, M, & Detre, JA. Functional activation during material specific memory encoding [Abstract]. NeuroImage 1998; 7: 811.

9. **Killgore, WD,** & DellaPietra, L. Using the WMS-III to detect malingering: Empirical development of the Rarely Missed Index. [Abstract]. Journal of the International Neuropsychological Society 1999; 5(2).

10. **Killgore, WD,** Glosser, G, & Detre, JA. Prediction of seizure outcome following anterior temporal lobectomy: fMRI vs. IAT [Abstract]. Archives of Clinical Neuropsychology 1999; 14(1): 143.

11. **Killgore, WD,** Glosser, G, King, D, French, JA, Baltuch, G, & Detre, JA. Functional MRI lateralization during memory encoding predicts seizure outcome following anterior temporal lobectomy [Abstract]. Journal of the International Neuropsychological Society 1999; 5(2): 122.

12. **Killgore, WD,** Casasanto, DJ, Maldjian, JA, Alsop, DC, Glosser, G, French, J, & Detre, J. A. Functional activation of mesial temporal lobe during nonverbal encoding [abstract]. Epilepsia, 1999; 40 (Supplement 7): 188.

13. **Killgore, WD,** Casasanto, DJ, Maldjian, JA, Gonzales-Atavales, J, & Detre, JA. Associative memory for faces preferentially activates the left amygdala and hippocampus [abstract]. Journal of the International Neuropsychological Society, 2000; 6: 157.

14. Casasanto, DJ, **Killgore, WD,** Maldjian, JA, Gonzales-Atavales, J, Glosser, G, & Detre, JA. Task-dependent and task-invariant activation in mesial temporal lobe structures during fMRI explicit encoding tasks [abstract]. Journal of the International Neuropsychological Society, 2000; 6: 134. ***[*Winner of Rennick Research Award]***.

15. **Killgore, WD,** Glahn, D, & Casasanto, DJ. Development and validation of the Design Organization Test (DOT): A rapid screening instrument for assessing for visuospatial ability [abstract]. Journal of the International Neuropsychological Society, 2000; 6: 147.

16. Casasanto DJ, **Killgore, WD,** Glosser, G, Maldjian, JA, & Detre, JA. Hemispheric specialization during episodic memory encoding in the human hippocampus and MTL. Proceedings of the Society for Cognitive Science 2000: Philadelphia, PA.

17. Casasanto, DJ, Glosser, G, **Killgore, WD,** Siddiqi, F, Falk, M, Maldjian, J, Lev-Reis, I, & Detre, JA. FMRI evidence for the functional reserve model of post-ATL neuropsychological outcome prediction. Poster Presented at the David Mahoney Institute of Neurological Sciences 17th Annual Neuroscience Retreat, University of Pennsylvania, April 17, 2000.

18. Casasanto, DJ, **Killgore, WD,** Maldjian, JA, Glosser, G, Grossman, M, Alsop, D. C, & Detre, JA. Neural Correlates of Successful and Unsuccessful Verbal Encoding [abstract]. Neuroimage, 2000 11: S381.

19. Siddiqui, F, Casasanto, DJ, **Killgore, WD,** Detre, JA, Glosser, G, Alsop, DC, & Maldjian, JA. Hemispheric effects of frontal lobe tumors on mesial temporal lobe activation during scene encoding [abstract]. Neuroimage, 2000 11: S448.

20. Oki, M, Gruber, SA, **Killgore, WD,** Yurgelun-Todd, DA. Bilateral thalamic activation occurs during lexical but not semantic processing [abstract]. Neuroimage, 2000 11: S353.

21. Yurgelun-Todd, DA, Gruber, SA, **Killgore, WD,** & Tohen, M. Neuropsychological performance

in first-episode bipolar disorder [Abstract]. Collegium Internationale Neuro-Psychopharmacologicum. Brussels, Belgium. July, 2000.

22. **Killgore, WD,** & DellaPietra, L. Detecting malingering with the WMS-III: A revision of the Rarely Missed Index (RMI) [abstract]. Journal of the International Neuropsychological Society, 2001; 7 (2): 143-144.

23. Casasanto, DJ, Glosser, G, **Killgore, WD,** Siddiqi, F, Falk, M, Roc, A, Maldjian, JA, Levy-Reis, I, Baltuch, G, & Detre, JA. Presurgical fMRI predicts memory outcome following anterior temporal lobectomy [abstract]. Journal of the International Neuropsychological Society, 2001; 7 (2): 183.

24. **Killgore, WD,** & Yurgelun-Todd, DA. Amygdala but not hippocampal size predicts verbal memory performance in bipolar disorder [abstract]. Journal of the International Neuropsychological Society, 2001; 7 (2): 250-251.

25. **Killgore, WD,** Kanayama, G, & Yurgelun-Todd, DA. Sex differences in functional activation of the amygdala during the perception of happy faces [abstract]. Journal of the International Neuropsychological Society, 2001; 7 (2): 198.

26. **Killgore, WD,** Gruber, SA, Oki, M, & Yurgelun-Todd, DA. Amygdalar volume and verbal memory in schizophrenia and bipolar disorder: A correlative MRI study [abstract]. Meeting of the International Congress on Schizophrenia Research. Whistler, British Columbia. April 2001.

27. Kanayama, G, **Killgore, WD,** Gruber, SA, & Yurgelun-Todd, DA. FMRI BOLD activation of the supramarginal gyrus in schizophrenia [abstract]. Meeting of the International Congress on Schizophrenia Research. Whistler, British Columbia. April 2001.

28. Gruber, SA, **Killgore, WD,** Renshaw, PF, Pope, HG. Jr, Yurgelun-Todd, DA. Gender differences in cerebral blood volume after a 28-day washout period in chronic marijuana smokers [abstract]. Meeting of the International Congress on Schizophrenia Research. Whistler, British Columbia. April 2001.

29. Rohan, ML, **Killgore, WD,** Eskesen, JG, Renshaw, PF, & Yurgelun-Todd, DA. Match-warped EPI anatomic images and the amygdala: Imaging in hard places. Proceedings of the International Society for Magnetic Resonance in Medicine, 2001; 9: 1237.

30. **Killgore, WD** & Yurgelun-Todd, DA. Developmental changes in the lateralized activation of the prefrontal cortex and amygdala during the processing of facial affect [Abstract]. Oral platform paper presented at the 30th Annual Meeting of the International Neuropsychological Society, Toronto, Ontario, Canada, February 13-16, 2002.

31. Yurgelun-Todd, DA. & **Killgore, WD.** Gray and white matter volume during adolescence correlates with cognitive performance: A morphometric MRI study [Abstract]. Oral platform paper presented at the 30th Annual Meeting of the International Neuropsychological Society, Toronto, Ontario, Canada, February 13-16, 2002.

32. **Killgore, WD,** Reichardt, R. Kautz, M, Belenky, G, Balkin, T, & Wesensten, N. Daytime melatonin-zolpidem cocktail: III. Effects on salivary melatonin and performance [abstract]. Poster presented at the 17th Annual Meeting of the Associated Professional Sleep Societies, Chicago, Illinois, June 3-8, 2003.

33. **Killgore, WD,** Young, AD, Femia, LA, Bogorodzki, P, Rogowska, J, & Yurgelun-Todd, DA. Cortical and limbic activation during viewing of high- versus low-calorie foods [abstract]. Poster Presented at the Organization for Human Brain Mapping Annual Meeting, New York, NY, June 18-22, 2003.

34. **Killgore, WD,** & Yurgelun-Todd, DA. Amygdala activation during masked presentations of sad and happy faces [abstract]. Poster presented at the Organization for Human Brain Mapping Annual Meeting, New York, NY, June 18-22, 2003.

35. **Killgore, WD,** Stetz, MC, Castro, CA, & Hoge, CW. Somatic and emotional stress symptom expression prior to deployment by soldiers with and without previous combat experience [abstract]. Poster presented at the 6th Annual Force Health Protection Conference, Albuquerque, NM, August, 11-17, 2003. ***[*Best Paper Award]***

36. Wesensten, NJ, Balkin, TJ, Thorne, D, **Killgore, WD,** Reichardt, R, & Belenky, G. Caffeine, dextroamphetamine, and modafinil during 85 hours of sleep deprivation: I. Performance and alertness effects [abstract]. Poster presented at the 75th Annual Meeting of the Aerospace Medical Association, Anchorage, AK, May 2-6 2004.

37. **Killgore, WD,** Braun, AR, Belenky, G, Wesensten, NJ, & Balkin, TJ. Regional cerebral metabolic correlates of electroencephalographic activity during stage-2 and slow-wave sleep: An H215O PET Study [abstract]. Oral platform presentation at the 18th Associated Professional Sleep Societies Annual Meeting, Philadelphia, PA, June 5-10, 2004.

38. **Killgore, WD,** Arora, NS, Braun, AR, Belenky, G, Wesensten, NJ, & Balkin, TJ. Sleep strengthens the effective connectivity among cortical and subcortical regions: Evidence for the restorative effects of sleep using H215O PET [abstract]. Poster presented at the 17th Congress of the European Sleep Research Society, Prague, Czech Republic, October 5-9, 2004.

39. **Killgore, WD,** Arora, NS, Braun, AR, Belenky, G, Wesensten, NJ, & Balkin, TJ An H215O PET study of regional cerebral activation during stage 2 sleep [abstract]. Poster presented at the 17th Congress of the European Sleep Research Society, Prague, Czech Republic, October 5-9, 2004.

40. Wesensten, N, **Killgore, WD,** Belenky, G, Reichardt, R, Thorne, D, & Balkin, T. Caffeine, dextroamphetamine, and modafinil during 85 H of sleep deprivation. II. Effects of tasks of executive function [abstract]. Poster presented at the 17th Congress of the European Sleep Research Society, Prague, Czech Republic, October 5-9, 2004.

41. Balkin, T, Reichardt, R, Thorne, D, **Killgore, WD,** Belenky, G, & Wesensten, N. Caffeine, dextroamphetamine, and modafinil during 85 hours of sleep deprivation. I. Psychomotor vigilance and objective alertness effects [abstract]. Oral paper presentation at the 17th Congress of the European Sleep Research Society, Prague, Czech Republic, October 5-9,

2004.

42. Belenky, G, Reichardt, R, Thorne, D, **Killgore, WD,** Balkin, T, & Wesensten, N. Caffeine, dextroamphetamine, and modafinil during 85 hours of sleep deprivation. III. Effect on recovery sleep and post-recovery sleep performance [abstract]. Oral paper presentation at the 17th Congress of the European Sleep Research Society, Prague, Czech Republic, October 5-9, 2004.

43. Vo, A, Green, J, Campbell, W, **Killgore, WD,** Labutta, R, & Redmond, D. The quantification of disrupted sleep in migraine via actigraphy: A pilot study [abstract]. Abstract presented at the Associated Professional Sleep Societies 19th Annual Meeting, Denver, CO, June 18-23, 2005. SLEEP, 28 (Supplement), A281.

44. Kendall, AP, **Killgore, WD,** Kautz, M, & Russo, MB. Left-visual field deficits in attentional processing after 40 hours of sleep deprivation [abstract]. Abstract presented at the Associated Professional Sleep Societies 19th Annual Meeting, Denver, CO, June 18-23, 2005. SLEEP, 28 (Supplement), A143.

45. Reichardt, RM, Grugle, NL, Balkin, TJ, & **Killgore, WD.** Stimulant countermeasures, risk propensity, and IQ across 2 nights of sleep deprivation [abstract]. Abstract presented at the Associated Professional Sleep Societies 19th Annual Meeting, Denver, CO, June 18-23, 2005. SLEEP, 28 (Supplement), A145.

46. Killgore, DB, McBride, SA, Balkin, TJ, & **Killgore, WD.** Post-stimulant hangover: The effects of caffeine, modafinil, and dextroamphetamine on sustained verbal fluency following sleep deprivation and recovery sleep [abstract]. Abstract presented at the Associated Professional Sleep Societies 19th Annual Meeting, Denver, CO, June 18-23, 2005. SLEEP, 28 (Supplement), A137.

47. **Killgore, WD,** Balkin, TJ, & Wesensten, NJ. Impaired decision-making following 49 hours of sleep deprivation [abstract]. Abstract presented at the Associated Professional Sleep Societies 19th Annual Meeting, Denver, CO, June 18-23, 2005. SLEEP, 28 (Supplement), A138.

48. **Killgore, WD,** McBride, SA, Killgore, DB, & Balkin, TJ. Stimulant countermeasures and risk propensity across 2 nights of sleep deprivation [abstract]. Abstract presented at the Associated Professional Sleep Societies 19th Annual Meeting, Denver, CO, June 18-23, 2005. SLEEP, 28 (Supplement), A136.

49. McBride, SA, Balkin, TJ, & **Killgore, WD.** The effects of 24 hours of sleep deprivation on odor identification accuracy [abstract]. Abstract presented at the Associated Professional Sleep Societies 19th Annual Meeting, Denver, CO, June 18-23, 2005. SLEEP, 28 (Supplement), A137.

50. Picchioni, D, **Killgore, WD,** Braun, AR, & Balkin, TJ. PET correlates of EEG activity during non-REM sleep. Poster presentation at the annual UCLA/Websciences Sleep Training Workshop, Lake Arrowhead, CA, September, 2005.

51. **Killgore, WD,** Killgore, DB, McBride, SA, & Balkin, TJ. Sustained verbal fluency following

sleep deprivation and recovery sleep: The effects of caffeine, modafinil, and dextroamphetamine. Poster presented at the 34th Meeting of the International Neuropsychological Society, Boston, MA, February 1-4, 2006.

52. **Killgore, WD,** Balkin, TJ, & Wesensten, NJ. Decision-making is impaired following 2-days of sleep deprivation. Poster presented at the 34th Meeting of the International Neuropsychological Society, Boston, MA, February 1-4, 2006.

53. **Killgore, WD,** & Yurgelun-Todd, DA. Neural correlates of emotional intelligence in adolescent children. Poster presented at the 34th Meeting of the International Neuropsychological Society, Boston, MA, February 1-4, 2006.

54. **Killgore, WD,** & Yurgelun-Todd, DA. Social anxiety predicts amygdala activation in adolescents viewing fearful faces. Poster presented at the 34th Meeting of the International Neuropsychological Society, Boston, MA, February 1-4, 2006.

55. McBride, SA & **Killgore, WD.** Sleepy people smell worse: Olfactory deficits following extended wakefulness. Paper presented at the Workshop on Trace Gas Detection Using Artificial, Biological, and Computational Olfaction. Monell Chemical Senses Center, Philadelphia, PA, March 29-31, 2006.

56. **Killgore, WD,** Day LM, Li, C, Kamimori, GH, Balkin, TJ, & Killgore DB. Moral reasoning is affected by sleep deprivation [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A137.

57. **Killgore, WD,** Killgore DB, Kahn-Green, E, Conrad, A, Balkin, TJ, & Kamimori, G. H. Introversion-Extroversion predicts resilience to sleep loss [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A137.

58. Newman, R, Kamimori, GH, **Killgore, WD.** Sleep deprivation diminishes constructive thinking [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A136-137.

59. Huck, NO, Kendall, AP, McBride, SA, **Killgore, WD.** The perception of facial emotion is enhanced by psychostimulants following two nights of sleep deprivation [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A136.

60. O'Sullivan, M, Reichardt, RM, Krugler, AL, Killgore, DB, & **Killgore, WD.** Premorbid intelligence correlates with duration and quality of recovery sleep following sleep deprivation [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A372.

61. McBride, SA, **Killgore, WD,** Kahn-Green, E, Conrad, A, & Kamimori, GH. Caffeine administered to maintain overnight alertness does not disrupt performance during the daytime withdrawal period [abstract]. Abstract presented at the 20th Meeting of the Associated

Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A136.

62. McBride, SA, Killgore DB, Balkin, TJ, Kamimori, GH, & **Killgore, WD.** Sleepy people smell worse: Olfactory decrements as a function of sleep deprivation [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A135.

63. Day, LM, Li, C, Killgore, DB, Kamimori, GH, & **Killgore, WD.** Emotional intelligence moderates the effect of sleep deprivation on moral reasoning [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A135.

64. Murray, CJ, Killgore, DB, Kamimori, GH, & **Killgore, WD.** Individual differences in stress management capacity predict responsiveness to caffeine during sleep deprivation [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A43.

65. Murray, CJ, Newman, R, O'Sullivan, M, Killgore, DB, Balkin, TJ, & **Killgore, WD.** Caffeine, dextroamphetamine, and modafinil fail to restore Stroop performance during sleep deprivation [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A370-371.

66. Richards, J, Killgore, DB, & **Killgore, WD.** The effect of 44 hours of sleep deprivation on mood using the Visual Analog Mood Scales [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A132.

67. Richards, J, & **Killgore, WD.** The effect of caffeine, dextroamphetamine, and modafinil on alertness and mood during sleep deprivation [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A43.

68. Lipizzi, EL, Leavitt, BP, Killgore, DB, Kamimori, GH, & **Killgore, WD.** Decision making capabilities decline with increasing duration of wakefulness [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A131.

69. Lipizzi, EL, Killgore, DB, Kahn-Green, E, Kamimori, GH, & **Killgore, WD.** Emotional intelligence scores decline during sleep deprivation [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A131.

70. Kahn-Green, E, Day, L, Conrad, A, Leavitt, BP, Killgore, DB, & **Killgore, WD.** Short-term vs. long-term planning abilities: Differential effects of stimulants on executive function in sleep deprived individuals [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A370.

71. Kahn-Green, E, Conrad, A, Killgore, DB, Kamimori, GH, & **Killgore, WD.** Tired and frustrated: Using a projective technique for assessing responses to stress during sleep deprivation [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A130.

72. Killgore, DB, Kahn-Green, E, Balkin, TJ, Kamimori, GH, & **Killgore, WD.** 56 hours of wakefulness is associated with a sub-clinical increase in symptoms of psychopathology [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A130.

73. Killgore, DB, McBride, SA, Balkin, TJ, Leavitt, BP, & **Killgore, WD.** Modafinil improves humor appreciation during sleep deprivation [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A42.

74. Reichardt, RM, Killgore, DB, Lipizzi, EL, Li, CJ, Krugler, AL, & **Killgore, WD.** The effects of stimulants on recovery sleep and post-recovery verbal performance following 61-hours of sleep deprivation [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A42.

75. Bailey, JD, Richards, J, & **Killgore, WD.** Prediction of mood fluctuations during sleep deprivation with the SAFTE Model [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A60.

76. Kendall, AP, McBride, S. A, & **Killgore, WD.** Visuospatial perception of line orientation is resistant to one night of sleep loss [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A369.

77. Kendall, AP, McBride, SA, Kamimori, GH, & **Killgore, WD.** The interaction of coping skills and stimulants on sustaining vigilance: Poor coping may keep yoiu up at night [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A129.

78. Muckle, A, Killgore, DB, & **Killgore, WD.** Gender differences in the effects of stimulant medications on the ability to estimate unknown quantities when sleep deprived [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A369.

79. Krugler, AL, **Killgore, WD,** & Kamimori, G. H. Trait anger predicts resistance to sleep loss [abstract]. Abstract presented at the 20th Meeting of the Associated Professional Sleep Societies, Salt Lake City, UT, June 17-22, 2006. SLEEP, 29 (Supplement), A129.

80. **Killgore, WD,** Cotting, DI, Vo, A. H, Castro, CA, & Hoge, CW. The invincibility syndrome: Combat experiences predict risk-taking propensity following redeployment [abstract].

Abstract presented at the 9th Annual Force Health Protection Conference, Albuquerque, NM, August 6-11, 2006.

81. **Killgore, WD,** Wesensten, NJ, & Balkin, TJ. Stimulants improve tactical but not strategic planning during prolonged wakefulness [abstract]. Abstract presented at the 9th Annual Force Health Protection Conference, Albuquerque, NM, August 6-11, 2006.

82. **Killgore, WD,** Balkin, TJ, Wesensten, NJ, & Kamimori, G. H. The effects of sleep loss and caffeine on decision-making [abstract]. Abstract presented at the 9th Annual Force Health Protection Conference, Albuquerque, NM, August 6-11, 2006.

83. **Killgore, WD,** Balkin, TJ, & Kamimori, GH. Sleep loss can impair moral judgment [abstract]. Abstract presented at the 9th Annual Force Health Protection Conference, Albuquerque, NM, August 6-11, 2006.

84. **Killgore, WD,** Lipizzi, EL, Reichardt, RM, Kamimori, GH, & Balkin, TJ. Can stimulants reverse the effects of sleep deprivation on risky decision-making [abstract]? Abstract presented at the 25th Army Science Conference, Orlando, FL, November 27-30, 2006.

85. **Killgore, WD,** Killgore, DB, Kamimori, GH, & Balkin, TJ. Sleep deprivation impairs the emotional intelligence and moral judgment capacities of Soldiers [abstract]. Abstract presented at the 25th Army Science Conference, Orlando, FL, November 27-30, 2006.

86. **Killgore, WD,** Cotting, DI, Vo, AH, Castro, C.A, & Hoge, CW. The post-combat invincibility syndrome: Combat experiences increase risk-taking propensity following deployment [abstract]. Abstract presented at the 25th Army Science Conference, Orlando, FL, November 27-30, 2006.

87. Adam, GE, Szelenyi, ER, **Killgore, WD,** & Lieberman, HR. A double-blind study of two days of caloric deprivation: Effects on judgment and decision-making. Oral paper presentation at the Annual Scientific Meeting of the Aerospace Medical Association, New Orleans, LA, May, 2007.

88. Killgore, DB, Kahn-Greene, ET, Kamimori, GH, & **Killgore, WD.** The effects of acute caffeine withdrawal on short category test performance in sleep deprived individuals [abstract]. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A43.

89. Richards, JM, Lipizzi, EL, Kamimori, GH, & **Killgore, WD.** Extroversion predicts change in attentional lapses during sleep deprivation [abstract]. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A137.

90. Lipizzi, EL, Richards, JM, Balkin, TJ, Grugle, NL, & **Killgore, WD.** Morningness-Eveningness and Intelligence [abstract]. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A345.

91. Lipizzi, EL, Richards, JM, Balkin, TJ, Grugle, NL, & **Killgore WD.** Morningness-Eveningness affects risk-taking propensity during sleep deprivation [abstract]. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A136.

92. McBride, SA, Ganesan, G, Kamimori, GH, & **Killgore, WD.** Odor identification ability predicts vulnerability to attentional lapses during 77 hours of sleep deprivation [abstract]. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A135.

93. Smith, KL, McBride, S. A, Kamimori, GH, & **Killgore, WD.** Individual differences in odor discrimination predict mood dysregulation following 56 hours of sleep deprivation [abstract]. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A136.

94. McBride, SA, Leavitt, BP, Kamimori, GH, & **Killgore, WD.** Odor identification accuracy predicts resistance to sleep loss. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A137.

95. Killgore, DB, McBride, SA, Balkin, TJ, Grugle, NL. & **Killgore, WD.** Changes in odor discrimination predict executive function deficits following 45 hours of wakefulness [abstract]. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A136.

96. Rupp, TL, Killgore, DB, Balkin, TJ, Grugle, NL, & **Killgore, WD.** The effects of modafinil, dextroamphetamine, and caffeine on verbal and nonverbal fluency in sleep deprived individuals [abstract]. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A43.

97. Newman, RA, Krugler, AL, Kamimori, GH, & **Killgore, WD.** Changes in state and trait anger following 56 hours of sleep deprivation [abstract]. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A138.

98. Rupp, TL, Grugle, NL, Krugler, AL, Balkin, TJ, & **Killgore, WD.** Caffeine, dextroamphetamine, and modafinil improve PVT performance after sleep deprivation and recovery sleep [abstract]. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A44.

99. **Killgore, WD,** Lipizzi, EL, Balkin, TJ, Grugle, NL, & Killgore, DB. The effects of sleep deprivation and stimulants on self-reported sensation seeking propensity [abstract]. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A42.

100. **Killgore, WD,** Richards, JM, Balkin, TJ, Grugle, NL, & Killgore DB. The effects of sleep deprivation and stimulants on risky behavior [abstract]. Abstract presented at the 21st Meeting

of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A41.

101. Newman, RA, Smith, KL, Balkin, TJ, Grugle, NL, & **Killgore, WD.** The effects of caffeine, dextroamphetamine, and modafinil on executive functioning following 45 hours of sleep deprivation [abstract]. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A45.

102. Richards, JM, Lipizzi, EL, Balkin, TJ, Grugle, NL, & **Killgore, WD.** Objective alertness predicts mood changes during 44 hours of sleep deprivation [abstract]. Abstract presented at the 21st Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 9-14, 2007. SLEEP, 30 (Supplement), A56.

103. **Killgore, WD,** & Yurgelun-Todd, DA. Cortical and Limbic Activation in Response to Visual Images of Low and High-Caloric Food [abstract]. Oral symposium presented at the 6th Annual Conference of the Society of Behavioral Nutrition and Physical Activity (ISBNPA), Oslo, Norway, June 20-23, 2007. Proceedings of the ISBNPA, 2007, 75.

104. Estrada, A, **Killgore, WD,** Rouse, T, Balkin, TJ, & Wildzunas, RM. Total sleep time measured by actigraphy predicts academic performance during military training [abstract]. Abstract presented at the 22nd Meeting of the Associated Professional Sleep Societies, Baltimore, MD, June 7-12, 2008. SLEEP, 31 (Supplement), A134.

105. **Killgore, WD,** Lipizzi, EL, Smith, KL, Killgore, DB, Rupp, TL, Kamimori, GH, & Balkin, T. J. Nonverbal intelligence is inversely related to the ability to resist sleep loss [abstract]. Abstract presented at the 22nd Meeting of the Associated Professional Sleep Societies, Baltimore, MD, June 7-12, 2008. SLEEP, 31 (Supplement), A134.

106. **Killgore, WD,** Lipizzi, EL, Killgore, DB, Rupp, TL, Kamimori, GH, & Balkin, TJ. Emotional intelligence predicts declines in emotion-based decision-making following sleep deprivation [abstract]. Abstract presented at the 22nd Meeting of the Associated Professional Sleep Societies, Baltimore, MD, June 7-12, 2008. SLEEP, 31 (Supplement), A134.

107. Reid, CT, Smith, K, **Killgore, WD,** Rupp, TL, & Balkin, TJ. Higher intelligence is associated with less subjective sleepiness during sleep restriction [abstract]. Abstract presented at the 22nd Meeting of the Associated Professional Sleep Societies, Baltimore, MD, June 7-12, 2008. SLEEP, 31 (Supplement), A375.

108. Newman, R, **Killgore, WD,** Rupp, T. L, & Balkin, TJ. Better baseline olfactory discrimination is associated with worse PVT and MWT performance with sleep restriction and recovery [abstract]. Abstract presented at the 22nd Meeting of the Associated Professional Sleep Societies, Baltimore, MD, June 7-12, 2008. SLEEP, 31 (Supplement), A375.

109. Smith, KL, Reid, CT, **Killgore, WD,** Rupp, TL, & Balkin, TJ. Personality factors associated with performance and sleepiness during sleep restriction and recovery [abstract]. Abstract presented at the 22nd Meeting of the Associated Professional Sleep Societies, Baltimore, MD, June 7-12, 2008. SLEEP, 31 (Supplement), A376.

110. Lipizzi, EL, **Killgore, WD,** Rupp, TL, & Balkin, TJ. Risk-taking behavior is elevated during recovery from sleep restriction [abstract]. Abstract presented at the 22nd Meeting of the Associated Professional Sleep Societies, Baltimore, MD, June 7-12, 2008. SLEEP, 31 (Supplement), A376.

111. Lipizzi, EL, Rupp, TL, **Killgore, WD,** & Balkin, TJ. Sleep restriction increases risk-taking behavior [abstract]. Poster presented at the 11th Annual Force Health Protection Conference, Albuquerque, NM, August, 9-15, 2008.

112. **Killgore, WD,** Estrada, A, Balkin, TJ, & Wildzunas, RM. Sleep duration during army training predicts course performance [abstract]. Poster presented at the 6th Annual Force Health Protection Conference, Albuquerque, NM, August, 11-17, 2008.

113. **Killgore, WD,** Lipizzi, EL, Smith, KL, Killgore, DB, Rupp, TL, Kamimori, GH, & Balkin, TJ. Higher cognitive ability is associated with reduced relative resistance to sleep loss [abstract]. Poster presented at the 6th Annual Force Health Protection Conference, Albuquerque, NM, August, 11-17, 2008.

114. **Killgore, WD,** Rupp, TL, Grugle, NL, Lipizzi, EL, & Balkin, TJ. Maintaining alertness during sustained operations: Which stimulant is most effective after 44 hours without sleep [abstract]? Poster presented at the 6th Annual Force Health Protection Conference, Albuquerque, NM, August, 11-17, 2008.

115. **Killgore, WD,** Newman, RA, Lipizzi, EL, Kamimori, GH, & Balkin, TJ. Sleep deprivation increases feelings of anger but reduces verbal and physical aggression in Soldiers [abstract]. Poster presented at the 6th Annual Force Health Protection Conference, Albuquerque, NM, August, 11-17, 2008.

116. Kelley, AM, Dretsch, M, **Killgore, WD,** & Athy, JR. Risky behaviors and attitudes about risk in Soldiers. Abstract presented at the 29th Annual Meeting of the Society for Judgment and Decision Making, Chicago, IL, November, 2008.

117. **Killgore, WD,** Ross, AJ, Silveri, MM, Gruber, SA, Kamiya, T, Kawada, Y, Renshaw, PF, & Yurgelun-Todd, DA. Citicoline affects appetite and cortico-limbic responses to images of high calorie foods. Abstract presented at the Society for Neuroscience, Washington DC, November 19, 2008.

118. Britton, JC, Stewart, SE, Price, LM, **Killgore, WD,** Gold, AL, Jenike, MA, & Rauch, SL. Reduced amygdalar activation in response to emotional faces in pediatric Obsessive-Compulsive Disorder. Abstract presented at the Annual meeting of the American College of Neuropsychopharmacology, Scottsdale, AZ, December 7-11, 2008.

119. **Killgore, WD,** Balkin, TJ, Estrada, A, & Wildzunas, RM. Sleep and performance measures in soldiers undergoing military relevant training. Abstract presented at the 26th Army Science Conference, Orlando, FL, December 1-4, 2008.

120. **Killgore, WD** & Yurgelun-Todd, DA. Cerebral correlates of amygdala responses during non-conscious perception of affective faces in adolescent children. Abstract presented at the 37th

Annual Meeting of the International Neuropsychological Society, Atlanta, GA, February 11-14, 2009.

121. **Killgore, WD,** Killgore, DB, Grugle, NL, & Balkin, TJ. Odor identification ability predicts executive function deficits following sleep deprivation. Abstract presented the 37th Annual Meeting of the International Neuropsychological Society, Atlanta, GA, February 11-14, 2009.

122. **Killgore, WD,** Rupp, TL, Killgore, DB, Grugle, NL, and Balkin, TJ. Differential effects of stimulant medications on verbal and nonverbal fluency during sleep deprivation. Abstract presented the 37th Annual Meeting of the International Neuropsychological Society, Atlanta, GA, February 11-14, 2009.

123. **Killgore, WD,** Killgore, DB, Kamimori, GH, & Balkin, TJ. When being smart is a liability: More intelligent individuals may be less resistant to sleep deprivation. Abstract presented the 37th Annual Meeting of the International Neuropsychological Society, Atlanta, GA, February 11-14, 2009.

124. **Killgore, WD,** Britton, JC, Price, LM, Gold, AL, Deckersbach, T, & Rauch, SL. Introversion is associated with greater amygdala and insula activation during viewing of masked affective stimuli. Abstract presented the 37th Annual Meeting of the International Neuropsychological Society, Atlanta, GA, February 11-14, 2009.

125. **Killgore, WD,** Britton, JC, Price, LM, Gold, AL, Deckersbach, T, & Rauch, SL. Amygdala responses of specific animal phobics do not differ from healthy controls during masked fearful face perception. Abstract presented the 37th Annual Meeting of the International Neuropsychological Society, Atlanta, GA, February 11-14, 2009.

126. **Killgore, WD,** Britton, JC, Price, LM, Gold, AL, Deckersbach, T, & Rauch, SL. Small animal phobics show sustained amygdala activation in response to masked happy facial expressions. Abstract presented the 37th Annual Meeting of the International Neuropsychological Society, Atlanta, GA, February 11-14, 2009. ***[*Merit Poster Award]***

127. Price, LM, **Killgore, WD,** Britton, JC, Kaufman, ML, Gold, AL, Deckersbach, T, & Rauch, SL. Anxiety sensitivity correlates with insula activation in response to masked fearful faces in specific animal phobics and healthy subjects. Abstract presented at the Annual Conference of the Anxiety Disorders Association of America, Santa Ana Pueblo, New Mexico, March 12-15, 2009.

128. **Killgore, WD,** Britton, JC, Price, LM, Gold, AL, Deckersbach, T, & Rauch, SL. Neuroticism is inversely correlated with amygdala and insula activation during masked presentations of affective stimuli. Abstract presented at the Annual Conference of the Anxiety Disorders Association of America, Santa Ana Pueblo, New Mexico, March 12-15, 2009.

129. **Killgore, WD,** Kelley, AM, & Balkin, TJ. Development and validation of a scale to measure the perception of invincibility. Abstract presented at the Annual Conference of the Anxiety Disorders Association of America, Santa Ana Pueblo, New Mexico, March 12-15, 2009.

130. Kelly, AM, **Killgore WD,** Athy, J, & Dretsch, M. Risk propensity, risk perception, risk aversion,

and sensation seeking in U.S. Army soldiers. Abstract presented at the 80th Annual Scientific Meeting of the Aerospace Medical Association, Los Angeles, CA, May 3-7, 2009.

131. Britton, JC, Stewart, SE, Price, LM, **Killgore, WD,** Jenike, MA, & Rauch, SL. The neural correlates of negative priming in pediatric obsessive-compulsive disorder (OCD). Abstract presented at the 64th Annual Scientific Meeting of the Society of Biological Psychiatry, Vancouver, Canada, May 14-16, 2009.

132. **Killgore, WD,** Killgore, DB, Kamimori, GH, & Balkin, TJ. Caffeine protects against increased risk-taking behavior during severe sleep deprivation. Abstract presented at the 23rd Annual Meeting of the Associated Professional Sleep Societies, Seattle, Washington, June 7-12, 2009.

133. Killgore, DB, **Killgore, WD,** Grugle, NL, & Balkin, TJ. Executive functions predict the ability to sustain psychomotor vigilance during sleep loss. Abstract presented at the 23rd Annual Meeting of the Associated Professional Sleep Societies, Seattle, Washington, June 7-12, 2009.

134. **Killgore, WD,** & Yurgelun-Todd, DA. Trouble falling asleep is associated with reduced activation of dorsolateral prefrontal cortex during a simple attention task. Abstract presented at the 23rd Annual Meeting of the Associated Professional Sleep Societies, Seattle, Washington, June 7-12, 2009.

135. **Killgore, WD,** Kelley, AM, & Balkin, TJ. A new scale for measuring the perception of invincibility. Abstract presented at the 12th Annual Force Health Protection Conference, Albuquerque, New Mexico, August 14-21, 2009.

136. **Killgore, WD,** Killgore, DB, Grugle, NL, & Balkin, TJ. Executive functions contribute to the ability to resist sleep loss. Abstract presented at the 12th Annual Force Health Protection Conference, Albuquerque, New Mexico, August 14-21, 2009.

137. **Killgore, WD,** Killgore, DB, Kamimori, GH, & Balkin, TJ. Caffeine reduces risk-taking behavior during severe sleep deprivation. Abstract presented at the 12th Annual Force Health Protection Conference, Albuquerque, New Mexico, August 14-21, 2009. ***[*Best Paper: Research]***

138. **Killgore, WD,** Castro, CA, & Hoge, CW. Normative data for the Evaluation of Risks Scale—Bubble Sheet Version (EVAR-B) for large scale surveys of returning combat veterans. Abstract presented at the 12th Annual Force Health Protection Conference, Albuquerque, New Mexico, August 14-21, 2009.

139. **Killgore, WD,** Castro, CA, & Hoge, CW. Combat exposure and post-deployment risky behavior. Abstract presented at the 12th Annual Force Health Protection Conference, Albuquerque, New Mexico, August 14-21, 2009.

140. **Killgore, WD**, Price, LM, Britton, JC, Simon, N, Pollack, MH, Weiner, MR, Schwab, ZJ, Rosso, IM, & Rauch, SL. Paralimbic responses to masked emotional faces in PTSD: Disorder and valence specificity. Abstract presented at the Annual McLean Hospital Research Day, January 29, 2010.

141. **Killgore, WD**, Killgore, DB, Kamimori, GH, & Balkin, TJ. Caffeine minimizes behavioral risk-taking during 75 hours of sleep deprivation. Abstract presented at the 38th Annual Meeting of the International Neuropsychological Society, Acapulco, Mexico, February 3-6, 2010.

142. **Killgore, WD** & Balkin, TJ. Vulnerability to sleep loss is affected by baseline executive function capacity. Abstract presented at the 38th Annual Meeting of the International Neuropsychological Society, Acapulco, Mexico, February 3-6, 2010.

143. **Killgore, WD**, Smith, KL, Reichardt, RM., Killgore, DB, & Balkin, TJ. Intellectual capacity is related to REM sleep following sleep deprivation. Abstract presented at the 38th Annual Meeting of the International Neuropsychological Society, Acapulco, Mexico, February 3-6, 2010.

144. **Killgore, WD** & Yurgelun-Todd, DA. Cerebral correlates of amygdala responses to masked fear, anger, and happiness in adolescent and pre-adolescent children. Abstract presented at the 38th Annual Meeting of the International Neuropsychological Society, Acapulco, Mexico, February 3-6, 2010.

145. **Killgore, WD**, Post, A, & Yurgelun-Todd, DA. Sex differences in cortico-limbic responses to images of high calorie food. Abstract presented at the 38th Annual Meeting of the International Neuropsychological Society, Acapulco, Mexico, February 3-6, 2010.

146. **Killgore, WD** & Yurgelun-Todd, DA. Self-reported insomnia is associated with increased activation within the default-mode network during a simple attention task. Abstract presented at the 38th Annual Meeting of the International Neuropsychological Society, Acapulco, Mexico, February 3-6, 2010.

147. **Killgore, WD**, Price, LM, Britton, JC, Gold, AL, Deckersbach, T, & Rauch, SL. Neural correlates of anxiety sensitivity factors during presentation of masked fearful faces. Abstract presented at the 38th Annual Meeting of the International Neuropsychological Society, Acapulco, Mexico, February 3-6, 2010.

148. **Killgore, WD**, Grugle, NL, Conrad, TA, & Balkin, TJ. Baseline executive function abilities predict risky behavior following sleep deprivation. Abstract presented at the 24th Annual Meeting of the Associated Professional Sleep Societies, San Antonio, Texas, June 5-9, 2010.

149. **Killgore, WD**, Grugle, NL, & Balkin, TJ. Judgment of objective vigilance performance is affected by sleep deprivation and stimulants. Abstract presented at the 24th Annual Meeting of the Associated Professional Sleep Societies, San Antonio, Texas, June 5-9, 2010.

150. Killgore, DB, **Killgore, WD**, Grugle, NL, & Balkin, TJ. Resistance to sleep loss and its relationship to decision making during sleep deprivation. Abstract presented at the 24th Annual Meeting of the Associated Professional Sleep Societies, San Antonio, Texas, June 5-9, 2010.

151. Killgore DB, **Killgore, WD**, Grugle, NL, & Balkin, TJ. Subjective sleepiness and objective performance: Differential effects of stimulants during sleep deprivation. Abstract presented at the 24th Annual Meeting of the Associated Professional Sleep Societies, San Antonio, Texas,

June 5-9, 2010.

152. Rupp, TL, **Killgore, WD**, & Balkin, TJ. Vulnerability to sleep deprivation is differentially mediated by social exposure in extraverts vs. introverts. Oral presentation at the "Data Blitz" section at the 24th Annual Meeting of the Associated Professional Sleep Societies, San Antonio, Texas, June 5-9, 2010.

153. Rupp, TL, **Killgore, WD**, & Balkin, TJ. Extraverts may be more vulnerable than introverts to sleep deprivation on some measures of risk-taking and executive functioning. Abstract presented at the 24th Annual Meeting of the Associated Professional Sleep Societies, San Antonio, Texas, June 5-9, 2010.

154. Rupp, TL, **Killgore, WD**, & Balkin, TJ. Vulnerability to sleep deprivation is differentially mediated by social exposure in extraverts vs. introverts. Abstract presented at the 24th Annual Meeting of the Associated Professional Sleep Societies, San Antonio, Texas, June 5-9, 2010.

155. Capaldi, VF, Guerrero, ML, & **Killgore, WD**. Sleep disorders among OIF and OEF Soldiers. Abstract presented at the 24th Annual Meeting of the Associated Professional Sleep Societies, San Antonio, Texas, June 5-9, 2010.

156. **Killgore, WD**, Killgore, DB, Kamimori, GH, & Balkin, TJ. Caffeine reduces behavioral risk-taking during sleep deprivation. Abstract presented at the 65th Annual Meeting of the Society for Biological Psychiatry, New Orleans, Louisiana, May 20-22, 2010.

157. **Killgore, WD**, Price, LM, Britton, JC, Simon, N, Pollack, MH, Weiner, MR, Schwab, ZJ, Rosso, IM, & Rauch, SL. Paralimbic responses to masked emotional faces in PTSD: Disorder and valence specificity. Abstract presented at the 65th Annual Meeting of the Society for Biological Psychiatry, New Orleans, Louisiana, May 20-22, 2010.

158. Rosso, IM, Makris, N, Britton, JC, Price, LM, Gold, AL, Deckersbach, T, **Killgore, WD**, & Rauch SL. Anxiety sensitivity correlates with insular cortex volume and thickness in specific animal phobia. Abstract presented at the 65th Annual Meeting of the Society for Biological Psychiatry, New Orleans, Louisiana, May 20-22, 2010.

159. Rupp, TL, **Killgore, WD**, & Balkin, TJ. Vulnerability to sleep deprivation is mediated by social exposure in extraverts versus introverts. Oral platform presentation at the 20th Congress of the European Sleep Research Society, Lisbon, Portugal, September 14-18, 2010.

160. **Killgore, WD**, Estrada, A, & Balkin, TJ. A tool for monitoring soldier fatigue and predicting cognitive readiness: The Sleep History and Readiness Predictor (SHARP). Abstract presented at the 27th Army Science Conference, Orlando, FL, November 29-December 2, 2010.

161. **Killgore, WD**, Kamimori, GH, & Balkin, TJ. Caffeinated gum minimizes risk-taking in soldiers during prolonged sleep deprivation. Abstract presented at the 27th Army Science Conference, Orlando, FL, November 29-December 2, 2010.

162. **Killgore, WD**, Britton, JC, Schwab, ZJ, Weiner, MR, Rosso, IM, & Rauch, SL. Exaggerated amygdala responses to masked fearful faces are specific to PTSD versus simple phobia. Oral

platform presentation at the 27th Army Science Conference, Orlando, FL, November 29-December 2, 2010. ***[*Winner Best Paper in Neuroscience]***

163. **Killgore, WD**, Kamimori, GH, & Balkin, TJ. Sleep deprivation selectively impairs emotional aspects of cognitive functioning. Oral platform presentation at the 27th Army Science Conference, Orlando, FL, November 29-December 2, 2010.

164. Rupp, TL, **Killgore, WD**, & Balkin, TJ. Evaluation of personality and social exposure as individual difference factors influencing response to sleep deprivation. Oral platform presentation at the 27th Army Science Conference, Orlando, FL, November 29-December 2, 2010.

165. **Killgore, WD**, Britton, JC, Rosso, IM, Schwab, ZJ, Weiner, MR, & Rauch, SL. Shared and differential patterns of amygdalo-cortical activation across anxiety disorders. Abstract presented at the 49th Annual Meeting of the American College of Neuropsychopharmacology, Miami Beach, FL, December 5-9, 2010.

166. Rosso, IM, **Killgore, WD**, Britton, JC, Weiner, MR, Schwab, ZJ, & Rauch, SL. Neural correlates of PTSD symptom dimensions during emotional processing: A functional magnetic resonance imaging study. Abstract presented at the 49th Annual Meeting of the American College of Neuropsychopharmacology, Miami Beach, FL, December 5-9, 2010.

167. **Killgore, WD,** Rosso, IM, Britton, JC, Schwab, ZJ, Weiner, MR, & Rauch, SL. Cortico-limbic activation differentiates among anxiety disorders with and without a generalized threat response. Abstract presented at the McLean Hospital Research Day, January 13, 2011.

168. Weiner, MR, Schwab, ZJ, Rauch, SL, & **Killgore WD**. Personality factors predict brain responses to images of high-calorie foods. Abstract presented at the McLean Hospital Research Day, January 13, 2011.

169. Schwab, ZJ, Weiner, MR, Rauch, SL, & **Killgore, WD.** Emotional and cognitive intelligence: Support for the neural efficiency hypothesis. Abstract presented at the McLean Hospital Research Day, January 13, 2011.

170. Crowley, DJ, Covell, MJ, **Killgore, WD**, Schwab, ZJ, Weiner, MR, Acharya, D, Rosso, IM, & Silveri, MM. Differential influence of facial expression on inhibitory capacity in adolescents versus adults. Abstract presented at the McLean Hospital Research Day, January 13, 2011.

171. **Killgore, WD**, Britton, JC, Rosso, IM, Schwab, ZJ, Weiner, MR, & Rauch, SL. Similarities and differences in cortico-limbic responses to masked affect probes across anxiety disorders. Abstract presented at the 39th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 2-5, 2011.

172. Rosso, IM, **Killgore, WD**, Britton, JC, Weiner, MR, Schwab, ZJ, & Rauch, SL. Hyperarousal and reexperiencing symptoms of post-traumatic stress disorder are differentially associated with limbic-prefrontal brain responses to threatening stimuli. Abstract presented at the 39th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 2-5, 2011.

173. Schwab, ZJ, Weiner, MR, Rauch, SL, & **Killgore, WD**. Neural correlates of cognitive and emotional intelligence in adults. Abstract presented at the 39th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 2-5, 2011.

174. Schwab, ZJ, Weiner, MR, Rauch, SL, & **Killgore, WD**. Cognitive and emotional intelligences: Are they distinct or related constructs? Abstract presented at the 39th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 2-5, 2011.

175. Schwab, ZJ, Weiner, MR, Rauch, SL, & **Killgore, WD**. Discrepancy scores between cognitive and emotional intelligence predict neural responses to affective stimuli. Abstract presented at the 39th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 2-5, 2011.

176. **Killgore, WD**, Schwab, ZJ, Weiner, MR, & Rauch, SL. Smart people go with their gut: Emotional intelligence correlates with non-conscious insular responses to facial trustworthiness. Abstract presented at the 39th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 2-5, 2011.

177. **Killgore, WD**, Weiner, MR, Schwab, ZJ, & Rauch, SL. Whom can you trust? Neural correlates of subliminal perception of facial trustworthiness. Abstract presented at the 39th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 2-5, 2011.

178. Weiner, MR, Schwab, ZJ, & Rauch, SL, **Killgore, WD**. Impulsiveness predicts responses of brain reward circuitry to high-calorie foods. Abstract presented at the 39th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 2-5, 2011.

179. Weiner, MR, Schwab, ZJ, & Rauch, SL, **Killgore, WD**. Conscientiousness predicts brain responses to images of high-calorie foods. Abstract presented at the 39th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 2-5, 2011.

180. Crowley, DJ, Covell, MJ, **Killgore, WD**, Schwab, ZJ, Weiner, MR, Acharya, D, Rosso, IM, & Silveri, MM. Differential influence of facial expression on inhibitory capacity in adolescents versus adults. Abstract presented at the 39th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 2-5, 2011.

181. Gruber, SA, Dahlgren, MK, **Killgore, WD**, Sagar, KA, & Racine, MT. Marijuana: Age of onset of use impacts executive function and brain activation. Abstract presented at the 39th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 2-5, 2011.

182. **Killgore, WD,** Conrad, TA, Grugle, NL, & Balkin, TJ. Baseline executive function abilities correlate with risky behavior following sleep deprivation. Abstract presented at the 39th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 2-5, 2011.

183. **Killgore, WD,** Grugle, NL, Killgore, DB, & Balkin, TJ. Resistance to sleep loss and decision making during sleep deprivation. Abstract presented at the 39th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 2-5, 2011.

184. **Killgore, WD,** Rosso, IM, Britton, JC, Schwab, ZJ, Weiner, MR, & Rauch, SL. Cortico-limbic activation differentiates among anxiety disorders with and without a generalized threat response. Abstract presented at the 66th Annual Meeting of the Society for Biological Psychiatry, San Francisco, CA, May 12-14, 2011. ***[*Blue Ribbon Finalist: Clinical/Translational]***

185. Schwab, ZJ, Weiner, MR, Rauch, SL, & **Killgore, WD.** Emotional and cognitive intelligence: Support for the neural efficiency hypothesis. Abstract presented at the 66th Annual Meeting of the Society for Biological Psychiatry, San Francisco, CA, May 12-14, 2011.

186. Weiner, MR, Schwab, ZJ, Rauch, SL, & **Killgore WD**. Personality factors predict brain responses to images of high-calorie foods. Abstract presented at the 66th Annual Meeting of the Society for Biological Psychiatry, San Francisco, CA, May 12-14, 2011.

187. **Killgore, WD,** Grugle, NL, & Balkin, TJ. Sleep deprivation impairs recognition of specific emotions. Abstract presented at the 25th Annual Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 11-15, 2011.

188. **Killgore, WD,** & Balkin, TJ. Does vulnerability to sleep deprivation influence the effectiveness of stimulants on psychomotor vigilance? Abstract presented at the 25th Annual Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 11-15, 2011.

189. Killgore, DB, **Killgore, WD,** Grugle, NJ, & Balkin, TJ. Sleep deprivation impairs recognition of specific emotions. Abstract presented at the 25th Annual Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 11-15, 2011.

190. Weiner, MR, Schwab, ZJ, & **Killgore, WD.** Daytime sleepiness is associated with altered brain activation during visual perception of high-calorie foods: An fMRI study. Abstract presented at the 25th Annual Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 11-15, 2011.

191. Schwab, ZJ, Weiner, MR, & **Killgore, WD.** Functional MRI correlates of morningness-eveningness during visual presentation of high calorie foods. Abstract presented at the 25th Annual Meeting of the Associated Professional Sleep Societies, Minneapolis, MN, June 11-15, 2011.

192. **Killgore, WD,** Weiner, MR, & Schwab, ZJ. Daytime sleepiness affects prefrontal regulation of food intake. Abstract presented at the McLean Hospital Research Day, January 11, 2012.

193. Kipman, M, Schwab ZJ, Weiner, MR, DelDonno, S, Rauch SL, & **Killgore WD**. The insightful yet bitter comedian: The role of emotional versus cognitive intelligence in humor appreciation. Abstract presented at the McLean Hospital Research Day, January 11, 2012.

194. Weber, M, & **Killgore, WD**. Gray matter correlates of emotional intelligence. Abstract presented at the McLean Hospital Research Day, January 11, 2012.

195. Schwab, ZJ, & **Killgore, WD**. Sex differences in functional brain responses to food. Abstract

presented at the McLean Hospital Research Day, January 11, 2012.

196. DelDonno, S, Schwab, ZJ, Kipman M, Rauch, SL, & **Killgore, WD**. The influence of cognitive and emotional intelligence on performance on the Iowa Gambling Task. Abstract presented at the McLean Hospital Research Day, January 11, 2012.

197. Song, CH, Kizielewicz, J, Schwab, ZJ, Weiner, MR, Rauch, SL, & **Killgore, WD**. Time is of the essence: The Design Organization Test as a valid, reliable, and brief measure of visuospatial ability. Abstract presented at the 40th Annual Meeting of the International Neuropsychological Society, Montreal, CA, February 15-18, 2012.

198. Kipman, M, Schwab, ZJ, DelDonno, S, & **Killgore, WD**. Gender differences in the contribution of cognitive and emotional intelligence to the left visual field bias for facial perception. Abstract presented at the 40th Annual Meeting of the International Neuropsychological Society, Montreal, CA, February 15-18, 2012.

199. Kipman, M., Schwab, ZJ, Weiner, MR, DelDonno, S, Rauch, SL, & **Killgore, WD**. Contributions of emotional versus cognitive intelligence in humor appreciation. Abstract presented at the 40th Annual Meeting of the International Neuropsychological Society, Montreal, CA, February 15-18, 2012.

200. Schwab, ZJ, & **Killgore, WD**. Disentangling emotional and cognitive intelligence. Abstract presented at the 40th Annual Meeting of the International Neuropsychological Society, Montreal, CA, February 15-18, 2012.

201. Schwab, ZJ, & **Killgore, WD**. Sex differences in functional brain responses to food. Abstract presented at the 40th Annual Meeting of the International Neuropsychological Society, Montreal, CA, February 15-18, 2012.

202. DelDonno, S, Schwab, ZJ, Kipman, M, Rauch, SL, & **Killgore, WD**. The influence of cognitive and emotional intelligence on performance on the Iowa Gambling Task. Abstract presented at the 40th Annual Meeting of the International Neuropsychological Society, Montreal, CA, February 15-18, 2012.

203. **Killgore, WD**, Britton, JC, Rosso, IM, Schwab, ZJ, Weiner, MR, & Rauch, SL. Shared and unique patterns of cortico-limbic activation across anxiety disorders. Abstract presented at the 40th Annual Meeting of the International Neuropsychological Society, Montreal, CA, February 15-18, 2012.

204. **Killgore, WD**, & Balkin, TJ. Sleep deprivation degrades recognition of specific emotions. Abstract presented at the 40th Annual Meeting of the International Neuropsychological Society, Montreal, CA, February 15-18, 2012.

205. **Killgore, WD**, & Schwab, ZJ. Emotional intelligence correlates with somatic marker circuitry responses to subliminal cues of facial trustworthiness. Abstract presented at the 40th Annual Meeting of the International Neuropsychological Society, Montreal, CA, February 15-18, 2012.

206. **Killgore, WD**, & Schwab, ZJ. Trust me! Neural correlates of the ability to identify facial trustworthiness. Abstract presented at the 40th Annual Meeting of the International Neuropsychological Society, Montreal, CA, February 15-18, 2012.

207. **Killgore, WD**, Schwab, ZJ, Weiner, MR, Kipman, M, DelDonno, S, & Rauch SL. Overeating is associated with altered cortico-limbic responses to images of high calorie foods. Abstract presented at the 40th Annual Meeting of the International Neuropsychological Society, Montreal, CA, February 15-18, 2012.

208. **Killgore, WD**, Weiner, MR, & Schwab, ZJ. Daytime sleepiness affects prefrontal regulation of food intake. Abstract presented at the 40th Annual Meeting of the International Neuropsychological Society, Montreal, CA, February 15-18, 2012.

209. Weber, M, DelDonno, S, Kipman M, Schwab, ZJ, & **Killgore WD**. Grey matter correlates of self-reported sleep duration. Abstract presented at the Harvard Medical School Research Day, Boston, MA, March 28, 2012.

210. **Killgore, WD**. Overlapping and distinct patterns of neurocircuitry across PTSD, Panic Disorder, and Simple Phobia. Abstract presented at the 32nd Annual Conference of the Anxiety Disorders Association of America, Arlington, VA, April 12-15, 2012.

211. **Killgore, WD**, Britton, JC, Rosso, IM, Schwab, ZJ, & Rauch, SL. Shared and unique patterns of cortico-limbic activation across anxiety disorders. Abstract presented at the 67th Annual Meeting of the Society of Biological Psychiatry, Philadelphia, PA, May 3-5, 2012.

212. **Killgore, WD**, Schwab, ZJ, & Rauch, SL. Daytime sleepiness affects prefrontal inhibition of food consumption. Abstract presented at the 67th Annual Meeting of the Society of Biological Psychiatry, Philadelphia, PA, May 3-5, 2012.

213. Rosso, IM, Britton, JC, Makris, N, **Killgore, WD**, Rauch SL, & Stewart ES. Impact of major depression comorbidity on prefrontal and anterior cingulate volumes in pediatric OCD. Abstract presented at the 67th Annual Meeting of the Society of Biological Psychiatry, Philadelphia, PA, May 3-5, 2012.

214. Kipman, M, Weber, M, DelDonno, S., Schwab, ZJ, & **Killgore, WD**. Morningness-Eveningness correlates with orbitofrontal gray matter volume. Abstract presented at the 26th Annual Meeting of the Associated Professional Sleep Societies, Boston, MA, June 9-13, 2012.

215. Kipman, M, Schwab, ZJ, Weber, M, DelDonno, S, & **Killgore, WD**. Yawning frequency is correlated with reduced medial thalamic volume. Abstract presented at the 26th Annual Meeting of the Associated Professional Sleep Societies, Boston, MA, June 9-13, 2012.

216. Weber, M, DelDonno, S, Kipman M, Schwab, ZJ, & **Killgore WD**. Grey matter correlates of daytime sleepiness. Abstract presented at the 26th Annual Meeting of the Associated Professional Sleep Societies, Boston, MA, June 9-13, 2012.

217. Weber, M, DelDonno, S, Kipman M, Schwab, ZJ, & **Killgore WD**. Grey matter correlates of self-reported sleep duration. Abstract presented at the 26th Annual Meeting of the Associated

Professional Sleep Societies, Boston, MA, June 9-13, 2012.

218. DelDonno, S, Weber, M, Kipman M, Schwab, ZJ, & **Killgore, WD**. Resistance to insufficient sleep correlates with olfactory cortex gray matter. Abstract presented at the 26th Annual Meeting of the Associated Professional Sleep Societies, Boston, MA, June 9-13, 2012.

219. DelDonno, S, Schwab, ZJ, Kipman, M, Weber, M, & **Killgore, WD**. Weekend sleep is related to greater coping and resilience capacities. Abstract presented at the 26th Annual Meeting of the Associated Professional Sleep Societies, Boston, MA, June 9-13, 2012.

220. Schwab, ZJ, DelDonno, S, Weber, M, Kipman M, & **Killgore, WD**. Habitual caffeine consumption and cerebral gray matter volume. Abstract presented at the 26th Annual Meeting of the Associated Professional Sleep Societies, Boston, MA, June 9-13, 2012.

221. Schwab, ZJ, & **Killgore, WD**. Daytime sleepiness affects prefrontal regulation of food intake. Abstract presented at the 26th Annual Meeting of the Associated Professional Sleep Societies, Boston, MA, June 9-13, 2012.

222. **Killgore, WD**, Schwab, ZJ, DelDonno S, Kipman, M, Weber M, & Rauch, SL. Greater nocturnal sleep time is associated with increased default mode functional connectivity. Abstract presented at the 26th Annual Meeting of the Associated Professional Sleep Societies, Boston, MA, June 9-13, 2012.

223. **Killgore, WD**, Kamimori, GH, & Balkin, TJ. Caffeine improves efficiency of planning and sequencing abilities during sleep deprivation. Abstract presented at the 26th Annual Meeting of the Associated Professional Sleep Societies, Boston, MA, June 9-13, 2012.

224. Sneider, JT, **Killgore, WD**, Crowley, DJ, Cohen-Gilbert, JE, Schwab, ZJ, & Silveri, MM. Inhibitory capacity in emerging adult binge drinkers: Influence of Facial Cues. Abstract presented at the 35th Annual Scientific Meeting of the Research Society on Alcoholism, San Francisco, CA, June 23-27, 2012.

225. **Killgore WD**. Multimodal neuroimaging to predict cognitive resilience against sleep loss. Abstract presented at the DARPA Young Faculty Award 2012 Meeting, Arlington, VA, July 30-31, 2012. ***[*Winner Young Faculty Award in Neuroscience]***

226. Cohen-Gilbert, JE, **Killgore WD**, Crowley, DJ, Covell, MJ, Schwab, ZJ, Weiner, MR, Acharya, D, Sneider, JT, & Silveri, MM. Differential influence of safe versus threatening facial expressions on inhibitory control across adolescence and adulthood. Abstract presented at the Society for Neuroscience 2012 Meeting, New Orleans, LA, October 13-17, 2012.

227. Weber, M, DelDonno, S, Kipman M, Schwab, ZJ, & **Killgore WD**. Grey matter correlates of self-reported sleep duration. Abstract presented at the Harvard Division of Sleep Medicine Annual Poster Session, Boston, MA, September 27, 2012.

228. Weber, M, DelDonno, SR, Kipman, M, Preer, LA, Schwab ZJ, Weiner, MR, & **Killgore, WD.** The effect of morning bight light therapy on sleep, cognition and emotion following mild traumatic brain injury. Abstract presented at the 2012 Sleep Research Network Meeting, 22-23

October 2012, Bethesda, MD.

229. Sneider, JT, **Killgore, WD**, Crowley, DJ, Cohen-Gilbert, JE, Schwab, ZJ, & Silveri, MM. Inhibitory capacity in emerging adult binge drinkers: Influence of Facial Cues. Abstract presented at the Annual McLean Hospital Research Day, January 16, 2013.

230. Cohen-Gilbert, JE, **Killgore WD**, Crowley, DJ, Covell, MJ, Schwab, ZJ, Weiner, MR, Acharya, D, Sneider, JT, & Silveri, MM. Differential influence of safe versus threatening facial expressions on inhibitory control across adolescence and adulthood. Abstract presented at the Annual McLean Hospital Research Day, January 16, 2013.

231. Tkachenko, O, Schwab, ZJ, Kipman, M, DelDonno, S, Gogel, H., Preer, L, & **Killgore, WD**. Smarter women need less sleep. Abstract presented at the Annual McLean Hospital Research Day, January 16, 2013.

232. DelDonno, S, Kipman, M, Schwab, ZJ, & **Killgore, WD**. The contributions of emotional intelligence and facial perception to social intuition. Abstract presented at the Annual McLean Hospital Research Day, January 16, 2013.

233. Kipman, M, Schwab, ZJ, DelDonno, S, Weber, M, Rauch, SL, & **Killgore, WD**. The neurocircuitry of impulsive behavior. Abstract presented at the Annual McLean Hospital Research Day, January 16, 2013.

234. Preer, LA, Tkachenko, O, Gogel, H, Schwab, ZJ, Kipman, M, DelDonno, SR, Weber, M, Webb, CA, & **Killgore, WD**. Emotional intelligence as a mediator of the association between anxiety sensitivity and anxiety symptoms. Abstract presented at the Annual McLean Hospital Research Day, January 16, 2013.

235. Gogel, H, DelDonno, S, Kipman M, Preer, LA, Schwab, ZJ, Tkachenko, O, & **Killgore, WD**. Validation of the Design Organization Test (DOT) in a healthy population. Abstract presented at the Annual McLean Hospital Research Day, January 16, 2013.

236. Brennan, BP, Schwab, ZS, Athey, AJ, Ryan, EM, Pope, HG, **Killgore, WD**, Jenike, MA, & Rauch, SL. A functional magnetic resonance imaging study of rostral anterior cingulate cortex activation in obsessive-compulsive disorder using an emotional counting stroop paradigm. Abstract presented at the Annual McLean Hospital Research Day, January 16, 2013.

237. Cohen-Gilbert, JE, Schwab, ZJ, **Killgore, WD**, Crowley, DJ, & Silveri MM. Influence of Binge Drinking on the Neural Correlates of Inhibitory Control during Emotional Distraction in Young Adults. Abstract presented at the 3rd International Conference on Applications of Neuroimaging to Alcoholism (ICANA-3), New Haven, CT, February 15-18, 2013.

238. Weber, M, & **Killgore, WD**. The interrelationship between 'sleep credit', emotional intelligence and mental health – a voxel-based morphometric study. Abstract presented at Harvard Medical School Psychiatry Research Day, April 10, 2013.

239. Cohen-Gilbert, JE, Schwab, ZJ, **Killgore, WD**, Crowley, DJ, & Silveri MM. Influence of Binge Drinking on the Neural Correlates of Inhibitory Control during Emotional Distraction in

Young Adults. Abstract presented at Harvard Medical School Psychiatry Research Day, April 10, 2013.

240. Mundy, EA, Weber, M, Rauch, SL, **Killgore, WD**, & Rosso, IM. The relationship between subjective stress levels in childhood and anxiety as well as perceived stress as an adult. Abstract presented at Harvard Medical School Psychiatry Research Day, April 10, 2013.

241. Webb, CA, **Killgore, WD**, Britton, JC, Schwab, ZJ, Price, LM, Weiner, MR, Gold, AL, Rosso, IM, Simon, NM, Pollack, MH, & Rauch, SL. Comparing categorical versus dimensional predictors of functional response across three anxiety disorders. Abstract presented at the 68th Annual Meeting of the Society of Biological Psychiatry, San Francisco, CA, May 16-18, 2013.

242. Preer, LA, Tkachenko, O, Gogel, H, Schwab, ZJ, Kipman, M, DelDonno, SR, Weber, M, Webb, CA, Rauch, SL, & **Killgore, WD**. Linking Sleep Trouble to Neuroticism, Emotional Control, and Impulsiveness. Abstract presented at the 68th Annual Meeting of the Society of Biological Psychiatry, San Francisco, CA, May 16-18, 2013.

243. Preer, LA, Tkachenko, O, Gogel, H, Schwab, ZJ, Kipman, M, DelDonno, SR, Weber, M, Webb, CA, Rauch, SL, & **Killgore, WD**. Emotional Intelligence as a Mediator of the Association between Anxiety Sensitivity and Anxiety Symptoms. Abstract presented at the 68th Annual Meeting of the Society of Biological Psychiatry, San Francisco, CA, May 16-18, 2013.

244. Kipman, M, Schwab, ZJ, DelDonno, S, Weber, M, Rauch, SL, & **Killgore, WD**. The neurocircuitry of impulsive behavior. Abstract presented at the 68th Annual Meeting of the Society of Biological Psychiatry, San Francisco, CA, May 16-18, 2013.

245. Weber, M, **Killgore, WD**, Rosso, IM, Britton, JC, Simon, NM, Pollack, MH, & Rauch, SL. Gray matter correlates of posttraumatic stress disorder—A voxel based morphometry study. Abstract presented at the 68th Annual Meeting of the Society of Biological Psychiatry, San Francisco, CA, May 16-18, 2013.

246. Weber, M, Penetar, DM, Trksak, GH, DelDonno, SR, Kipman, M, Schwab, ZJ, & **Killgore, WD**. Morning blue wavelength light therapy improves sleep, cognition, emotion and brain function following mild traumatic brain injury. Abstract presented at the 68th Annual Meeting of the Society of Biological Psychiatry, San Francisco, CA, May 16-18, 2013.

247. Tkachenko, O, Schwab, ZJ, Kipman, M, Preer, LA, Gogel, H, DelDonno, SR, Weber, M, Webb, CA, Rauch, SL, & **Killgore, WD**. Difficulty in falling asleep and staying asleep linked to a sub-clinical increase in symptoms of psychopathology. Abstract presented at the 68th Annual Meeting of the Society of Biological Psychiatry, San Francisco, CA, May 16-18, 2013.

248. **Killgore, WD**, Schwab, ZJ, Kipman, M, DelDonno, SR, Rauch, SL, & Weber, M. Problems with sleep initiation and sleep maintenance correlate with functional connectivity among primary sensory cortices. Abstract presented at the 68th Annual Meeting of the Society of Biological Psychiatry, San Francisco, CA, May 16-18, 2013.

249. **Killgore, WD**, Schwab, ZJ, Kipman, M, DelDonno, SR, Rauch, SL, & Weber, M. A Couple of Hours Can Make a Difference: Self-Reported Sleep Correlates with Prefrontal-Amygdala

Connectivity and Emotional Functioning. Abstract presented at the 68th Annual Meeting of the Society of Biological Psychiatry, San Francisco, CA, May 16-18, 2013.

250. Brennan, BP, Schwab, ZS, Athey, AJ, Ryan, EM, Pope, HG, **Killgore, WD**, Jenike, MA, & Rauch, SL. A functional magnetic resonance imaging study of rostral anterior cingulate cortex activation in obsessive-compulsive disorder using an emotional counting stroop paradigm. Abstract presented at the 68th Annual Meeting of the Society of Biological Psychiatry, San Francisco, CA, May 16-18, 2013.

251. Weber, M, & **Killgore, WD**. The interrelationship between 'sleep credit', emotional intelligence and mental health – a voxel-based morphometric study. Abstract presented at the SLEEP 2013 Annual Meeting, Baltimore, MD, June 1-5, 2013.

252. Weber, M, Penetar, DM, Trksak, GH, DelDonno, SR, Kipman, M, Schwab, ZJ, & **Killgore, WD**. Morning blue wavelength light therapy improves sleep, cognition, emotion and brain function following mild traumatic brain injury. Abstract presented at the SLEEP 2013 Annual Meeting, Baltimore, MD, June 1-5, 2013.

253. **Killgore, WD**, Schwab, ZJ, Kipman, M, DelDonno, SR, & Weber, M. Problems with Sleep Initiation and Sleep Maintenance Correlate with Functional Connectivity Among Primary Sensory Cortices. Abstract presented at the SLEEP 2013 Annual Meeting, Baltimore, MD, June 1-5, 2013.

254. **Killgore, WD**, Schwab, ZJ, Kipman, M, DelDonno, SR, & Weber, M. A Couple of Hours Can Make a Difference: Self-Reported Sleep Correlates with Prefrontal-Amygdala Connectivity and Emotional Functioning. Abstract presented at the SLEEP 2013 Annual Meeting, Baltimore, MD, June 1-5, 2013.

255. Tkachenko, O, Schwab, ZJ, Kipman, M, DelDonno, SR, Preer, LA, Gogel, H, Weber, M, Webb, CA, & **Killgore, WD**. Difficulty in falling asleep and staying asleep linked to a sub-clinical increase in symptoms of psychopathology. Abstract presented at the SLEEP 2013 Annual Meeting, Baltimore, MD, June 1-5, 2013.

256. Preer, LA, Tkachenko, O, Gogel, H, Schwab, ZJ, Kipman, M, DelDonno, SR, Weber, M, Webb, CA, & **Killgore, WD**. Linking Sleep Initiation Trouble to Neuroticism, Emotional Control, and Impulsiveness. Abstract presented at the SLEEP 2013 Annual Meeting, Baltimore, MD, June 1-5, 2013.

257. **Killgore, WD**. Sleep duration contributes to cortico-limbic functional connectivity, emotional functioning, & psychological health. Abstract presented at the 52nd Annual Meeting of the American College of Neuropsychopharmacology, Hollywood, FL, December 8-12, 2013.

258. Preer, L, Tkachenko, O, Gogel, H, Bark, JS, Kipman, M, Olson, EA, & **Killgore, WD**. The role of personality in sleep initiation problems. Abstract presented at the Annual McLean Hospital Research Day, January 22, 2014.

259. Demers, LA, Olson, EA, Weber, M, Divatia, S, Preer, L, & **Killgore, WD**. Paranoid traits are related to deficits in complex social decision-making and reduced superior temporal sulcus

volume. Abstract presented at the Annual McLean Hospital Research Day, January 22, 2014.

260. Tkachenko, O, Weber, M, Gogel, H, & **Killgore, WD**. Predisposition towards unhealthy foods linked with increased gray matter in the cerebellum. Abstract presented at the Annual McLean Hospital Research Day, January 22, 2014.

261. Olson, EA, Weber, M, Tkachenko, O, & **Killgore, WD**. Daytime sleepiness is associated with decreased integration of remote outcomes on the IGT. Abstract presented at the Annual McLean Hospital Research Day, January 22, 2014.

262. Cui, J, Tkachenko, O, & **Killgore, WD**. Can the activation of anterior cingulate predict the emotional suppression? An fMRI study with masked faces. Abstract presented at the Annual McLean Hospital Research Day, January 22, 2014.

263. Gogel, H, & **Killgore WDS**. A psychometric validation of the Design Organization Test (DOT) in a healthy sample. Abstract presented at the 42nd Annual Meeting of the International Neuropsychological Society, Seattle WA, February 12-15, 2014.

264. **Killgore, WD**, Kipman, M, Tkachenko, O, Gogel, H., Preer, L, Demers, LA, Divatia, SC, Olson, EA, & Weber, M. Predicting resilience against sleep loss with multi-modal neuroimaging. Abstract presented at the 42nd Annual Meeting of the International Neuropsychological Society, Seattle WA, February 12-15, 2014.

265. **Killgore, WD**, Weber, M, Bark, JS, Kipman, M, Gogel, H, Preer, L, Tkachenko, O, Demers, LA, Divatia, SC, & Olson, EA. Physical exercise correlates with hippocampal volume in healthy adults. Abstract presented at the 42nd Annual Meeting of the International Neuropsychological Society, Seattle WA, February 12-15, 2014.

266. **Killgore, WD**, Tkachenko, O, Weber, M, Kipman, M, Preer, L, Gogel, H, & Olson, EA. The association between sleep, functional connectivity, and emotional functioning. Abstract presented at the 42nd Annual Meeting of the International Neuropsychological Society, Seattle WA, February 12-15, 2014.

267. Preer, L, Tkachenko, O, Gogel, H, Bark, JS, Kipman, M, Olson, EA, & **Killgore, WD**. The role of personality in sleep initiation problems. Abstract presented at the 42nd Annual Meeting of the International Neuropsychological Society, Seattle WA, February 12-15, 2014.

268. Tkachenko, O, Weber, M, Olson, EA, Gogel, H, Preer, LA, Divatia, SC, Demers, LA, & **Killgore, WD**. Gray matter volume within the medial prefrontal cortex correlates with behavioral risk taking. Abstract presented at the 42nd Annual Meeting of the International Neuropsychological Society, Seattle WA, February 12-15, 2014.

269. Olson, EA, Weber, M, Bark JS, Demers L, Divatia, SC, Gogel, H, Kipman M, Preer, L, Tkachenko, O, & **Killgore, WD**. Sex differences in threat evaluation of emotionally neutral faces. Abstract presented at the 42nd Annual Meeting of the International Neuropsychological Society, Seattle WA, February 12-15, 2014.

270. Cui, J, Tkachenko, O, & **Killgore, WD**. Can the activation of anterior cingulate predict the

emotional suppression? An fMRI study with masked faces. Abstract presented at the 36nd Annual Conference of the Anxiety Disorders Association of America, Chicago, IL, March 27-30, 2014.

271. Webb, CA, Weber, M, Mundy, EA, & **Killgore, WD**. Reduced gray matter volume in the anterior cingulate, orbitofrontal cortex and thalamus as a function of depressive symptoms: A voxel-based morphometric analysis. Abstract presented at the 36nd Annual Conference of the Anxiety Disorders Association of America, Chicago, IL, March 27-30, 2014.

272. Weber, M, Penetar, DM, Trksak, GH, Kipman, M, Tkachenko, O, Bark, JS, Jorgensen, AL, Rauch, SL, & **Killgore, WD**. Light therapy may improve sleep and facilitate recovery from mild traumatic brain injury. Abstract presented at the 10th World Congress on Brain Injury, San Francisco, CA, March 19-22, 2014.

273. Cui, J, Tkachenko, O, & **Killgore, WD**. Can the activation of anterior cingulate predict the emotional suppression? An fMRI study with masked faces. Abstract presented at the 21st Annual Meeting of the Cognitive Neuroscience Society, Boston, MA, April 5-8, 2014.

274. Divatia, S, Demers, LA, Preer, L, Olson, EA, Weber, M, & **Killgore, WD**. Advantageous decision making linked with increased gray matter volume in the ventromedial prefrontal cortex. Abstract presented at the 21st Annual Meeting of the Cognitive Neuroscience Society, Boston, MA, April 5-8, 2014.

275. Demers, LA, Olson, EA, Weber, M, Divatia, S, Preer, L, & **Killgore, WD**. Paranoid traits are related to deficits in complex social decision making and reduced superior temporal sulcus volume. Abstract presented at the 21st Annual Meeting of the Cognitive Neuroscience Society, Boston, MA, April 5-8, 2014.

276. Preer, LA, Weber, M, Tkachenko, O, Divatia, S, Demers, LA, Olson, EA, & **Killgore, WD**. Gray matter volume in the amygdala is associated with facial assessments of trustworthiness. Abstract presented at the 21st Annual Meeting of the Cognitive Neuroscience Society, Boston, MA, April 5-8, 2014.

277. Tkachenko, O, Weber, M, Gogel, H, & **Killgore, WD**. Predisposition towards unhealthy foods linked with increased gray matter volume in the cerebellum. Abstract presented at the 21st Annual Meeting of the Cognitive Neuroscience Society, Boston, MA, April 5-8, 2014.

278. Olson, EA, Weber, M, Gogel, H, & **Killgore, WD**. Daytime sleepiness is associated with decreased integration of remote outcomes on the IGT. Abstract presented at the 21st Annual Meeting of the Cognitive Neuroscience Society, Boston, MA, April 5-8, 2014.

279. Demers, LA, Preer, LA, Gogel, H, Olson, EA, Weber, M, & **Killgore, WD**. Left-hemifield bias on sad chimeric face task correlates with interpersonal emotional intelligence. Abstract presented at the 69th Annual Meeting of the Society of Biological Psychiatry, New York, NY, May 8-10, 2014.

280. Weber, M, **Killgore, WD**, Olson, EA, Rosso, IM, & Rauch, SL. Morphological brain network organization in relation to trauma and posttraumatic stress disorder. Abstract presented at the

69th Annual Meeting of the Society of Biological Psychiatry, New York, NY, May 8-10, 2014.

281. Divatia, S, Demers, LA, Preer, L, Gogel, H, Kipman, M, & **Killgore, WD**. Schizotypal and manic traits are associated with poorer perception of emotions in healthy individuals. Abstract presented at the 69th Annual Meeting of the Society of Biological Psychiatry, New York, NY, May 8-10, 2014.

282. **Killgore, WD**, Weber, M, Olson, EA, & Rauch, SL. Sleep reduction and functioning of the emotion regulation circuitry. Abstract presented at the 69th Annual Meeting of the Society of Biological Psychiatry, New York, NY, May 8-10, 2014. ***[*Blue Ribbon Finalist for Top Poster Award: Basic Neuroscience]***

283. Webb, CA, Weber, M, Mundy, EA, & **Killgore, WD**. Reduced gray matter volume in the anterior cingulate, orbitofrontal cortex and thalamus as a function of depressive symptoms: A voxel-based morphometric analysis. Abstract presented at the 69th Annual Meeting of the Society of Biological Psychiatry, New York, NY, May 8-10, 2014.

284. Marin MF, Song H, Landau AJ, Lasko NB, Foy Preer LA, Campbell A, Pace-Schott EF, **Killgore WD**, Orr SP, Pitman RK, Simon NM, Milad MR (2014). Psychophysiological and Neuroimaging Correlates of Fear Extinction Deficits Across Anxiety Disorders. Abstract presented at the 69th Annual Meeting of the Society of Biological Psychiatry, New York, NY, May 8-10, 2014.

285. **Killgore, WD**. The effects of sleep loss on food preference. Abstract presented at SLEEP 2014, Minneapolis, MN, May 31-June 4, 2014.

286. Weber, M, & **Killgore, WD**. Sleep habits reflect in functional brain network organization. Abstract presented at SLEEP 2014, Minneapolis, MN, May 31-June 4, 2014. ***[*2014 AASM Young Investigator Award, Honorable Mention]***

287. Freed, MC, Novak, LA, **Killgore, WD**, Koehlmoos, TP, Ginsberg, JP, Krupnick, J, Rauch S, Rizzo, A, Engle, CC. DoD IRB delays: Do they really matter? And if so, why and for whom? Abstract presented at the Military Health System Research Symposium, Fort Lauderdale, FL, August 18-21, 2014.

288. Freed, MC, Novak, LA, **Killgore, WD**, Koehlmoos, TP, Ginsberg, JP, Krupnick, J, Rauch S, Rizzo, A, Engle, CC. DoD IRB delays: Do they really matter? And if so, why and for whom? Abstract presented at the AMSUS Annual Meeting, Washington DC, December 2-5, 2014.

289. **Killgore, WD**, Demers, LA, Olson, EA, Rosso, IM, Webb, CA, & Rauch, SL. Anterior cingulate gyrus and sulcus thickness: A potential predictor of remission following internet-based cognitive behavioral therapy for major depressive disorder. Abstract presented at the 53rd Annual Meeting of the American College of Neuropsychopharmacology, Phoenix, AZ, December 7-11, 2014.

290. Olson, EA, Buchholz, J, Rosso, IM, **Killgore, WD**, Webb, CA, Gogel, H, & Rauch, SL. Internet-based cognitive behavioral therapy effects on symptom severity in major depressive disorder:

preliminary results from a randomized controlled trial. Abstract presented at the 53rd Annual Meeting of the American College of Neuropsychopharmacology, Phoenix, AZ, December 7-11, 2014.

291. Brennan, B, Tkachenko, O, Schwab, Z, Ryan, E, Athey, A, Pope, H, Dougherty, D, Jenike, M, **Killgore, WD**, Hudson, J, Jensen, E, & Rauch SL. Abstract presented at the 53rd Annual Meeting of the American College of Neuropsychopharmacology, Phoenix, AZ, December 7-11, 2014.

292. Alkozei, A, Pisner, D, & **Killgore, WD**. Emotional intelligence is differentially correlated with prefrontal cortical responses to backward masked fearful and angry faces. Abstract presented at the 43rd Annual Meeting of the International Neuropsychological Society, Denver, CO, February 4-7, 2015.

293. Alkozei, A, Schwab, Z, & **Killgore, WD**. Looking for evil intent: Emotional intelligence and the use of socially relevant facial cues during an emotional decision making task. Abstract presented at the 43rd Annual Meeting of the International Neuropsychological Society, Denver, CO, February 4-7, 2015.

294. Shane, BR, Alkozei, A, & **Killgore, WD**. The contribution of general intelligence and emotional intelligence to the ability to appreciate humor. Abstract presented at the 43rd Annual Meeting of the International Neuropsychological Society, Denver, CO, February 4-7, 2015.

295. Markowski, SM, Alkozei, A, & **Killgore, WD**. Sleep onset latency and duration are associated with self-perceived invincibility. Abstract presented at the 43rd Annual Meeting of the International Neuropsychological Society, Denver, CO, February 4-7, 2015.

296. Pisner, D, Alkozei, A, & **Killgore, WD**. Visuospatial reasoning mediates the relationship between emotion recognition and emotional intelligence. Abstract presented at the 43rd Annual Meeting of the International Neuropsychological Society, Denver, CO, February 4-7, 2015.

297. Vanuk, JR, Fridman, A, Demers, LA, Divatia, S, & **Killgore, WD**. Engaging in meditation and internet based training as a means of enhancing emotional intelligence. Abstract presented at the 43rd Annual Meeting of the International Neuropsychological Society, Denver, CO, February 4-7, 2015.

298. Vanuk, JR, Divatia, S, Demers, LA, Markowski, SM, & **Killgore, WD**. Napping in conjunction with brief internet-based training as a means of enhancing emotional intelligence. Abstract presented at the 43rd Annual Meeting of the International Neuropsychological Society, Denver, CO, February 4-7, 2015.

299. Cui, J, Tkachenko, O, Gogel, H, Kipman, M, Preer, LA, Weber, M, Divatia, SC, Demers, LA, Olson, EA, Buchholz, JL, Bark, JS, Rosso, IM, Rauch, SL, & **Killgore, WD**. Fractional Anisotropy of frontoparietal connections presicts individual resistance to sleep deprivation. Abstract presented at the 43rd Annual Meeting of the International Neuropsychological Society, Denver, CO, February 4-7, 2015.

300. **Killgore, WD**, Olson, EA, Weber, M, Rauch, SL, & Nickerson, LD. Emotional intelligence is associated with coordinated resting state activity between emotion regulation and interoceptive experience networks. Abstract presented at the 43rd Annual Meeting of the International Neuropsychological Society, Denver, CO, February 4-7, 2015.

301. **Killgore, WD**, Demers, LA, Divatia, S, Kipman, M, Tkachenko, O, Weber, M, Preer, LA, Gogel, H, Olson, EA, Vanuk, JR, & Rauch, SL. Enhancing emotional intelligence via brief internet-based training. Abstract presented at the 43rd Annual Meeting of the International Neuropsychological Society, Denver, CO, February 4-7, 2015.

302. Buchholz, JL, Rosso, IM, Olson, EA, **Killgore, WD**, Fukunaga, R, Webb, CA, & Rauch, SL. Internet-based cognitive behavioral therapy is associated with symptom reduction and cognitive restructuring in adults with major depressive disorder. Abstract presented at the Anxiety and Depression Conference, Miami, FL, April 9-12, 2015.

303. Alkozei, A, Pisner, D, Rauch, SL, & **Killgore, WD**. Emotional intelligence and subliminal presentations of social threat. Abstract presented at the 70th Annual Meeting of the Society of Biological Psychiatry, Toronto, Ontario, CA, May 14-16, 2015.

304. Shane, BR, Alkozei, A, Vanuk, JR, Weber, M, & **Killgore, WD**. The effect of bright light therapy for improving sleep among individuals with mild traumatic brain injury. Abstract presented at the 70th Annual Meeting of the Society of Biological Psychiatry, Toronto, Ontario, CA, May 14-16, 2015.

305. Vanuk, JR, Shane, BR, Alkozei, A, & **Killgore, WD**. Trait emotional intelligence is associated with greater resting state functional connectivity within the default mode and task positive networks. Abstract presented at the 70th Annual Meeting of the Society of Biological Psychiatry, Toronto, Ontario, CA, May 14-16, 2015.

306. Vanuk, JR, Fridman, A, Demers, LA, & **Killgore, WD**. Engaging in meditation and internet-based training as a means of enhancing emotional intelligence. Abstract presented at the 70th Annual Meeting of the Society of Biological Psychiatry, Toronto, Ontario, CA, May 14-16, 2015.

307. Pisner, D, Alkozei, A, & **Killgore, WD**. Trait emotional suppression is associated with decreased activation of the insula and thalamus in response to masked angry faces. Abstract presented at the 70th Annual Meeting of the Society of Biological Psychiatry, Toronto, Ontario, CA, May 14-16, 2015.

308. Markowski, SM, Alkozei, A, & **Killgore, WD**. The trait of neuroticism predicts neurocognitive performance in healthy individuals. Abstract presented at the 70th Annual Meeting of the Society of Biological Psychiatry, Toronto, Ontario, CA, May 14-16, 2015.

309. Buchholz, JL, Rosso, IM, **Killgore, WD**, Fukunaga, R, Olson, EA, Demers, LA, & Rauch, SL. Amygdala volume is associated with helplessness in adults with major depressive disorder (MDD). Abstract presented at the 70th Annual Meeting of the Society of Biological Psychiatry, Toronto, Ontario, CA, May 14-16, 2015.

310. Sneider, JT, **Killgore, WD**, Rauch, SL, Jensen, JE, & Silveri, MM. Sex differences in the associations between prefrontal GABA and resistance to sleep deprivation. Abstract presented at the 70th Annual Meeting of the Society of Biological Psychiatry, Toronto, Ontario, CA, May 14-16, 2015.

311. **Killgore, WD**, Rosso, IM, Rauch, SL, & Nickerson, LD. Emotional intelligence correlates with coordinated resting state activity between brain networks involved in emotion regulation and interoceptive experience. Abstract presented at the 70th Annual Meeting of the Society of Biological Psychiatry, Toronto, Ontario, CA, May 14-16, 2015.

312. **Killgore, WD**, Demers, LA, Divatia, S, Rosso, IM, & Rauch, SL. Boosting Emotional intelligence with a brief internet-based program. Abstract presented at the 70th Annual Meeting of the Society of Biological Psychiatry, Toronto, Ontario, CA, May 14-16, 2015.

313. **Killgore, WD**, Vanuk, JR, Alkozei, A, Markowski, SM, Pisner, D, Shane, BR, Fridman, A, & Knight, SA. Greater daytime sleepiness correlates with altered thalamocortical connectivity. Abstract presented at the 70th Annual Meeting of the Society of Biological Psychiatry, Toronto, Ontario, CA, May 14-16, 2015.

314. **Killgore, WD**, Tkachenko, O, Gogel, H, Kipman, M, Sonis, LA, Divatia, SC, Demers, LA, Olson, EA, Buchholz, JL, Rosso, IM, & Rauch, SL. Activation of the ventral striatum predicts overeating during subsequent sleep loss. Abstract presented at the 70th Annual Meeting of the Society of Biological Psychiatry, Toronto, Ontario, CA, May 14-16, 2015.

315. Alkozei, A, Markowski, SM, Shane, BR, Rauch, SL, & **Killgore, WD**. Emotional resilience is not associated with increased emotional resistance to sleep deprivation. Abstract presented at the SLEEP 2015 Meeting, Seattle, WA, June 6-10, 2015.

316. Alkozei, A, Pisner, D, Markowski, SM, Rauch, SL, & **Killgore, WD**. The effect of emotional resilience on changes in appetitie for high-sugary food during sleep loss. Abstract presented at the SLEEP 2015 Meeting, Seattle, WA, June 6-10, 2015.

317. Markowski, SM, Alkozei, A, Rauch, SL, & **Killgore, WD**. Self-perceived invincibility is associated with sleep onset latency and duration. Abstract presented at the SLEEP 2015 Meeting, Seattle, WA, June 6-10, 2015.

318. Markowski, SM, Alkozei, A, Rauch, SL, & **Killgore, WD**. Sex differences in the association between personality and resistance to sleep deprivation. Abstract presented at the SLEEP 2015 Meeting, Seattle, WA, June 6-10, 2015.

319. Shane, BR, Alkozei, A, & **Killgore, WD**. Physical exercise may contribute to vulnerability to sleep deprivation. Abstract presented at the SLEEP 2015 Meeting, Seattle, WA, June 6-10, 2015.

320. Cui, J, Tkachenko, O, Gogel, H, Kipman, M, Sonis, LA, Weber, M, Divatia, SC, Demers, LA, Olson, EA, Buchholz, JL, Rosso, IM, Rauch, SL, & **Killgore, WD**. Resistance to sleep deprivation involves greater functional activation and white matter connectivity within a fronto-parietal network. Abstract presented at the SLEEP 2015 Meeting, Seattle, WA, June 6-

10, 2015.

321. Vanuk, JR, Rosso, IM, Rauch, SL, Alkozei, A, Markowski, SM, Pisner, D, Shane, BR, Fridman A, Knight, SA, & **Killgore, WD**. Daytime sleepiness is associated with altered thalamocortical connectivity. Abstract presented at the SLEEP 2015 Meeting, Seattle, WA, June 6-10, 2015.

322. Sneider, JT, Jensen JE, Silveri, MM, & **Killgore, WD**. Prefrontal GABA predicts resistance to sleep deprivation. Abstract presented at the SLEEP 2015 Meeting, Seattle, WA, June 6-10, 2015.

323. **Killgore, WD**, Tkachenko, O, Gogel, H, Kipman, M, Sonis, LA, Weber, M, Divatia, SC, Demers, LA, Olson, EA, Buchholz, JL, Rosso, IM, & Rauch, SL. Individual differences in rested activation of the ventral striatum predict overeating during sleep deprivation. Abstract presented at the SLEEP 2015 Meeting, Seattle, WA, June 6-10, 2015.

324. **Killgore, WD**, Tkachenko, O, Rosso, IM, Rauch, SL, & Nickerson, LA. Multimodal neuroimaging to predict resistance to sleep deprivation. Abstract presented at the SLEEP 2015 Meeting, Seattle, WA, June 6-10, 2015.

325. Nickerson, LD & **Killgore, WD**. Resting state brain circuits underpinning a neurobiological model of Theory of Mind and Mentalizing. Abstract presented at the Organization for Human Brain Mapping Annual Meeting, 2015, Honolulu, HI, June 14-18, 2015.

326. Rosso, IM, Olson, EA, **Killgore WD**, Fukunaga, R, Webb, CA, & Rauch SL. A randomized trial of internet-based cognitive behavioral therapy for major depressive disorder. Abstract presented at the 54th Annual Meeting of the American College of Neuropsychopharmacology, Hollywood, FL, December 6-10, 2015.

327. Alkozei, A & **Killgore, WD**. Exposure to blue wavelength light is associated with increased dorsolateral prefrontal cortex responses during a working memory task. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

328. Klimova, A, Pisner, D & **Killgore, WD**. Neural correlates of cognitive and emotional impairments in acute versus chronic mild traumatic brain injury: a diffusion tensor imaging study. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

329. Markowski, S, Alkozei, A, & **Killgore, WD.** Greater neuroticism predicts higher performance in immediate memory, language, and attention in healthy individuals. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

330. Alkozei, A & **Killgore, WD.** Exposure to blue wavelength light suppresses anterior cingulate cortex activation in response to uncertainty during anticipation of negative or positive stimuli. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

331. Smith, R, Alkozei, A, Bao, J, & **Killgore, WD.** Successful goal-directed memory suppression is associated with increased inter-hemispheric coordination between right and left fronto-parietal control networks. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

332. Singh, P, Fridman, A, Pisner, D, Singh, A, & **Killgore, WD.** A voxel based morphometric analysis of ventromedial prefrontal cortex volume related with executive function task performance post mild traumatic injury. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

333. **Killgore, WD.** Baseline responsiveness of the ventral striatum predicts overeating during subsequent sleep deprivation. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

334. **Killgore, WD** & Nickerson, LD. Predicting resistance to sleep deprivation using multimodal neuroimaging. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

335. Sneider, J, Jensen, JE, Silveri, MM, & **Killgore, WD.** Prefrontal GABA correlates with the ability to sustain vigilance during sleep deprivation. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

336. Buchholz, JL, Olson, EA, Fukunaga, R, Webb, CA, **Killgore, WD**, Rauch, SL, & Rosso, IM. Expressive suppression is associated with greater lateral orbitofrontal cortex volume in adults with major depressive disorder. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

337. Fridman, A, Pisner, D, Singh, P, & **Killgore, WD**. Gray matter volume in left medial prefrontal cortex is related to life satisfaction in individuals with mild traumatic brain injury. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

338. Singh, P, Pisner, D, Fridman, A, Roberts, S, & **Killgore, WD.** Volumetric differences in gray matter in healthy versus overweight/obese individuals post mild traumatic brain injury: A voxel based morphometric study. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

339. **Killgore, WD** & Weber, M. Blue wavelength light therapy reduces daytime sleepiness following mild traumatic brain injury. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

340. **Killgore, WD**, Weber, M, & Penetar, D. Blue wavelength light therapy improves balance following mild traumatic brain injury. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

341. Pisner, D, Smith, R, Alkozei, A, Klimova, A, & **Killgore, WD.** Highways of the emotional intellect: White matter microstructural correlates of an ability-based measure of emotional

intelligence. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

342. Vanuk, JR, Smith, R, Knight, S, & **Killgore, WD.** Resting RSA correlates with coordinated resting state activity between brain networks involved in emotion perception. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

343. Vanuk, JR, Alkozei, A, Markowski, S, & **Killgore WD.** Greater resting state functional connectivity within the default mode and task positive networks is associated with trait emotional intelligence. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

344. Fukunaga, R, Webb, CA, Olson, EA, **Killgore, WD**, Rauch, SL, & Rosso, IM. Reduced rostral anterior cingulate volume is associated with greater frequency of negative automatic thoughts in adults with major depressive disorder. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

345. Olson, EA, Fukunaga, R., Webb, CA, Rosso, IM, **Killgore, WD**, & Rauch, SL. Delay discounting and anhedonia are independently associated with suicidal ideation in depression. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

346. Pisner, D, Singh, P, Fridman, A, & **Killgore, WD**. Resilience following mild traumatic brain injury is associated with gray matter volume in the left precentral gyrus. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

347. Sing, P, Fridman, A, Pisner, D, & **Killgore, WD.** Time dependent differences in gray matter volume in individuals post mild traumatic brain injury: A voxel based morphometric study. Abstract presented at the 44th Annual Meeting of the International Neuropsychological Society, Boston, MA, February 3-6, 2016.

348. Quan, M, Gruber, SA, Lukas, SE, Hill, KP, **Killgore, WD**, & Nickerson, LD. Altered functional connectivity within large-scale brain networks during a cognitive task in chronic marijuana smokers. Abstract presented at the Harvard Psychiatry Research Day, Boston, MA, March 23, 2016. ***[*Semi Finalist Poster: Harvard Medical School Mysell Award]***

349. Fukunaga, R, Webb, CA, Olson, EA, **Killgore, WD**, Rauch, SL, & Rosso, IM. Improvement in negative automatic thoughts as a mediator of symptom improvement in internet-based cognitive behavioral therapy for major depressive disorder. Abstract presented at the 2016 Meeting of the Anxiety and Depression Association of America, Philadelphia, PA, March 31-April 3, 2016.

350. Bernstein, AS, Pisner, D, Klimova, A, Umapathy, L, Do, L, Squire, S, **Killgore, WD**, & Trouard, T. Effects of multiband acceleration on high angular resolution diffusion imaging data collection, processing, and analysis. Abstract presented at the 24th Annual Meeting of the International Society for Magnetic Resonance in Medicine (IMSRM), Singapore, May 7-8,

2016.

351. Alkozei, A, Markowski, SM, Pisner, D, Fridman, A, Shane, BR, Vanuk, JR, Knight, SA, & **Killgore, WD.** Exposure to blue wavelength light reduces activation within the anterior cingulate cortex during anticipation of certain reward stimuli. Abstract presented at the 71st Annual Scientific Convention of the Society for Biological Psychiatry, Atlanta, GA, May 12-14, 2016.

352. Alkozei, A., Pisner, D, Markowski, SM, Vanuk, JR, Fridman, A, Shane, BR, Knight SA, & **Killgore, WD.** Increases in prefrontal activation after exposure to blue versus amber wavelength light during cognitive load. Abstract presented at the 71st Annual Scientific Convention of the Society for Biological Psychiatry, Atlanta, GA, May 12-14, 2016.

353. Pisner, DA, Smith, R, Alkozei, A, Klimova, A, Millan, M, & **Killgore, WD.** Highways of the emotional intellect: White matter mictrostructural correlates of an ability-based measure of emotional intelligence. Abstract presented at the 71st Annual Scientific Convention of the Society for Biological Psychiatry, Atlanta, GA, May 12-14, 2016.

354. Singh, P, Pisner, D, Fridman, A, Singh A, Millan, M, & **Killgore, WD.** A voxel based morphometric analysis of ventromedial prefrontal cortex volume related with executive function task performance post mild traumatic brain injury. Abstract presented at the 71st Annual Scientific Convention of the Society for Biological Psychiatry, Atlanta, GA, May 12-14, 2016.

355. Smith, R, Smith, C, Khodr, O, Nettles, M, Sanova, A, & **Killgore, WD.** Emotional working memory: A relatively unexplored aspect of emotional and cognitive ability. Abstract presented at the 71st Annual Scientific Convention of the Society for Biological Psychiatry, Atlanta, GA, May 12-14, 2016.

356. Smith, R, Nettles, M, Khodr, O, Sanova, A, Smith, C, Alkozei, A, & **Killgore, WD.** Conflict-related dorsomedial frontal activation during healthy food decisions is associated with increased cravings for high-fat foods. Abstract presented at the 71st Annual Scientific Convention of the Society for Biological Psychiatry, Atlanta, GA, May 12-14, 2016.

357. Smith, R, Sanova, A, Nettles, M, Khodr, O, Smith, C, Alkozei, A, Lane, RD, & **Killgore, WD**. Unwanted reminders: The effects of emotional memory suppression on later neuro-cognitive processing. Abstract presented at the 71st Annual Scientific Convention of the Society for Biological Psychiatry, Atlanta, GA, May 12-14, 2016.

358. **Killgore, WD**, Weber, M, Palmer, W, & Penetar, D. Blue wavelength light therapy improves balance following mild traumatic brain injury. Abstract presented at the 71st Annual Scientific Convention of the Society for Biological Psychiatry, Atlanta, GA, May 12-14, 2016.

359. **Killgore, WD**, Tkachenko, O, Palmer, W, & Rauch, SL. Default mode activation predicts vulnerability to sleep deprivation in domains of mood, sleepiness, and vigilance. Abstract presented at the 71st Annual Scientific Convention of the Society for Biological Psychiatry, Atlanta, GA, May 12-14, 2016.

360. Alkozei, A, Markowski, SM, Pisner, D, Fridman, A, Shane, BR, Vanuk, JR, Knight, SA, Grandner, MA, & **Killgore, WD.** Exposure to blue wavelength light reduces activation within the anterior cingulate cortex during anticipation of certain reward stimuli. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

361. Alkozei, A, Pisner, D, Markowski, SM, Vanuk, JR, Fridman, A, Shane, BR, Knight, SA, Grandner, MA, & **Killgore, WD.** Exposure to blue wavelength light is associated with increased dorsolateral prefrontal cortex responses and increases in response times during a working memory task. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

362. Davis, B, Yang, R, **Killgore, WD**, Gallagher, RA, Carrazco, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Nightmares in a community sample: Prevalence and associations with daytime function independent of poor sleep quality and depression. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

363. Fisseha, E, Havens, C, **Killgore, WD**, Gallagher, RA, Carrazco, N, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Sleep duration's important role in the relationship among difficulty concentrating, fatigue, stress, and depressed mood: Data from the SHADES study. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

364. Graham, PM, Goldstein, M, David, BM, Perlis, ML, Perfect, MM, Frye, S, **Killgore, WD**, Carrazco, N, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Longitudinal analysis of sleep duration using actigraphy and sleep diary: Stability and agreement over 8-11 months. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

365. Granados, K, Rojo-Wissar, DM, Chakravorty, S, Prather, A, Perfect, MM, Frye, S, **Killgore, WD**, Gallagher, RA, Carrazco, N, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Adverse childhood exposures associated with adult insomnia symptoms. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

366. Grandner, MA, **Killgore, WD**, Khader, W, & Perlis, ML. Positive and negative mood ratings across 24-hours. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

367. Hall, C, Forbush, S, Youngstedt, S, **Killgore, WD**, Barilla, H, Gehrels, J, Alfonso-Miller, P, Palmer, W, Carrazco, N, & Grandner, MA. Habitual sleep duration and health: A possible role for exercise. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

368. Jackson, N, Patterson, F, Seixas, A, Jean-Louis, G, **Killgore, WD**, & Grandner, MA. Using big data to determine the social, behavioral, and environmental, determinants of sleep duration in the U.S. population: Application of a machine learning approach to data from approximately

700,000 Americans. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

369. **Killgore, WD**, Tkachenko, O, Grandner, MA, & Rauch, SL. Default mode activation predicts vulnerability to sleep deprivation in the domains of mood, sleepiness, and vigilance. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

370. **Killgore, WD**, Weber, M, Grandner, MA, & Penetar, DM. Blue wavelength light therapy improves balance following mild traumatic brain injury. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

371. Knight, SA & Killgore, WD. Typical sleep duration is associated with constructive thinking patterns. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

372. Kotzin, MD, Alkozei, A, Knight, SA, Grandner, MA, & **Killgore, WD**. The effects of trait gratitude on quality of sleep, intrusiveness, of pre-sleep cognitions, and daytime energy in healthy individuals. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

373. Markowski, SM, Alkozei, A, McIntosh, MB, Grandner, MA, & **Killgore, WD**. Chronotype and risk-taking propensity. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

374. McIntosh, MB, Markowski, SM, Grandner, MA, & **Killgore, WD**. Prior-night sleep duration is negatively associated with impulsivity in women. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

375. Ocano, D, Jean-Louis, G, **Killgore, WD**, Gallagher, RA, Carrazco, N, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Sleep duration and decreased social support from family, friends, and significant other: Influence of insomnia and perceived stress level. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

376. Okuagu, A, Perlis, ML, Ellis, JA, Prather, AA, **Killgore, WD**, Gallagher, RA, Carrazco, N, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Does thinking keep people awake? Or does it matter what they are thinking about? Self-directed cognitions associated with insomnia and insufficient sleep. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

377. Olivier, K, Gallagher, RA, **Killgore, WD**, Carrazco, N, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Development and initial validation of the Assessment of Sleep Environment: A novel inventory for describing and quantifying the impact of environmental factors on sleep. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

378. Paine, KN, Forbush, S, Ellis, J, Nowakowski, S, Newman-Smith, K, **Killgore, WD**, Gallagher, RA, Carrazco, N, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Sleep duration and satisfaction with life, health, finances and relationship. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

379. Rhee, JU, Haynes, P, Chakravorty, S, Patterson, F, **Killgore, WD**, Gallagher, RA, Carrazco, N, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Susceptibility to smoking during the day and its relationship with insomnia and sleep duration. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

380. Roberts, SE, Singh, P, Grandner, MA, & **Killgore, WD.** Later wake up time and impulsivity. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

381. Saccone, J, Davis, B, Chakravorty, S, **Killgore, WD**, Gallagher, RA, Carrazco, N, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Habitual caffeine use and motivation to consume caffeine: Associations with sleep duration, sleepiness, fatigue, and insomnia severity. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

382. Singh, A, Fridman, A, Silveri, MM, Grandner, MA, & **Killgore, WD.** Medial prefrontal GABA predicts hunger ratings during sleep deprivation for men but not women. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

383. Vanuk, JR, Alkozei, A, Smith, R, Pisner, D, Markowski, SM, Shane, BR, Fridman, A, Knight, SA, Grandner, MA, & **Killgore, WD.** Changes in heart rate variability due to light exposure predict frontoparietal connectivity. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

384. Vanuk, JR, Alkozei, A, Knight, SA, Fridman, A, Markowski, SM, Pisner, D, Shane, BR, Grandner, MA, & **Killgore, WD.** The effects of light exposure on heart rate variability predict sleepiness and vigilance. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

385. Warlick, C, Chakravorty, S, **Killgore, WD**, Gallagher, RA, Carrazco, N, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Timing of alcohol intake associated with insomnia symptoms. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

386. Waugaman, DL, Markowski, SM, Alkozei, A, Grandner, MA, & **Killgore, WD.** Chronotype and Emotional Intelligence. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

387. Weber, M, Grandner, MA, & **Killgore, WD.** Smaller gray matter volume of the visual cortex

predicts vulnerability to sleep deprivation. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

388. Weber, M, Grandner, MA, & **Killgore, WD.** Blue wavelength light therapy reduces daytime sleepiness following mild traumatic brain injury. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

389. Yang, R, Ocano, D, Chakravorty, S, **Killgore, WD**, Gallagher, RA, Carrazco, N, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Relationship between insomnia and depression moderated by caffeine. Abstract presented at the 30th Annual Meeting of the Associated Professional Sleep Societies (SLEEP 2016), Denver, CO, June 11-15, 2016.

390. **Killgore, WD**, Vanuk, JR, Pisner, D, Penetar, DM, & Weber, M. Short wavelength light therapy facilitates recovery from mild traumatic brain injury. Abstract presented at the 2016 Military Health System Research Symposium (MHSRS), Orlando, FL, August 15-18, 2016.

391. **Killgore, WD**, Alkozei, A, Smith, R, Divatia, S, & Demers, L. Enhancing emotional intelligence skills with a brief internet-based program: A pilot study. Abstract presented at the 2016 Military Health System Research Symposium (MHSRS), Orlando, FL, August 15-18, 2016.

392. **Killgore, WD**, Rosso, IM, Olson, EA, Webb, CA, Fukunaga, R, Gogel, H, Buchholz, JL, & Rauch, SL. Efficacy of an internet-based cognitive behavior therapy program for major depression. Abstract presented at the 2016 Military Health System Research Symposium (MHSRS), Orlando, FL, August 15-18, 2016.

393. **Killgore, WD**, & Nickerson, LA. Linked analysis of multimodal neuroimaging identifies neural systems associated with the ability to resist sleep deprivation. Abstract presented at the 2016 Military Health System Research Symposium (MHSRS), Orlando, FL, August 15-18, 2016.

394. Vanuk, JR, Allen, JJB, & **Killgore, WD**. Heart rate variability during light exposure and subsequent network connectivity patterns. Abstract presented at the Annual Meeting of the Society for Psychophysiological Research, Minneapolis, MN, September 21-25, 2016.

395. Haberman, JT, Olson, EA, Webb, CA, **Killgore, WD**, Rauch, SL, & Rosso, IM. The relation between treatment expectancies and outcome in internet-based cognitive behavioral therapy for major depressive disorder. Abstract presented at the Association for Behavioral and Cognitive Therapies, New York, NY, October 27-30, 2016.

396. Rosso, IM, Olson, EA, Thomas, MO, Webb, CA, **Killgore, WD**, & Rauch, SL. Anterior cingulate cortex morphology predicts remission from major depression following internet-based cognitive behavior therapy. Abstract submitted for presentation at the 55th Annual Meeting of the American College of Neuropsychopharmacology, Hollywood, FL, December 4-8, 2016.

397. Shane, BR, Vanuk, JR, Bajaj, S, Millan, M, **Killgore, WD**. Multimodal brain imaging in patients receiving bright light therapy following a mild traumatic brain injury. Abstract presented at the Western Medical Research Conference, Carmel CA, January 26-28, 2017.

398. Franco, J, Millan, M, Shane, BR, Castellanos, A, **Killgore, WD**. Blue wavelength light therapy increases thalamic grey matter volume following mild traumatic brain injury. Abstract presented at the 45th Annual Meeting of the International Neuropsychological Society, New Orleans, LA, February 1-4, 2017.

399. Alkozei, A, Smith, R, Demers, LA, Divatia, S, Weber, M, Berryhill, SM, & **Killgore, WD**. Emotional intelligence can be trained via an online training program and is associated with better performance on the IGT. Abstract accepted for oral platform presentation at the 45th Annual Meeting of the International Neuropsychological Society, New Orleans, LA, February 1-4, 2017.

400. Li, H, Gruber, S, Lukas, S, Silveri, M, Hill, K, **Killgore, WD**, & Nickerson, LD. Data fusion to investigate the effect of chronic heavy marijuana use on brain structure. Abstract submitted for presentation at the 2017 Harvard Psychiatry Research Day Poster Session, Boston, MA, April 12, 2017.

401. Challener, S, Alkozei, A, Fridman, A, Dormer A, & **Killgore, WD.** Higher depressive symptoms are associated with lower activation in the orbitofrontal cortex when anticipating negative stimuli in individuals with PTSD. Abstract presented at the 72nd Annual Convention of the Society for Biological Psychiatry, San Diego, CA, May 18-20, 2017.

402. Alkozei, A, Smith R, Fridman A, Dormer, A, Challener, S, & **Killgore, WD.** Neural responses to emotional stimuli in individuals with PTSD after daily morning blue light exposure. Abstract presented at the 72nd Annual Convention of the Society for Biological Psychiatry, San Diego, CA, May 18-20, 2017.

403. Alkozei, A, Smith R, Fridman, A, Dormer, A, Challener, S, & **Killgore, WD.** The role of trait gratitude on functional brain activation changes when anticipating negative events in individuals with PTSD. Abstract presented at the 72nd Annual Convention of the Society for Biological Psychiatry, San Diego, CA, May 18-20, 2017.

404. Fridman, AJ, Alkozei, A, Smith, R, Challener, S, Knight, SA, & **Killgore, WD**. Resiliency is associated with reduced activation within the retrosplenial cortex and secondary motor area for individuals with PTSD during anticipation of a negative event. Abstract presented at the 72nd Annual Convention of the Society for Biological Psychiatry, San Diego, CA, May 18-20, 2017.

405. Vanuk, JR, Millan, M, Shane, BR, Bajaj, S, & **Killgore, WD**. Blue light therapy following a mild traumatic brain injury improves MPFC-amygdala functional connectivity and mood. Abstract presented at the 72nd Annual Convention of the Society for Biological Psychiatry, San Diego, CA, May 18-20, 2017.

406. **Killgore, WD**, Shane, BR, Vanuk, JR, Franco, J, Castellanos, A, Millan, M, Grandner, MA, & Bajaj, S. Light therapy facilitates thalamo-cortical brain recovery from mild traumatic brain injury. Abstract presented at the 72nd Annual Convention of the Society for Biological Psychiatry, San Diego, CA, May 18-20, 2017.

407. Smith, R, Lane, RD, Alkozei, A, Bao J, Smith, C, Sanova, A, Nettles, M, & **Killgore, WD**. Common and unique neural systems underlying the maintenance of emotional vs. bodily reactions to affective stimuli: the moderating role of emotional awareness. Abstract presented at the 72nd Annual Convention of the Society for Biological Psychiatry, San Diego, CA, May 18-20, 2017.

408. Bajaj, S, Alkozei, A & **Killgore, WD**. Effect of bright light therapy on white matter abnormalities following a mild traumatic brain injury. Abstract presented at the 72nd Annual Convention of the Society for Biological Psychiatry, San Diego, CA, May 18-20, 2017.

409. Alkozei, A, Smith, R, Fridman, A, Dormer A, Challener, S, Grandner, MA, & **Killgore, WD**. Daily morning blue light exposure leads to changes in functional brain responses during emotional anticipation in individuals with PTSD. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

410. Gottschlich, MK, Hyman, S, Millan M, Pisner, D, Singh, A, Knight, SA, Grandner, MA, & **Killgore, WD**. Post-concussion severity is associated with sleep problems and neuropsychological status. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

411. Vanuk, JR, Shane, BR, Millan, M., Bajaj, S, Grandner, MA, & **Killgore, WD**. Short-wavelength light therapy as a way of improving sleep, cognition, and functional connectivity following mild traumatic brain injury. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

412. **Killgore, WD**, Shane, BR, Vanuk, JR, Franco, J, Castellanos, A, Millan, M, Grandner, MA, & Bajaj, S. Short wavelength light therapy facilitates recovery from mild traumatic brain injury. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

413. **Killgore, WD**, Capaldi, VF, Balkin, TJ, & Kamimori, GH. The trait of introversion-extraversion contributes to sustained performance on planning and sequencing abilities during sleep deprivation. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

414. Bajaj, S, Alkozei, A, Grandner, MA, & **Killgore, WD**. Effect of bright light therapy on brain and behavioral abnormalities following a mild traumatic brain injury. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

415. Oliver, K, Gallagher, R, Hale, L, Barrett, M, Branas, C, **Killgore, WD**, Parthasarathy, S, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Development and initial validation of a brief measure of control over sleep. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

416. Grandner, MA, Athey, A, **Killgore WD**, Alfonso-Miller, P. Preliminary results of a sleep health intervention in student athletes: Changes in sleep, energy level, and mental well-being, and body weight. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

417. Yang, R, Gallagher, R, Hale, L, Perlis, M, Barrett, M, Branas, C, **Killgore, WD**, Parthasarathy, S, Alfonso-Miller, P, Gehrels, J, Grandner, MA. Would you call yourself a short or long sleeper?

Perceptions of sleep category associated with reported sleep duration, insomnia, and health. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

418. Fisseha, E, Gallagher, R, Hale, L, Branas, C, Barrett, M, **Killgore, WD**, Alfonso-Miller, P, Jean-Louis, G, Seixas, A, Williams, N, Gehrels, J, & Grandner, MA. Habitual weekday sleep duration associated with multiple dimensions of socioeconomic status. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

419. Poling, K, Gallagher, R, Hale, L, Branas, C, Seixas, A, Jean-Louis, G, **Killgore, WD**, Alfonso-Miller, P, Parthasarathy, S, Gehrels, J, & Grandner, MA. Sleep partially mediates the association between food insecurity and obesity: Roles of short sleep duration, insomnia, and socioeconomic factors. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

420. Forbush, S, Fisseha, E, Gallagher, R, Hale, L, Malone, S, Patterson, F, Branas, C, Barrett, M, **Killgore, WD**, Gehrels, J, Alfonso-Miller, P, & Grandner, MA. Sociodemographics, poor overall health, cardiovascular disease, depression, fatigue, and daytime sleepiness associated with social jetlag independent of sleep duration and insomnia. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

421. Till, K, Athey, A, Chakravorty, S, **Killgore, WD**, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Insomnia and daytime tiredness in student athletes associated with risky behaviors and poor decision making when under the influence of alcohol. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

422. Warlick, C, Hall, C, Athey, A, Chakravorty, S, **Killgore, WD**, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Difficulty sleeping associated with substance use among student athletes. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

423. Jaszewski, A, Athey, A, **Killgore, WD**, Alfonso-Miller, P, Gehrels, J, & Grandner, MA. Sleep duration and quality associated with mental well-being in student athletes. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

424. Athey, A, Alfonso-Miller, P, **Killgore, WD**, & Grandner, MA. Preliminary results of a sleep health intervention in student athletes: Perceived changes to sleep, performance, and mental and physical wellbeing. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

425. Goel, N, Taylor, DM, Abel, T, **Killgore, WD**, Pearson-Leary, J, & Bhatnagar, S. MicroRNAs are cross-species markers of sleep loss in humans and rats. Abstract submitted for presentation at the Organization for Human Brain Mapping Conference, Boston, MA, June 3-7, 2017.

426. Meridew, C, Jaszewski, A, Athey, A, Alfonso-Miller, P, **Killgore, WD**, Gehrels, J, & Grandner, MA. Impact of time and activity demands on sleep of student athletes: It's not about reduced sleep opportunity. Abstract presented at the SLEEP Meeting, Boston, MA, June 3-7, 2017.

427. Bajaj, S, Rosso, IM, Rauch, SL, & **Killgore WD**. Impact of bright light therapy on volume and cortical thickness of the brain following mild traumatic brain injury. Abstract presented at the

Organization for Human Brain Mapping Conference, Vancouver, Canada, June 25-29, 2017.***[selected for travel award]**

428. Bajaj, S, Rosso, IM, Rauch, SL, & **Killgore, WD**. Effect of bright light therapy on white matter abnormalities following mild traumatic brain injury. Abstract submitted for presentation at the Organization for Human Brain Mapping Conference, Vancouver, Canada, June 25-29, June 3-7, 2017.

429. Alkozei, A, Haack, M, Smith, R, Dailey, N, Bajaj, S, & **Killgore, WD**. Chronic sleep restriction increases negative implicit attitudes toward Arab Muslims. Abstract submitted for presentation at the Military Health Systems Research Symposium, Kissimmee, FL, August 27-30, 2017.

430. **Killgore WD**, Vanuk, JR, Bajaj, S. Blue wavelength light therapy increases axonal myelination in mild traumatic brain injury. Abstract presented at the Military Health Systems Research Symposium, Kissimmee, FL, August 27-30, 2017.

431. **Killgore WD**. What makes a Super-Soldier: Identifying the neural correlates of individual differences in resilience against sleep deprivation. Abstract presented at the Military Health Systems Research Symposium, Kissimmee, FL, August 27-30, 2017.

432. Dailey, NS, Bajaj, S, Alkozei, A, & **Killgore WD**. Neural correlates of aggression during chronic and subacute stages of recovery from mild traumatic brain injury. Abstract presented at the Military Health Systems Research Symposium, Kissimmee, FL, August 27-30, 2017.

433. Bajaj, S, Alkozei, A, & **Killgore WD**. Short wavelength light therapy following mild traumatic brain injury: Can we normalize the abnormal diffusion and quantity of water within the brain? Abstract presented at the Military Health Systems Research Symposium, Kissimmee, FL, August 27-30, 2017.

434. Goel, N, Taylor, DM, Abel, T, **Killgore, WD**, Pearson-Leary, J, & Bhatnagar, S. MicroRNAs are cross-species markers of sleep loss in humans and rats. Abstract presented at the Society for Neuroscience, Washington, DC, November 11-15, 2017.

435. Dailey, NS, Bajaj, S, Alkozei, A, Smith, R, Knight, SA, & **Killgore, WD**. Neural correlates of aggression in the chronic and post-acute stages of recovery from mild traumatic brain injury: A diffusion tensor imaging study. Abstract presented at the University of Arizona Junior Investigator Poster Forum, Tucson, AZ, November 17, 2017.

436. Challener, S, Alkozei, A, Fridman, A, Dormer, A, & **Killgore, WD**. Higher depressive symptoms are associated with lower activation in the orbital frontal cortex when anticipating negative stimuli in individuals with PTSD. Abstract presented at the University of Arizona Junior Investigator Poster Forum, Tucson, AZ, November 17, 2017.

437. Alkozei, A, Smith, R, Demers, L, Divatia, S, Weber, M, Berryhill, S, & **Killgore, WD**. Emotional intelligence can be trained via an online training program and is associated with better performance on the IGT. Abstract presented at the University of Arizona Junior Investigator Poster Forum, Tucson, AZ, November 17, 2017.

438. Satterfield, B, Raikes, AC, & **Killgore, WD**. A voxel-based morphometric analysis of resilience to vigilant attention impairment during sleep deprivation. Abstract presented at the University of Arizona Junior Investigator Poster Forum, Tucson, AZ, November 17, 2017.

439. Singh, A, Thurston, MD, Gottschlich, MK, Miller, MA, & **Killgore, WD**. Trait anxiety predicts hostile tendencies post-traumatic brain injury. Abstract presented at the University of Arizona Junior Investigator Poster Forum, Tucson, AZ, November 17, 2017.

440. Raikes, AC, Satterfield, BC, Knight, SA, & **Killgore, WD**. Grey matter volumetric differences with increasing numbers of previous mild traumatic brain injuries: A voxel-based morphometric study. Abstract presented at the University of Arizona Junior Investigator Poster Forum, Tucson, AZ, November 17, 2017.

441. Bajaj, S, Dailey, N, Alkozei, A, Vanuk, JR, & **Killgore, WD**. Preservation of limbic network structure in healthy young adults. Abstract presented at the University of Arizona Junior Investigator Poster Forum, Tucson, AZ, November 17, 2017.

442. Alkozei, A, **Killgore, WD**, Smith, R, Dailey, NS, Bajaj, S, & Haack, M. Chronic sleep restriction increases negative implicit attitudes toward Arab Muslims. Abstract presented at the University of Arizona Junior Investigator Poster Forum, Tucson, AZ, November 17, 2017.

443. Skalamera, J, Alkozei, A, Haack, M, & **Killgore, WD**. Chronic sleep restriction increases racial bias and affects actual decision-making about people. Abstract presented at the University of Arizona Junior Investigator Poster Forum, Tucson, AZ, November 17, 2017.

444. Alkozei, A, Smith, R, & **Killgore, WD**. Increases in prefrontal activation after exposure to blue versus amber wavelength light during cognitive load. Abstract presented at the University of Arizona Junior Investigator Poster Forum, Tucson, AZ, November 17, 2017.

445. Knight, SA, & **Killgore, WD**. Typical sleep duration is associated with constructive thinking patterns. Abstract presented at the University of Arizona Junior Investigator Poster Forum, Tucson, AZ, November 17, 2017.

446. Nickerson, L, Li, H, Smith, S, Lukas, S, Silveri, M, Hill, K, **Killgore, WD**, & Gruber, S. Combining multi-site/study MRI data: A novel linked-ICA denoising method for removing scanner and site variability from muli-modal MRI data. Abstract presented at the American College of Neuropsychopharmacology (ACNP) 56th Annual Meeting, Palm Springs, CA, December 3-7, 2017.

447. Bajaj, S, Raikes, AC, Dailey, NS, Vanuk, JR, Weber, M, Rosso, IM, Rauch, SL, & **Killgore, WD**. Changes in cortical structure, sleep, and anxiety symptoms following blue-wavelength light therapy in individuals with mild traumatic brain injury. Abstract presented at the Big Sky Athletic Training Sports Medicine Conference, Big Sky, MT, February 4-8, 2018.

448. Dailey, NS, Raikes, AC, Smith, R, Alkozei, A, & **Killgore, WD**. The executive control network after mild traumatic brain injury: Associations between functional connectivity and aggression. Abstract presented at the Big Sky Athletic Training Sports Medicine Conference, Big Sky,

MT, February 4-8, 2018.

449. Raikes, AC, Satterfield, BC, Dailey, NS, Bajaj, S, & **Killgore, WD**. Self-reported sleep quality is related to cerebellar grey matter volume after mild traumatic brain injury. Abstract presented at the Big Sky Athletic Training Sports Medicine Conference, Big Sky, MT, February 4-8, 2018.

450. Raikes, AC, Bajaj, S, Dailey, NS, Satterfield, BC, Alkozei, A, Smith, R, & **Killgore, WD**. White matter correlates of self-reported sleep quality after a mild traumatic brain injury: A DTI study. Abstract presented at the Big Sky Athletic Training Sports Medicine Conference, Big Sky, MT, February 4-8, 2018.

451. Satterfield, BC, Raikes, AC, & **Killgore, WD**. A voxel-based morphometric analysis of resilience to vigilant attention impairment during sleep deprivation. Abstract presented at the 46th Annual Meeting of the International Neuropsychological Society, Washington, DC, February 14-17, 2018.

452. Alkozei, A, Smith, R, Dailey, NS, Bajaj, S, Knight SA, & **Killgore, WD**. Exposure to blue wavelength light during memory consolidation improves long-delay verbal memory performance. Abstract presented at the 46th Annual Meeting of the International Neuropsychological Society, Washington, DC, February 14-17, 2018.

453. Alkozei, A, Smith, R, Dailey, NS, Bajaj, S, Haack, M, & **Killgore, WD**. Men, but not Women, show a decrease in implicit preferences for low-calorie food after 3 weeks of chronic sleep restriction. Abstract presented at the 46th Annual Meeting of the International Neuropsychological Society, Washington, DC, February 14-17, 2018.

454. Alkozei, A, Smith, R, & **Killgore, WD**. A positive cognitive style mediates the relationship between trait gratitude and depressive symptoms. Abstract presented at the 46th Annual Meeting of the International Neuropsychological Society, Washington, DC, February 14-17, 2018.

455. Bajaj, S, Dailey, NS, Alkozei, A, Vanuk, JR, & **Killgore, WD**. Preservation of limbic network structure in healthy young adults. Abstract presented at the 46th Annual Meeting of the International Neuropsychological Society, Washington, DC, February 14-17, 2018.

456. Alkozei, A, Smith, R, Demers, LA, Divatia, S, Weber, M, Berryhill, SM, & **Killgore, WD**. Emotional intelligence can be trained via an online training program and is associated with better performance on the IGT. Abstract presented at the 46th Annual Meeting of the International Neuropsychological Society, Washington, DC, February 14-17, 2018.

457. Dailey, NS, Bajaj, S, Alkozei, A, Smith, R, Knight, SA, & **Killgore, WD**. Neural correlates of aggression in the chronic and post-acute stages of recovery from mild traumatic brain injury: A diffusion tensor imaging study. Abstract presented at the 46th Annual Meeting of the International Neuropsychological Society, Washington, DC, February 14-17, 2018.

458. **Killgore, WD**, Shane, BR, Vanuk, JR, Millan, M, Knight, SA, & Bajaj, S. Blue light therapy accelerates brain and cognitive recovery from mild traumatic brain injury. Abstract presented

at the 46th Annual Meeting of the International Neuropsychological Society, Washington, DC, February 14-17, 2018.

459. **Killgore, WD**. Default mode activation and the ability to resist sleep deprivation. Abstract presented at the 46th Annual Meeting of the International Neuropsychological Society, Washington, DC, February 14-17, 2018.

460. **Killgore, WD**, Capaldi, VF, Balkin, TJ, & Kamimori, GH. Personality traits predict the ability to sustain executive function abilities during sleep deprivaiton. Abstract presented at the 46th Annual Meeting of the International Neuropsychological Society, Washington, DC, February 14-17, 2018.

461. Raikes, AC, & **Killgore, WD**. Increased cerebellar grey matter in the presence of decreased subjective sleep quality following mild traumatic brain injury. Abstract presented at the 46th Annual Meeting of the International Neuropsychological Society, Washington, DC, February 14-17, 2018.

462. Raikes, AC, Satterfield, BC, Knight, SA, & **Killgore, WD**. Gray matter volumetric differences with increasing numbers of previous mild traumatic brain injuries: A voxel-based morphometric study. Abstract presented at the 46th Annual Meeting of the International Neuropsychological Society, Washington, DC, February 14-17, 2018.

463. Skalamera, J, Alkozei, A, Haack, M, & **Killgore, WD**. Chronic sleep restriction increases implicit racial biases and affects actual decision-making about people. Abstract presented at the 46th Annual Meeting of the International Neuropsychological Society, Washington, DC, February 14-17, 2018.

464. Huanjie, L, Silveri, M, Lukas, SE, Hill, K, **Killgore, WD**, Gruber, S, & Nickerson, LD. Data fusion to investigate multimodal MRI patterns associated with chronic heavy marijuana use. Abstract presented at the Harvard Psychiatry Day Poster Session, Boston, MA, April 4, 2018.

465. Bajaj, S, Dailey, NS, Vanuk, JR, Raikes, A, Weber, M, Rosso, IM, Rauch, SL, & **Killgore, WD**. Impact of blue light therapy on cortical volume, sleep and anxiety symptoms following mild traumatic brain injury. Abstract presented at the Anxiety and Depression Association of America (ADAA) Conference, Washington, DC, April 5-8, 2018.

466. Knight, SA, & **Killgore, WD**. Constructive thinking patterns correlate with typical sleep habits. Abstract presented at the Anxiety and Depression Association of America (ADAA) Conference, Washington, DC, April 5-8, 2018.

467. Raikes, AC, Dailey, NS, Bajaj, S, & **Killgore, WD**. White matter structure changes associated with depressive symptoms following recent mild traumatic brain injury. Abstract presented at the Anxiety and Depression Association of America (ADAA) Conference, Washington, DC, April 5-8, 2018.

468. Singh, A, Thurston, MD, Gottschlich, MK, Miller, MA, & **Killgore, WD**. Trait anxiety predicts hostile tendencies post-traumatic brain injury. Abstract presented at the Anxiety and Depression Association of America (ADAA) Conference, Washington, DC, April 5-8, 2018.

469. Bajaj, S, Raikes, AC, Alkozei, A, Dailey, NS, Satterfield, BC, Vanuk, JR, & **Killgore, WD**. Association between suicidal ideation and cortical volume in a sub-clinical sample of young individuals. Abstract presented at the Society of Biological Psychiatry 73rd Annual Meeting, New York, NY, May 10-12, 2018.

470. Challener, S, Alkozei, A, Young, A, Ozcan, M, Raikes, AC, & **Killgore, WD**. Sleep problems are associated with greater default mode network activation when anticipating negative stimuli in individuals with PTSD. Abstract presented at the Society of Biological Psychiatry 73rd Annual Meeting, New York, NY, May 10-12, 2018.

471. Dailey, NS, Smith, R, Raikes, AC, Alkozei, A, & **Killgore, WD**. Reduced functional connectivity in the executive control network following mild traumatic brain injury: Implications for emotional regulation. Abstract presented at the Society of Biological Psychiatry 73rd Annual Meeting, New York, NY, May 10-12, 2018.

472. **Killgore, WD**, Kent, HC, Knight, SA, & Alkozei, A. Changes in morning salivary melatonin correlate with prefrontal responses during working memory performance. Abstract presented at the Society of Biological Psychiatry 73rd Annual Meeting, New York, NY, May 10-12, 2018.

473. **Killgore, WD**, Alkozei, A, & Weber, M. Blue light therapy improves executive function following mild traumatic brain injury. Abstract presented at the Society of Biological Psychiatry 73rd Annual Meeting, New York, NY, May 10-12, 2018.

474. Ozcan, M, Challener, S, Yung, A, Alkozei, A, Raikes, AC, & **Killgore, WD**. Daytime sleepiness in individuals with PTSD is associated with greater activation in the right angular gyrus when viewing negative images. Abstract presented at the Society of Biological Psychiatry 73rd Annual Meeting, New York, NY, May 10-12, 2018.

475. Smith, R, Sanova, A, Lane, RD, & **Killgore, WD**. Graph-theoretic correlates of trait differences in emotional awareness. Abstract presented at the Society of Biological Psychiatry 73rd Annual Meeting, New York, NY, May 10-12, 2018.

476. Yung, A, Challener, S, Ozcan, M, Alkozei, A, Raikes, AC, & **Killgore, WD**. Improvements in PTSD symptom severity are associated with greater activation in the hippocampus during anticipation of negative stimuli. Abstract presented at the Society of Biological Psychiatry 73rd Annual Meeting, New York, NY, May 10-12, 2018.

477. Satterfield, BC, Silveri, M, Alkozei, A, Raikes, AC, & **Killgore, WD**. GABA: A neural marker of resilience to psychomotor vigilance impairment during sleep deprivation. Abstract accepted for presentation at the SLEEP 2018 Annual Meeting, Baltimore, MD, June 2-6, 2018. [*Trainee Merit Award]

478. Satterfield, BC, Alkozei, A, Raikes, AC, & **Killgore, WD**. Habitual sleep duration predicts caloric and mactronutrient intake during sleep deprivation. Abstract accepted for presentation at the SLEEP 2018 Annual Meeting, Baltimore, MD, June 2-6, 2018.

479. Bajaj, S, Raikes, A, Dailey, NS, Vanuk, JR, Satterfield, BC, Alkozei, A, Weber, M, Rosso, IM, Rauch, SL, Grandner, MA, & **Killgore, WD**. Impact of blue light therapy on cortical structure, sleep, and anxiety symptoms following mild traumatic brain injury. Abstract accepted for presentation at the SLEEP 2018 Annual Meeting, Baltimore, MD, June 2-6, 2018.

480. Challener, S, Alkozei, A, Yung, A, Ozcan, M, Raikes, AC, & **Killgore, WD**. Functional impairment due to excessive daytime sleepiness is associated with greater activation in the default mode network when anticipating negative stimuli in individuals with PDSD. Abstract accepted for presentation at the SLEEP 2018 Annual Meeting, Baltimore, MD, June 2-6, 2018.

481. **Killgore, WD**, Alkozei, A, Knight, SA, Miller, MA, Grandner, MA, & Weber, M. Daily morning blue light exposure enhances executive functioning in individuals with mild traumatic brain injury. Abstract accepted for presentation at the SLEEP 2018 Annual Meeting, Baltimore, MD, June 2-6, 2018.

482. **Killgore, WD**, & Nickerson, LA. Resistance to sleep deprivation is predicted by gray matter volume in the posterior brain stem. Abstract accepted for presentation at the SLEEP 2018 Annual Meeting, Baltimore, MD, June 2-6, 2018.

483. Alkozei, A, Kent, HC, Knight, SA, & **Killgore, WD**. Changes in morning salivary melatonin correlate with prefrontal responses during working memory performance. Abstract accepted for presentation at the SLEEP 2018 Annual Meeting, Baltimore, MD, June 2-6, 2018.

484. Ozcan, M, Alkozei, A, Raikes, A, & **Killgore, WD**. Pre-sleep cognitions partially mediate the relationship between depression and daytime energy. Abstract accepted for presentation at the SLEEP 2018 Annual Meeting, Baltimore, MD, June 2-6, 2018.

485. Raikes, AC, Dailey, NS, Satterfield, BC, Bajaj, S, & **Killgore, WD**. Self-reported sleep quality is associated with reductions in white-matter integrity following recent mild traumatic brain injury. Abstract accepted for presentation at the SLEEP 2018 Annual Meeting, Baltimore, MD, June 2-6, 2018.

486. Raikes, AC, Satterfield, BC, Dailey, NS, Bajaj, S, & **Killgore, WD**. Subjectively poor sleep quality is associated with increased cerebellar grey matter volume following mild traumatic brain injury. Abstract accepted for presentation at the SLEEP 2018 Annual Meeting, Baltimore, MD, June 2-6, 2018.

487. Skalamera, J, Alkozei, A, Haack, M, & **Killgore, WD**. The effect of chronic sleep restriction on implicit racial biases and explicit judgmental decision-making. Abstract accepted for presentation at the SLEEP 2018 Annual Meeting, Baltimore, MD, June 2-6, 2018.

488. Sanchez, C, Hale, L, Branas, C, Gallagher, R, **Killgore, WD**, Gehrels, J, Alfonso,-Miller, P, & Grandner, MA. RElationsihips between dietary supplement intake and sleep duration, insomnia, and fatigue. Abstract accepted for presentation at the SLEEP 2018 Annual Meeting, Baltimore, MD, June 2-6, 2018.

489. Tubbs, A, Perlis, M, Chakravorty, S, Basner, M, **Killgore, WD**, Gehreles, J, Alfonso-Miller, P, & Grandner, MA. Does increased risk of suicide at night favor one method of suicide over

another? Abstract accepted for presentation at the SLEEP 2018 Annual Meeting, Baltimore, MD, June 2-6, 2018.

490. Huanjie, L, Gruber, S, Smith, SM, Lukas, SE, Silveri, M, Hill, KP, **Killgore, WD**, & Nickerson, LD. Combining multi-site/study MRI data: A novel linked-ICA denoising method for removing scanner and site variability from multi-modal MRI data. Abstract submitted for presentation at the Joint Annual Meeting of ISMRM-ESMRMB, Paris, France, June 16-21, 2018. [*Trainee Stipend Award]

491. Bajaj, S, Raikes, AC, Alkozei, A, Dailey, NS, Vanuk, J, Satterfield, BC, & **Killgore, WD**. Suicidal ideation is associated with diminished cortical volume in a sub-clinical population. Abstract presented at the Organization for Human Brain Mapping (OHBM) Annual Meeting, Singapore, June 17-21, 2018.

492. Bajaj, S, Raikes, AC, Dailey, NS, Vanuk, J, Alkozei, A, Satterfield, BC, Weber, M, Rosso, IM, Rauch, SL, & **Killgore, WD**. Effect of blue light therapy on cortical volume, sleep, and anxiety symptoms following mild traumatic brain injury. Abstract presented at the Organization for Human Brain Mapping (OHBM) Annual Meeting, Singapore, June 17-21, 2018.

493. Dailey, NS, Bajaj, S, Smith, R, Raikes, AC, Alkozei, A, & **Killgore, WD**. Disrupted functional connectivity and elevated aggression in young adults with mild traumatic brain injury. Abstract presented at the Organization for Human Brain Mapping (OHBM) Annual Meeting, Singapore, June 17-21, 2018.

494. Raikes, AC, Bajaj, S, Dailey, NS, Alkozei, A, Smith, R, & **Killgore, WD**. Post-mTBI white matter correlates of self-reported sleep quality: A DTI study. Abstract presented at the Organization for Human Brain Mapping (OHBM) Annual Meeting, Singapore, June 17-21, 2018.

495. Nickerson, LD, Li, H, , Silveri, MM, Lukas, SE, Hill, KP, **Killgore, WD**, & Gruber, SA. Multimodal MRI data fusion reveals structure-function patterns associated with chronic heavy marijuana use. Abstract presented at the Organization for Human Brain Mapping (OHBM) Annual Meeting, Singapore, June 17-21, 2018.

496. Raikes, AC, Satterfield, BC, Alkozei, A, & **Killgore, WD**. Blue light therapy improves self-reported sleep quality in individuals with a recent mild traumatic brain injury. Abstract submitted for presentation at the Military Health Systems Research Symposium, Orlando, FL, 2018.

497. **Killgore, WD**. Executive functioning in individuals with mild traumatic brain injury is enhanced by daily morning blue light therapy. Abstract submitted for presentation at the Military Health Systems Research Symposium, Orlando, FL, 2018.

498. **Killgore, WD, &** Nickerson, LA. Why can't you just stay awake? Resistance to sleep deprivation is associated with measureable differences in brainstem gray matter. Abstract submitted for presentation at the Military Health Systems Research Symposium, Orlando, FL, 2018.

499. Dailey, NS, Smith, R, Satterfield, BC, Raikes, AC, & **Killgore, WD**. Verbal fluency following mild traumatic brain injury: The strength of switching. Abstract submitted for presentation at the American Speech-Language-Hearing Association Annual Convention, November 15-17, 2018.

500. Forbeck, B, Dailey, NS, Esbit, S, & **Killgore, WD**. Reduced information processing speed: A dynamic deficit in mild traumatic brain injury. Abstract submitted for presentation at the American Speech-Language-Hearing Association Annual Convention, November 15-17, 2018.

501. Raikes, AC, Dailey, NS, & **Killgore, WD**. Neural and neurocognitive correlates of responsiveness to blue light therapy following mild traumatic brain injury. Abstract submitted for presentation at the American Speech-Language-Hearing Association Annual Convention, November 15-17, 2018.

AWARDED GRANTS AND CONTRACTS

Completed

2001-2003 fMRI of Unconscious Affect Processing in Adolescence.
NIH, 1R03HD41542-01
PI: **Killgore** ($79,000.)

2003-2006 The Effects of Sleep-Loss and Stimulant Countermeasures on Judgment and Decision Making.
U.S. Army Medical Research and Materiel Command (USAMRMC) Competitive Medical Research Proposal Program (CMRP); Intramural Funding,
PI: **Killgore** (Total Award: $1,345,000.)

2004-2005 Sleep/wake Schedules in 3ID Aviation Brigade Soldiers.
Defense Advanced Research Projects Agency (DARPA)
PI: **Killgore** (Total Award: $60,000.)

2005-2006 Functional Neuroimaging Studies of Neural Processing Changes with Sleep and Sleep Deprivation.
U.S. Army Medical Research and Materiel Command (USAMRMC); Intramural Funding Task Area C (Warfighter Judgment and Decision Making) Program Funding
PI: **Killgore** (Total Award: $219,400.)

2006-2007 Establishing Normative Data Sets for a Series of Tasks to Measure the Cognitive Effects of Operationally Relevant Stressors.
U.S. Army Medical Research and Materiel Command (USAMRMC); Intramural Funding

Task Area C (Warfighter Judgment and Decision Making) Program Funding,
PI: **Killgore** (Total Award: $154,000.)

2006-2007 Military Operational Medicine Research Program (MOM-RP), Development of the Sleep History and Readiness Predictor (SHARP).
U.S. Army Medical Research and Materiel Command (USAMRMC); Intramural Funding
PI: **Killgore** (Total Award:$291,000.)

2009-2014 The Neurobiological Basis and Potential Modification of Emotional Intelligence through Affective Behavioral Training (W81XWH-09-1-0730).
U.S. Army Medical Research and Materiel Command (USAMRMC),
PI: **Killgore** (Total Award: $551,961.)
Major Goal: To identify the neurobiological basis of cognitive and emotional intelligence using functional and structural magnetic resonance imaging.

2011-2016 Effects of Bright Light Therapy on Sleep, Cognition, and Brain Function following Mild Traumatic Brain Injury (W81XWH-11-1-0056).
U.S. Army Medical Research and Materiel Command (USAMRMC),
PI: **Killgore** (Total Award: $941,924)
Major Goal: To evaluate the effectiveness of morning exposure to bright light as a treatment for improving in sleep patterns among individuals with post-concussive syndrome. Effects of improved sleep on recovery due to this treatment will be evaluated using neurocognitive testing as well as functional and structural neuroimaging.

2012-2014 Neural Mechanisms of Fear Extinction Across Anxiety Disorders
NIH NIMH
PI: Milad, M. Site Subcontract PI: **Killgore** (Subcontract Award: $505,065)
Major Goal: To examine the neurocircuitry involved in fear conditioning, extinction, and extinction recall across several major anxiety disorders.

2012-2014 Multimodal Neuroimaging to Predict Cognitive Resilience Against Sleep Loss
Defense Advance Research Projects Agency (DARPA) Young Faculty Award in Neuroscience (D12AP00241)
PI: **Killgore** (Total Award: $445,531)
Major Goal: To combine several neuroimaging techniques, including functional and structural magnetic resonance imaging, diffusion tensor imaging, and magnetic resonance spectroscopy to predict individual resilience to 24 hours of sleep deprivation.

2012-2015 Internet Based Cognitive Behavioral Therapy Effects on Depressive Cognitions and Brain function (W81XWH-12-1-0109).
U.S. Army Medical Research and Materiel Command (USAMRMC),
PI: Rauch, SL; Co-PI: **Killgore** (Total Award: $1,646,045)
Major Goal: To evaluate the effectiveness of an internet-based cognitive behavioral therapy treatment program on improving depressive symptoms, coping and resilience skills, cognitive processing and functional brain activation patterns within the prefrontal cortex.

Current

2012-2016 A Model for Predicting Cognitive and Emotional Health from Structural and Functional Neurocircuitry following Traumatic Brain Injury (W81WH-12-0386)
Congressionally Directed Medical Research Program (CDMRP), Psychological Health/Traumatic Brain Injury (PH/TBI) Research Program: Applied Neurotrauma Research Award.
PI: **Killgore** (Total Award: $2,272,098)
Percent Effort: 25%
Major Goal: To evaluate the relation between axonal damage and neurocognitive performance in patients with traumatic brain injury at multiple points over the recovery trajectory, in order to predict recovery.

2014-2017 Bright Light Therapy for Treatment of Sleep Problems following Mild TBI (W81XWH-14-1-0571).
Psychological Health and Traumatic Brain Injury Research Program (PH/TBI RP) Traumatic Brain Injury Research Award-Clinical Trial.
PI: **Killgore** (Total Award: $1,853,921)
Percent Effort: 40%
Major Goal: To verify the effectiveness of morning exposure to bright light as a treatment for improving in sleep patterns, neurocognitive performance, brain function, and brain structure among individuals with a recent mild traumatic brain injury.

2014-2018 A Non-pharmacologic Method for Enhancing Sleep in PTSD (W81XWH-14-1-0570)
Military Operational Medicine Research Program (MOMRP) Joint Program Committee 5 (JPC-5), FY13 Basic and Applied Psychological Health Award (BAPHA)
PI: **Killgore** (Total Award: $3,821,415)
Percent Effort: 35%
Major Goal: To evaluate the effectiveness of blue light exposure to modify sleep in PTSD and its effects on fear conditioning/extinction, symptom expression, and brain functioning.

2015 Effects of Blue Light on Melatonin Levels and EEG Power Density Spectrum
Arizona Area Health Education Centers (AHEC) Program
Co-PI: Alkozei, A.; Co-PI: **Killgore** (Total Award: $4,373)
Percent Effort: 0%
Major Goal: Adjunctive intramural funding to add a melatonin collection to an ongoing study of the effects of blue wavelength light on alertness and brain function.

2014-2018 Refinement and Validation of a Military Emotional Intelligence Training Program (JW150005)
Joint Warfighter Medical Research Program 2015
PI: **Killgore** (Total Award: $5,977,570)
Percent Effort: 45%
Major Goal: To develop and validate a new internet-based training program to enhance emotional intelligence capacities in military Service Members.

2017-2019 Emotional State and Personality: A Proof-of-Concept Model for Predicting Performance Under Stress (DM160347)
USAMRMC 2015
PI: **Killgore** (Total Award: $1,247,290)
Percent Effort: 20%
Major Goal: To develop a statistical model to predict effective cognitive performance under stress using personality and state emotion metrics.

LIST OF COLLABORATORS ON GRANTS AND PUBLICATIONS FROM LAST FIVE YEARS

Acharya, D.
Alkozei, Anna
Athey, A. J.
Baker, Justin. T.
Balkin, Thomas J.
Bark, John S.
Brennan, Brian P.
Britton, Jennifer C.
Bruyere, J.
Buchholz, Jennifer L.
Capaldi, Vincent F.
Castro, Carl A.
Chosak, A.
Cohen-Gilbert, Julia E.
Conrad, Turner A.
Covell, Michael J.
Crowley, David J.
Cui, Jiaolong
Dagher, Joseph
Dahlgren, Mary Kate
Deckersbach, Thilo
DelDonno, Sophie R.
Demers, Lauren A.
Dillon, Daniel G.
Divatia, Shreya C.
Dougherty, Darin
Engle, Charles C.
Estrada, Arthur
Freed, Michael C.
Fridman, Andrew
Fukunaga, Rena
Ginsberg, Jay P.
Gogel, Hannah
Gold, Andrea L.
Gonenc, Atilla
Gruber, Staci A.
Grugle, Nancy, L.
Guerrero, Melanie L.
Hammeroff, Stuart
Hartman, A. S.
Hezel, D.
Hoge, Charles W.
Hudson, James I.
Jenike, Michael A.
Jensen, J. Eric
Jorgensen, Alli L.
Juelich, R. J.
Kamimori, Gary H.

Kamiya, T.
Kaufmann, Marc
Kawada, Y.
Kelley, Amanda M.
Killgore, Desiree B.
Kipman, Maia
Kizielewicz, Jill
Knight, Sara A.
Koehlmoos, T. P.
Krizan, Zlatan
Krupnick, J.
Lane, Richard
Lasko, N. B.
Laundau, A. J.
Leibenluft, E.
Makris, Nicos
Marin, M. F.
Markowski, Sarah M.
Meloni, Edward G.
Milad, Mohammed R
Mundy, Elizabeth A.
Nickerson, Lisa D.
Novak, L.A.
Olson, Elizabeth A.
Orr, Scott P.
Pace-Schott, Edward F.
Papadimitriou, G.
Pauls, D. L.
Pechtel, Pia
Penetar, David M.
Pine, Daniel S.
Pisner, Derek
Pitman, R. K.
Pizzagalli, Diego A.
Pollack, M. H.
Pope, Harrison G.
Post, Alex
Preer (Sonis), Lilly
Price, Lauren M.
Racine, Megan T.
Ragan, J.
Raison, Charles L.
Rauch, Scott L.
Rauch, Shiela
Reichardt, Rebecca M.
Renshaw, Perry F.
Rizzo, Albert (Skip)
Rohan, Michael
Ross, Amy J.
Rosso, Isabelle M.
Rupp, Tracy L.
Ryan, E. M.
Sagar, Kelly A.
Schoenberg, Michael R.
Schwab, Zachary J.
Shane, Bradley R.
Silveri, Marisa M.
Simon, Naomi M.
Smith, Kacie L.
Smith, Ryan S.
Sneider, Jennifer T.
Song, Christina H.
Song, H.
Steward, S. E.
Thomas, Jennifer J.
Tkachenko, Olga
Trksak, George H.
Vanuk, John R.

Webb, Christian A.
Weber, Mareen
Weihs, Karen
Weiner, Melissa R.
Whte, C. N.
Wilhelm, S.
Yurgelun-Todd, Deborah, A.
Zai, D.

GRADUATE, POSTDOCTORAL, THESIS ADVISORS OR SPONSORS

Steven W. Gangestad, Ph.D.—Undergraduate Senior Honors Thesis Advisor

Lawrence Overby, III, Ph.D.—Masters Thesis Advisor

Bill J. Locke, Ph.D.—Doctoral Thesis Advisor

Keith A. Hawkins, Ph.D.—Doctoral Internship Advisor

Russell L. Adams, Ph.D.—Postdoctoral Fellowship Advisor

James G. Scott, Ph.D.—Postdoctoral Fellowship Advisor

Guila Glosser, Ph.D.—Postdoctoral Fellowship Advisor

Deborah A. Yurgelun-Todd, Ph.D.—Postdoctoral Fellowship Advisor

This is a true and accurate statement of my activities and accomplishments. I understand that misrepresentation in securing promotion and tenure may lead to dismissal or suspension under ABOR Policy 6-201 J.1.b.

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William D. "Scott" Killgore, Ph.D.