



CENTEC: CENTER FOR EXCELLENCE IN NEUROERGONOMICS, TECHNOLOGY, AND COGNITION

**James Thompson
GEORGE MASON UNIVERSITY**

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Final Report**

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George Mason University

**Center of Excellence in Neuroergonomics,
Technology, and Cognition (CENTEC)**

Final Report

Submitted: October 25th 2016

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Executive Summary

This report provides a final description of work undertaken as part of Center of Excellence in Neuroergonomics, Technology, and Cognition (CENTEC) at George Mason University (GMU). CENTEC was funded jointly by the Air Force Office of Scientific Research (AFOSR) and the Air Force Research Laboratory (AFRL). Program Managers were Dr. James Lawton (AFOSR) and Dr. Scott Galster (AFRL). The original Principal Investigator (PI) and Director of CENTEC was Dr Raja Parasurman, who passed away unexpectedly in early 2015. Dr James Thompson was appointed PI and Director for the remainder of the period of award.

The major goal of CENTEC was to conduct theory-based research in neuroergonomics to support the US Air Force mission of enhanced human effectiveness in air, space, and cyberspace operations. This final report describes the major CENTEC research efforts over the five years of award in support of that mission. It also describes graduate student and postdoctoral fellow training as well as scientific collaborative activities with AFRL. This report covers the period of July 15, 2010 through July 14, 2016. Financial reports have been sent separately.

The CENTEC Project areas and GMU Project Leads were as follows:

1. Molecular Genetic and Neuroimaging Studies of Complex Cognition (Greenwood, Parasuraman).
2. Computational Analysis of Neural Mechanisms of Learning and Memory (Ascoli).
3. Interruptions and Multi-Tasking (Boehm-Davis).
4. Multimodal Cognition (Baldwin).
5. Neuroadaptive Systems (Shaw).
6. Training the Brain (Greenwood, Parasuraman).

This report provides an overview of the activities in each of these Projects, including experiments jointly designed, executed, and published by GMU and AFRL scientists, as described in sections 1-6. Training of graduate students and postdoctoral fellows associated with each Project area is also described. Publications and paper presentations are listed in section 7. Project Leads in each Project area have also met with AFRL personnel and conducted joint studies and made plans for future collaborative research past the end of the award period. In addition to these 69 Project areas, a number of other collaborative GMU-AFRL research activities are described throughout the report. Note that considerable cross-fertilization has also taken place between these areas, so that some studies span more than one project area. In addition, training of graduate students and postdoctoral fellows, as well as collaborative activities with AFRL scientists, has also taken place both within and across Project.

Notable Scientific Breakthroughs

- A collaboration with Ryan Jankord (WPAFB) using mice identified a human gene with a previously unknown role in working memory, a novel and important finding.
- A study of episodic memory training is the first to demonstrate that episodic memory can be trained by the formation and retrieval of new memories.
- Previous research has shown that people completing procedural tasks can overcome the deleterious effects of interruptions given sufficient time. Our research is the first to show that this does not seem to be the case for creative, content production tasks, and to provide a theoretical account of why this may be the case.
- In the area of reading comprehension, we demonstrated that earlier research, which claimed that comprehension was immune to interruptions (based on interpretations of long term working memory), was incorrect. We argued that earlier work focused on recognition performance, not comprehension, and were able to show that although recognition performance is unaffected, comprehension is. This work has generated some controversy and an upcoming issue of the *Journal of Experimental Psychology: General*, which published the original article, will publish a commentary by Delaney & Ericsson as well as a rejoinder from us.
- We obtained convincing evidence of a strong placebo effect in working memory training related to suggested recruitment (Foroughi et al., 2016, *PNAS*). This study received considerable news coverage.
- Using a search-and-rescue simulation, Brian Falcone found that tDCS improved perceptual sensitivity without affecting response bias in complex perceptual learning. This indicates that the stimulation resulted in neural modulation rather than increased general arousal (Callan, Falcone et al., 2016, *Frontiers in Human Neuroscience*; Falcone et al., submitted).

Awards and Honors

- The Jerome H. Ely *Human Factors* Article Award was awarded to Raja Parasuraman, Brian Kidwell, Ryan Olmstead, Ming-Kuan Lin, Ryan Jankord, and Pamela Greenwood for their paper, "Interactive Effects of the COMT Gene and Training on Individual Differences in Supervisory Control of Unmanned Vehicles."

Awards to Raja Parasuraman.

- 2012: Celebration of Scholarship Award for Directorship of CENTEC and Outstanding Professional Achievement and Dedication to George Mason University, College of Humanities and Social Sciences.
- 2012: Outstanding Educator Award, International Ergonomics Association Triennial

Awards to Deborah Boehm-Davis

- Member, “Offshore Oil and Gas Safety Culture Framing Study” conducted by the Transportation Research Board of the National Academies.
- Member, Organization of Scientific Area Committees Human Factors Committee, National Institute of Standards and Technology, 2014 – present
- Member, Intelligence Science and Technology Experts Group (ISTEG). This group was developed by the National Academies of Sciences, Engineering, and Medicine to support the Office of the Director of National Intelligence, 2015 - present

Awards to Cyrus Foroughi

- Recipient, CEDM Travel Award from the Cognitive Engineering and Decision-Making Technical Group of the Human Factors and Ergonomics Society.
- APA Early Graduate Student Researcher Award, 2015
- OSCAR Graduate Student Mentor Award, 2015
- HFES Student Member with Honors, 2015

Awards to Nicole Werner

- Selected attendee, Johns Hopkins University School of Nursing Center for Innovative Care in Aging Summer Research Institute – Developing Behavioural interventions
- Finalist, International Ergonomics Society 2011 KU Smith Student Paper Award
- Selected Scholar, Telluride Patient Safety Summer Camp Leadership Roundtable
- Human Factors and Ergonomics Society Student Member with Honors Award
- Briggs Dissertation Award, American Psychological Association Division 21, Applied Experimental and Engineering Psychology
- *Applied Ergonomics* Best Paper Award, 2015

Awards to Brian Falcone

- Fellowship Award, National Science Foundation (NSF) East Asia and Pacific Summer Institutes, 2014
- Best Student Paper Award, Human Factors and Ergonomics Society, Augmented Cognition Technical Group, 2013
- Student Grant Award, Human Factors and Ergonomics Society, Augmented Cognition Technical Group, 2011

Awards to Ryan McKendrick

- Air Force Scholar, CENTEC.
- Second best paper from the Cognitive Engineering and Decision Making Technical Group of the Human Factors and Ergonomics Society (HFES), 2011

Project 1: Molecular Genetic and Neuroimaging Studies of Complex Cognition (Parasuraman and Greenwood)

1.1 Research

CENTEC support was instrumental to this project in supporting our collaboration with Ryan Jankord at Wright-Patterson Air Force Base (WPAFB). That collaboration, described below under “*Discovery of novel genes with a role in human cognition*,” used genetic work in mice to identify a human gene with a heretofore unknown role in memory.

Role of neurotransmitter genes in individual differences in performance of complex cognitive tasks

Over the life of CENTEC our goals in Project 1 were to (a) extend our previous studies on the genetics of cognition to cognitive tasks of Air Force relevance and (b) identify novel genes with a role in cognitive performance. Regarding the first goal, we reported on the effects of normal variation in the DBH gene on performance on a command-and-control task (Parasuraman et al., 2012), the effects of variation in the COMT gene on supervisory control of unmanned vehicles (Parasuraman et al., 2014), and were the first to report the combined effect of COMT and DBH genes on extracellular dopamine and working memory (Greenwood et al., 2014). We also found that ability to navigate in a wilderness setting depends less on sense of direction and more on episodic memory (modulated by a KIBRA SNP) and ability to focus attention (modulated by a CHRNA4 SNP, Greenwood et al., 2012; Rovira, Mackie, Clark, Squire, Hendricks, Pulido, Greenwood, 2016). Using another “real-world” measure, our group obtained the first evidence implicating the oxytocin receptor OXTR SNP (rs53576) in human trust behavior (Krueger, Parasuraman et al., 2012). Our findings of effects of normal genetic variation on cognitive performance in military simulations are relevant both for selection of people for specific tasks and for tailoring of training to specific processing weaknesses associated with genotype.

Epigenetic changes in peripheral monocytes related to episodic memory formation

Our work described above shows that normal genetic variation contributes to individual differences in cognitive performance, including in real-world complex tasks such as unmanned vehicle control. However, allelic association studies cannot reveal the effects of dynamic changes in gene expression. There is evidence that epigenetic marks are subject to environmental influences, including new memory formation. There is reason to predict epigenetic effects of memory formation are detectable in human peripheral tissues. DNA methylation changes related to parental care have been measured in vivo in human lymphocytes in blood. Based on this and other work, we hypothesized that training on episodic memory formation and retrieval would (a) improve episodic memory performance and b) be related to changes in DNA methylation (assessed across the genome) in peripheral blood mononuclear cells. DNA methylation of monocytes will differ between episodic memory-trained and control groups. Data collection was recently completed showing the effectiveness of store-and-retrieve episodic memory training on memory performance. DNA methylation analysis is being planned. (Aaron Booth, Masters thesis defended July, 2016; Booth, Lipsky, Lin, Parasuraman & Greenwood, in preparation)

Discovery of novel genes with a role in human cognition

To advance the second goal of Project 1 to identify novel genes with a role in cognitive performance, we collaborated with Ryan Jankord and Kevin Schmidt at WPAFB. Most studies of cognitive genetics are carried out on a relatively small number of known SNPs, most in neurotransmission genes. For the field to advance, it is important to identify novel genes. One approach involves use of the genome-wide allelic study approach (GWAS) which is not well-suited for cognitive phenotype due to the need for tens of thousands of participants. To date, application of this approach to cognition has not found SNPs reaching genome-wide significance, in part because samples of cognitively characterized individuals, limited to IQ, are not large enough for GWAS. We used a different approach. Collaborating with Ryan Jankord, our approach to identifying novel gene lists used BXD recombinant inbred mice to model individual differences in cognition which were correlated to sections of DNA on the chromosomes through quantitative trait loci (QTL) analysis. Jankord's lab used QTL mapping to successfully identify candidate genes associated with Morris water maze performance in both control and chronic stress conditions. Using this approach, the FTCD gene (encodes the protein formiminotransferase cyclodeaminase) was found within a correlation peak on chromosome 10 in both control and high environmentally stressed mice and was selected for human analysis. We then tested this gene in humans. Based on the literature we selected SNPs rs914246 and rs914245 and analyzed them in a human allelic association study using our stored DNA and associated working memory data (702 healthy males and females aged 17 – 90). Group effects on accuracy (3 levels of load and 3 levels of difficulty) were significant for both SNPs. A reporter gene assay in mammalian cell lines and human primary neuron cultures was used to determine which SNP was important. The C allele of the rs914246 SNP introduced significantly higher expression of Firefly luciferase than the A allele. This indicates that the rs914246 genotype is the main factor regulating FTCD gene expression. This mouse to human approach has the potential to increase knowledge of molecular mechanisms modulating working memory—offering novel genetic predictors of WM performance and pathways for WM interventions. (Schmidt, Jankord, Lin, Parasuraman, Greenwood, 2015).

Neuroimaging

Neuroimaging is fundamental to a number of our projects, including several described in Project 6 (which has the same investigators as Project 1) that used neuroimaging to measure brain changes related to training (e.g. Cisler et al., 2015; Strenziok et al., 2014). In Project 1, several studies used functional near infrared spectroscopy (fNIRS) in investigations of workload in real-world tasks. fNIRS provides a low-cost method of measuring brain activation. Using this method, Ryan McKendrick found non-linear increases in the cerebral hemodynamic response in left dorsolateral and right ventrolateral prefrontal cortex over the course of working memory training (Ayaz et al., 2013; McKendrick et al., 2014, 2015). This method is well-suited to measuring workload during real-world tasks. Using a portable fNIRS, the same group was able to determine that a navigation method that used an “augmented reality wearable display” had lower workload compared to a cell phone (McKendrick et al., 2016).

1.2 Training

Two postdoctoral fellows contributed to Project 1, Maren Strenziok (MRI) and Ming-Kuan Lin (molecular genetics). Several doctoral students also worked Project 1 required the training

of several students in DNA collection, processing, and genotyping. Masters student (and SMART scholar, currently at WPAFB) Kevin Schmidt and GMU undergraduates Amanda Harwood, Aaron Booth, and David Maisel.

1.3 Collaborative activities

For the FTCD project we collaborated with Ryan Jankord, and Kevin Schmidt at WPAFB. Dr. Jankord conducted the QTL mapping work with the BXD mice. Kevin Schmidt, then a GMU grad student, worked with our human samples. For the epigenetics study, we collaborated with Robert Lipsky and Ming Kuan-Lin of the Krasnow. Hasan Ayaz of Drexel University was instrumental in the fNIRS work with Ryan McKendrick.

Project 2: Computational Analysis of Neural Mechanisms of Memory (Ascoli)

2.1 Research

The Hippocampome.org team has continued to mine the ever-expanding body of literature for information pertaining to neuron types in the rodent hippocampus. The knowledge we have accumulated is a set of more than 120 neuron types with information about morphology, molecular marker expression, electrophysiological parameters and firing patterns, plus known and potential connectivity. In each of these project facets, the bioinformatics PhD student directly supported by CENTEC (Christopher Rees) played a direct role in mining, vetting, and/or graphically representing the data. In all, the Hippocampome.org knowledge base currently contains information from ~500 peer-reviewed articles and book chapters; thousands more sources have been examined and found to be outside the current scope of the project.

The gathered data is organized in a database that is browsable via a freely accessible web portal at www.hippocampome.org.

Amassing this information into a centralized resource facilitates analyses that can lead to new discoveries. CENTEC integrally supported three particular analysis avenues, which are discussed at length below.

First, we explored pairwise correlations between 148 properties of neuronal types, including the major neurotransmitter, the axonal, dendritic, and somatic locations in the 26 partitions and the 6 subregions of the hippocampal formation, clear positive or negative expression of 36 molecular biomarkers, and having extremely high or low preferred values for 10 electrophysiological properties. We tested for correlations between these categorical properties by utilizing contingency tables and Barnard's exact test to unveil new, statistically significant relationships and confirm previously held understandings.

Secondly, Hippocampome.org contains comprehensive knowledge of hippocampal type-based circuitry. We have compiled information on network connectivity in two stages: by (1) literature mining for experimentally verified data on synapses (or lack thereof) between neuron types; and (2) determining the binary (and later, weighted) potential for synapsing that arises from a spatial overlap of axons and dendrites of any two types. We then analyzed the resulting network by employing graph theory metrics (e.g. degree distribution, betweenness centrality, rich club coefficient, and motif composition, among others) to uncover the fundamental architectural principles of the network.

The motif composition analysis, in particular, was computationally intensive, and we took advantage of our CENTEC-fostered partnership with the military to utilize DoD High-

Performance Computing (HPC) resources. Specifically, porting our network motif analysis code to the Navy's Kilrain supercomputer drastically reduced the computation time for the generation of a statistically significant set of random "control" networks for comparison of their motif composition to the Hippocampome.org network. Furthermore, using new measures like absorption and driftiness, we began investigating the relationship between network topology and the dynamic behaviors of information flow, with the hopes of furthering intuition on hippocampal operation.

Third, in certain cases where molecular marker expression information from the literature cannot be directly ascribed to one of our neuron types, we still may be able to use inferential logic to match the expression data to a set of applicable types. This may be the case when the authors did not fully describe or provide references that describe the morphology. For instance, data on the co-expression or lack of co-expression (i.e. mutual exclusivity) of one marker with a second in a certain parcel (or parcels) can be used to infer information without the need of a direct assay of marker expression by a particular neuron type. In such a circumstance, as long as the first marker is known to be positively expressed for any neuron type, the second marker can be reasonably inferred to be expressed (in the case of co-expression) or not expressed (in the case of mutual exclusivity). Such inferences can also be applied in their contrapositive form, and multiple inferences can even be chained together. With CENTEC support, we gathered these inferences and built the system that applies their logic. Currently, inferences such as those described here increase the molecular marker information in the knowledge base by approximately 33%.

2.2 Training

This project supported one full time PhD student in Bioinformatics, Christopher Rees, with partial tuition support for a second PhD student in biopsychology, Robert (Bob) Gardner. Both doctoral students supported by this project are approaching graduation: Christopher Rees (Bioinformatics) on graph theory & network analysis, and Robert (Bob) Gardner (Psychology) on human memory and rat behavior. Several other graduate students are also indirectly involved in the project (although not funded by CENTEC): Ben Holmes (Wright State Univ.) on hippocampome applications, David Hamilton (Neuroscience) for the neuroinformatics portal, Siva Venkadesh (Neuroscience, Presidential fellow) on firing dynamics, Sean Mackesey (MS in Bioinformatics, now at Berkeley) on neuron counts. Postdoctoral trainees include Dr. Diek Wheeler (team lead), Dr. Alexander Komendantov (electrophysiology), Dr. Charise White (biomarkers), and Dr. Alexei Samsonovich (functional modeling).

2.3 Collaborative Activities

The 3-yr Laboratory Research Initiation grant "Computational Modeling in the Biological Band: Integrating Computational Cognitive Neuroscience into the Human Effectiveness Directorate" started at AFRL, with Dr. Tim Halverson as Task Manager, and Dr. Ascoli committing a 1.5 months/year effort. Dr. Ascoli fielded weekly calls with Dr. Halverson and Mr. Ben Holmes (a PhD student at Wright State Univ. and research intern at AFRL) and hosted Mr. Holmes at GMU for a 9-day visit in Fall 2013 for a Hippocampome crash-course, presentation seminar, and sharing database/server access. Mr. Holmes also attended weekly "pow-wow" technical meetings by teleconference with 3 postdocs and 3 PhD students ("Hippocampome

team”) in Ascoli’s lab. A senior postdoc from Ascoli’s Lab, Dr. Charise White, visited AFRL in Dayton for 3 days in Spring 2013. Dr. Ascoli paid a 1-day visit to AFRL in Spring 2014 to discuss Hippocampome applications of potential interest to WPAFB, and Dr. Halverson visited Ascoli’s lab in Fairfax 2 weeks later. The two labs regularly exchanged reports, technical documents (e.g. release specifications, SfN posters, manuscript drafts), and email feedback. In the course of these interactions, several collaborative threads were identified, including (1) use of hippocampal modeling in spatial navigation & memory processing, (2) browsing/searching of hippocampus neuron type data and knowledge, (3) specific application of chemical biomarkers (e.g. NPY / stress), (4) upload of hippocampus parameters into knowledge base, (5) shared use and development of web portal and database, and (6) pursuit of joint funding opportunities.

The collaboration with AFRL DoD Supercomputing Resource Center (POC: W. Larkin) is still ongoing for remote usage of Spirit at WPAFB (73,440 CPUs/1.5 petaflops – the 14th fastest computer in the world and fastest machine for unclassified work. In addition to the collaboration with WPAFB, Dr. Ascoli has a continuing Cooperative Research And Development Agreement with Dr. David Marchette from the Dahlgren NSWC. Lastly, a "Robust Intelligence" 3-year collaborative grant with Dr. Ken DeJong (former CENTEC sub-project) was funded this year by NSF for network fine-tuning.

Project 3: Interruptions and Multi-tasking (Boehm-Davis)

3.1 Research

Interruptions

Few of us have the luxury of working without interruptions of one sort or another. In most workplaces, jobs arrive independent of jobs already in the queue, workers need to consult with each other to pursue parallel work streams, and jobs are suspended when parts or information needed are not readily available. In short, interruption is the norm in almost all work environments. Although interruptions have been the focus of much research, the findings have been incongruent. A majority of research has found interruptions to be disruptive to performance on a task, leading to an increased time on task and errors. However, other studies have pointed to interruptions as facilitating performance. Clearly, there are relationships that still need to be explored as well as mediating factors that may be determining these disparate outcomes.

Over the course of this project, we developed a model that allowed us to capture known relationships between characteristics of interruptions and performance outcomes. We then expanded the model to account for characteristics that have not yet been explored in the literature. We have also examined factors that play a role in successful resumption of a task. Specifically, we have been focusing on whether resumption is guided primarily by the retrieval of goals from memory or by cues present in the environment. We expanded this work to include more naturalistic settings. The task we chose was specifically designed to present realistic representations of decisions soldiers make, as well as test their recognition of threats. This study required extensive collaboration between AFRL and GMU. This work demonstrated that the findings we were seeing in the laboratory held up when “quality” was defined as making a good decision in a threatening environment.

We have also explored the measurement of “overall quality” in the laboratory. Most interruptions research has been focused on the time required to resume a task and errors made at the point of resumption on tasks that do not require significant integration of information over

time. However, many decisions or products that people care about in the workplace have this characteristic. For example, in a military setting, it is likely more important that an operator make the correct decision about whether observed threats in an environment signal an attack than about whether that decision is made in 5 versus 8 seconds (although timing can also be important). In business settings, the quality of a report is likely more important than whether it took the individual writing it 2 hours, or 2 hours and 10 minutes. A similar case can be made in academia; the quality of the final paper is more important than the amount of time it took the student to write it.

Thus, we began to focus on tasks beyond the procedural tasks used in most interruptions research. In this work, we completed a series of studies examining the impact of interruptions on the quality of essays produced under either interrupted or non-interrupted conditions. We found that being interrupted while outlining or writing an essay reduces the final quality of that essay compared to when not interrupted. A secondary, unexpected finding revealed that interruptions also significantly reduced the amount of content produced in the essays. As a result, we extended this research line examining how interruptions affect the amount of content created in creative tasks. In this work, we collected data on participants completing the Alternate/Unusual Use Task developed by Guilford. Here again, we found that interruptions had a significant negative effect on the amount of content produced.

In a separate line of research, we investigated how noninvasive brain stimulation from transcranial direct stimulation (tDCS) could affect interrupted task performance. Because interruptions and multitasking in general rely heavily on working memory (and the brain networks governing working memory such as the prefrontal cortex), we showed that anodal stimulation of the prefrontal cortex significantly reduces the time it takes to resume tasks following interruptions. Similarly, we showed that stimulating the posterior parietal cortex can significantly reduce the number of errors made when resuming a task following an interruption.

Finally, we conducted a series of studies investigating the impact of interruptions on reading comprehension. This work contradicted much of the existing literature in this area, which claimed that reading was immune to interruption decrements due to peoples' expertise in reading. Our research showed that when comprehension performance is distinguished from recognition performance, decrements are seen. We extended this work to show that individuals with high working memory capacity do not show decrements following interruptions for comprehension or recognition while individuals with low working memory capacity show decrements for both. Thus, we revealed that limitations in working memory may be a possible mechanism mediating interrupted task performance.

Multitasking Research

In the area of multitasking, we examined multitasking performance and eye gaze patterns to provide some insight into the relationship between different tracking strategies and task performance. We have been particularly interested in the extent to which individuals of different ages use different strategies in performing multiple tasks simultaneously. There has been extensive research investigating performance-related differences in multitasking associated with age, and while there has been specific work looking at the relationship between age and psychophysical behaviors, such as eye-movements in applications like reading, very little has been done to relate these behaviors to multitasking. Our work sought to bridge this gap. We found that older adults exhibit a more focused pattern of fixations in a multitask environment than younger adults, who demonstrate a significantly more diffuse pattern of fixations.

Perceptual Cueing

Finally, our research team was engaged in a collaborative effort between AFRL and GMU where we examined the relative usefulness of 2-D versus 3-D cueing to help guide participants and improve performance in a multitask paradigm. This work suggests that 3-D cuing does not improve performance above that seen for 2-D versus simulated 3-D cuing. The data therefore suggest that simulated depth cues alone may be sufficient to improve task performance without introducing additional task load.

3.2 Training

Over the course of this project, CENTEC funding specifically has supported three doctoral students on this project: Nicole Werner, Eric Nelson, and Cyrus Foroughi. In addition, William (Bill) Miller, with support from the ASEE SMART program, worked on this project. Finally, other doctoral students in the Human Factors and Applied Program worked on this project without formal support, including Daniela Barragán and Patrick Mead.

A number of undergraduate students worked in our laboratory over the course of this project and received training under the supervision of Dr. Boehm-Davis and the graduate students supported on this project. They included: , Zahraa Akhwand, Rukhsar Anjum, Nohelia Argote, Celine Asbury, Roberto Azanon, Jack Belkin, Aaron Benson, Shirley Borja, Tori Chamberlin, Jessica Chang, Michael Dawkins, Maria D'Agostino, Mahtab Farid, Stacy Fernandes, Reema Halabi, Rachel Hall, Mark Cameron Hatcher**, Katherine Herbst, Beth Hosek, Kaitlyn Hull, Alex Kelly, Hibah Khan, Skylar Kissam, Christina Lau, Anthony Lopez**, Parasteh Malihi*, Justine-Louise Manning, Rod Morrisse, Adeela Nasreen, Theodore Parks, Palak Patel, Arzo Raoufi, Christine Sabin, Carolyn Serraino*, Anuj Sharma, Khadija Siddiqui, Mariam Talib, Dennis Trammel, Eliana Vela, and Shannon Walsh, Taha Zafar*.

Bill Miller spent each summer from 2011 through 2015 at AFRL with the 711 Human Performance Wing's Human Effectiveness Directorate. In that capacity, he met with Drs. Gloria Calhoun, Terry Stanard, Paul Havig and Eric Geiselman to continue our CENTEC research collaborations.

* denotes earning publication credit

** denotes proceedings publication credit

3.3 Collaborative Activities

Over the course of this program, our project team worked with Paul Havig and Eric Geiselman regarding use of their 3_D (and simulated 3_D) version of the Multi-Attribute Task Battery AF_MATB. We also worked with Dr. Gloria Calhoun and members of her team (including Terry Stanard) to do some collaborative work examining interruptions using a military-related task. In this work, we teamed with AFRL to use imagery that they are generating to present more realistic representations of decisions soldiers would need to make, recognizing threats in street scenes and making decisions about what action to take.

Project 4: Multimodal Cognition (Baldwin)

4.1 Research Overview

This research program had two major tracks. The first one involved developing and validating a method of determining perceived urgency and annoyance for alerts and warnings across modalities (visual, auditory and tactile) and then determining the specific auditory parameters most critical to achieving both the perception and appropriate response to time critical warnings.

The second track involved examinations of behavioral and neurophysiological indices of auditory spatial cognition, including individual differences in perceptions of verbal versus spatial auditory cues within and across spatial frames of reference. As described in further detail below, both of these collaborative tracks led to a number of publications and presentations, graduate students were trained in neuroergonomic methods and applications in each of these areas and both led, either directly or indirectly to further research and additional external funding.

Multimodal Urgency Scaling

We conducted multiple, programmatic, research studies investigating subjective and behavioral responses to multimodal alerting systems. Subjective studies included investigations of changes perceptions of urgency, annoyance and acceptability with changes in key parameters of visual, auditory and tactile signals, as well as bimodal combinations. In particular, measures of utility, or the ratio of perceived urgency versus perceived annoyance, were determined. Subjective studies (Lewis & Baldwin, 2012; Baldwin & Lewis, 2013) indicate that manipulations of tactile signals have greater utility compared with manipulations of auditory parameters and although manipulations of visual color showed high utility, they were not generally perceived as particularly urgent.

Behavioral studies (Lewis, Penaranda, Roberts & Baldwin, 2013a, 2013b) indicated that response times in the context of a simulated driving paradigm showed similar trends to those observed for subjective measures of urgency in that signals rated higher in urgency were also typically responded to more quickly. In addition, bimodal signals were typically responded to more quickly than unimodal counterparts and the use of multiple modalities typically increased the chance of detecting the signal.

Auditory Spatial Cognition

A series of studies investigated change deafness within complex auditory scenes. Specifically, the influence of differentiating sounds on identity versus spatial location on the facilitation of change detection.

Behaviorally, participants were poorer at detecting changes when items in the auditory scene were differentiated on spatial location alone, relative to identity alone. However, differentiating items on both identity and spatial location facilitated change detection to levels above those observed for sounds differentiated on identity alone. From an individual differences perspective, participants with a strong Verbal cognitive style had higher performance on detecting changes to the auditory scene relative to participants with a strong Visuospatial cognitive style.

A follow-up study focused on the facilitation of change detection for scenes containing identity and spatial information, relative to scenes containing identity information alone. Change

detection performance was again facilitated when spatial information was added to the auditory scene. Physiologically, scenes containing spatial information were associated with decreased amplitude of the auditory N100 component of the event-related potential (ERP) to the sound scene onset, as well as an enhanced amplitude of the P300 component of the ERP to sound disappearance. Taken together, these results suggest that spatialization of items in the auditory scene reduces the attentional demand for scene segregation.

A second series of investigations in this track included examining perception and response to auditory signals within and across spatial frames of reference. This work provided a foundation for the dissertation work of Centec Scholar, Andre Garcia.

Project 5: Neuroadaptive Systems (Shaw)

5.1 Research

The primary focus of project area 5 has been on exploring the feasibility of using measures of hemodynamics to assess attentional resources during cognitive task performance. We've done this using two approaches. First, multiple research studies were conducted to investigate hemodynamic response to a variety of cognitive tasks, including multimodal displays, supervisory control simulations, and sustained attention. Second, we explored a wide array of individual differences in neurophysiological response to simple and complex supervisory control tasks. These individual differences included examining working memory capacity, extraversion, Neuroticism, self-control. The overarching goal of both of these approaches was to examine the extent to which diagnostic monitoring for cognitive workload can be achieved using hemodynamic measures. The primary neurophysiological method that was used was Transcranial Doppler Sonography (TCD), but we also demonstrated the feasibility of using a new hemodynamic measure that can be used to measure cognitive load during vigilance tasks. The new technique, called functional Tissue Pulsatility Imaging (fTPI), measures tissue which has higher backscatter than blood. For this reason, tissue from specific regions of the brain can be viewed and analyzed, which overcomes the low spatial resolution of TCD.

5.2 Training and collaborative activities

Three doctoral students, Kelly Satterfield, Raul Ramirez, entered the program in Fall 2011 and have been consistently working on Centec related projects. For example, Kelly has taken the lead on projects evaluating the workload of the MMC and has been instrumental in facilitating the collaborative efforts between Tyler Shaw and Victor Finomore. Raul Ramirez has been carrying out studies further examining the vigilance/CBFV relation from an individual differences vantage point, including the effects of extrinsic motivation on vigilance performance.

There is also strong evidence of collaboration. Almost 45% of the publications produced under this project area featured an author from WPAFB. One of the students funded under this project area interned for a summer at WPAFB (Kelly Satterfield). At WPAFB, Kelly interned worked in the laboratory of Drs. Greg Funke and Adam Strang.

Project 6: Training the Brain (Greenwood and Parasuraman)

6.1 Research

CENTEC support has allowed us to extend our previous work on cognitive training using laboratory tasks of perception and memory to training on simulations of military missions. Without CENTEC support and collaboration with Richard McKinley at WPAFB, we would not have had access to the military simulations. Such simulations are complex multi-tasks which allowed us to look at effects of transcranial direct current stimulation (tDCS) on subtask performance. These simulations are also cognitively demanding, which revealed the presence of subgroups in our participants with high and low performers responding differently to tDCS.

Over the course of CENTEC, Project 6 has investigated ways to train mind and brain that support the Air Force mission of enhanced human effectiveness in air, space, and cyberspace operations. Several strands of investigation made up our line of research on training the brain.

One strand of our research efforts concerns the particular advantage of perception training for inducing far transfer of training. The ‘holy grail’ of cognitive training is far transfer to fluid intelligence, but such transfer has not been consistently demonstrated. In one of the few studies to directly compare the effectiveness of different types of training regarding transfer to fluid intelligence, we found 6 weeks of perception training to be more effective than reasoning or multi-task training (Strenziok et al., 2014). We also investigated this in an ongoing follow-up study (Harwood et al., 2015). Perception training has been a relatively neglected approach as most investigators of far transfer of cognitive training have used working memory training. However, our findings are consistent with those from some recent studies of perceptual training from two other research groups. This evidence has led us to advance the hypothesis that perception training improves the attentional control that we argue is critical to induce far transfer of training to fluid intelligence (Greenwood & Parasuraman, 2015). The field of cognitive training is lacking in theory and ours is the first comprehensive hypothesis aimed at guiding research into the fundamentals of cognitive training and transfer of training.

A second strand of our CENTEC-supported research efforts on training the brain concerns the use of direct current stimulation (tDCS) to facilitate cognitive training. We have a number of findings from this work finding that tDCS not only facilitates cognitive training, but also affects brain function. Eric Blumberg found that tDCS rapidly heightened motion perception (Blumberg et al., 2015). Melissa Scheldrup conducted several studies finding tDCS facilitated acquisition of complex multi-tasks (Scheldrup et al., 2014) including a multi-tasks simulation of aircraft carrier defense (Scheldrup et al., 2016). Those studies found effects of tDCS on only one of the two subtasks, and only in low performers. High performers were unaffected by tDCS. Thus these difficult military simulations revealed more complex effects of tDCS than are typically reported. Two studies have found that tDCS affected not only task acquisition but also brain function. Dean Cisler found that tDCS promoted far transfer of working memory training to Gf but in a manner related to brain functional connectivity changes (Cisler et al., 2014). Brian Falcone found that tDCS increased functional connectivity in parietal cortex in a manner related to improved search performance in a search-and-rescue simulation (Callan et al., 2016; Falcone et al., submitted).

A third strand to our research efforts on training the brain involves automated decision making during training (Scheldrup et al., 2014, 2016). This work is currently being conducted in collaboration with Lincoln Labs at MIT using the “Strike Group Defender: The Missile Matrix ” task, a simulation of surface electronic warfare.

A fourth strand to our research efforts on training the brain involves investigating the role of placebo effects in cognitive training studies. We obtained convincing evidence that apparent cognitive training effects could be obtained in participants recruited with a suggestive flyer (“studies have shown that working memory training can increase fluid intelligence”) who showed a strong prior belief in the malleability of IQ. Participants recruited neutrally did not show training effects (Foroughi et al., 2016). This work is important for showing not only the importance of careful experimental control to avoid placebo effects in cognitive training studies but also the importance of understanding participant expectation in cognitive training effects.

6.2 Training

A number of graduate students worked on Project 6. Doctoral students, Brian Falcone and Ryan McKendrick, were recruited as “Air Force scholars” in Year 1 of CENTEC and Brian Kidwell was recruited later. All contributed strong work to this project. Project 6 also required the training of several Masters students Dean Cisler, Amanda Harwood, and Aaron Booth (all now doctoral students).

6.3 Collaborative activities

Our main collaborator on the tDCS work has been Richard (Andy) McKinley at WPAFB. We visited his lab a number of times over the life of CENTEC and he has provided us (and helped set up) with several Air Force-relevant simulations that we have used in our studies (Warship Commander, Cyber Defense). We have continued our collaboration with Marom Bikson of CUNY, who modeled the electrical field for our tDCS stimulation montages. Another important collaborator has been Dan Callan, of Osaka University in Japan who has been a mentor to our graduate student Brian Falcone. We are also collaborating with Reed Jensen at MIT’s Lincoln Laboratory. Doctoral student Melissa Scheldrup developed a collaboration with that group involving automatic decision making for the simulation “Strike Group Defender: The Missile Matrix.” This simulation of defense against antiship cruise missiles was named best serious game in the “Serious Games Showcase and Challenge” in 2014. The collaboration will be continuing into this fall.

Conclusions/ Other direct and indirect benefits

In addition to the work reported above, it is also worth mentioning that CENTEC offered many other direct and indirect benefits to George Mason faculty and students. One of the more direct benefits has been in the training and support CENTEC provided for George Mason students. At least 1 post-doc, 15 doctoral students, and 3 Masters students have been formally funded during the life of the grant. In addition, several students at the doctoral, MA, and undergraduate level were affiliated with CENTEC but did not receive formal support. To that end, CENTEC directly contributed to the education and training of those students, and in several

cases offered a focus for doctoral research in neuroscience and human factors. In addition, the establishment of CENTEC offered an infrastructure to conduct research on the application of neuroscience to critical issues in human factors. That infrastructure facilitated lasting collaborations between personnel at GMU and AFRL. An additional, important indirect benefit of the CENTEC award was to assist researchers at GMU in conducting high quality cognitive neuroscience research. One effect of this was to provide the basis for an application to the National Science Foundation Major Research Instrumentation program for funding for a new 3T Prisma Magnetic Resonance Imaging scanner. We were successful in obtaining this award, worth \$2.3 million, and we anticipate installation of the new scanner in 2017.

Publications and Presentations

7.1 Patents

US Patent Application 12/785,556 “Music Recommender,” E. T. Nelson, Filed May 24, 2010

US Patent Application 12/784,832 “Tamper Detection RFID Tape,” E. T. Nelson, Filed May 21, 2010

US Patent Application 12/758,273 “Inclement Condition Speedometer,” D. Cades, J. Barrow, D. Kidd, E. Nelson, D. Roberts, Filed April 12, 2010

7.2 Peer-Reviewed Journal Articles

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- Werner, N. E., Cades, D. M., Boehm-Davis, D. A., Peterson, M. S., Alothman, S. J., Zhang, X. (2010). Individual differences in resuming interrupted tasks. *Journal of the Washington Academy of Sciences*, 96 (3), 35-49.
- Werner, N.E. & Holden, R.J. (2015). Interruptions in the wild: A systematic review and socio-technical model of interruptions in the emergency department. *Applied Ergonomics*, 51, 244-254.
- Werner, N.E., Cades, D.M., Peterson, M.S., Alothman, S.J., Zhang, X. Boehm-Davis, D.A. (2011). Individual differences in resuming interrupted tasks. *Journal of the Washington Academy of Sciences*, 96(3), 35-49.

7.3 Conference Proceedings and Presentations

- A. Komendantov, G. Ascoli, et al.: Electrophysiological phenotypes of hippocampal neurons. Society for Neuroscience, New Orleans, LA, Oct. 2012.
- A. Komendantov, G. Ascoli, et al.: Electrophysiology of hippocampal neurons. Society for Neuroscience, 2012.
- Arbaje, A.I., Werner, N.E., Leff, B.A., Gurses, A.P., Tanner, E. (2014). Identifying Information Management Challenges Faced by Home Healthcare Nurses Managing Older Adults' Transitions from Hospital to Home Care. International Home Care Nurses Organization Conference, Singapore, September 2014.
- Arbaje, A.I., Werner, N.E., Leff, B.A., Gurses, A.P., Tanner, E. (2014). Identifying Information Management Challenges Faced by Home Healthcare Nurses Managing Older Adults' Transitions from Hospital to Home Care. International Home Care Nurses Organization Conference, Singapore.
- Arbaje, A.I., Werner, N.E., Nasarwanji, M.F., Leff, B.A., Gurses, A.P. (2014). Evaluation of healthcare professionals' information management during older adults' transitions from hospital to home care. Association for Clinical and Translational Science 2014 Meeting, Washington, DC, April 2014.

- Arbaje, A.I., Werner, N.E., Nasarwanji, M.F., Leff, B.A., Gurses, A.P. (2014, April). Evaluation of healthcare professionals' information management during older adults' transitions from hospital to home care. Association for Clinical and Translational Science 2014 Meeting, Washington, DC.
- Ascoli, G. (2010). Quantifying autobiographical memory content. Presented at the Psychiatric Colloquium, University of Milan, Italy.
- Ascoli, G. (2010). The neuron registry and the Hippocampome. Presented at the HHMI Conference, JFRC.
- Ascoli, G. (2011, January). Recent advances, low-hanging fruit, strategic vision in Cognitive Modeling. Presented at the AFRL Workshop Advanced Initiatives, Dayton, OH.
- Baccus, W., Thompson, J.C. (June 2010). Contribution of body form and motion to responses to biological motion in MT+ and EBA depends on cue reliability. 17th Annual Meeting Human Brain Mapping Abstracts.
- Baldwin, C, Spence, C., Bliss, J., Brill, C. J., Wogalter, M. S., Mayhorn, C. B., & Ferris, T. (2012). Multimodal cueing: The relative benefits of the auditory, visual, and tactile channels in complex environments. Proceedings of the Human Factors and Ergonomics Society 56th Annual Meeting. Santa Monica, CA.
- Baldwin, C. L. (2013). Auditory Cognition: Individual Differences in Navigation & Auditory Spatial Perception. Invited Colloquium presented at Benares Hindu University. (February 2013: Varanasi, India).
- Baldwin, C. L. (2014). Invited address entitled, "Individual Differences In Change Deafness: Implications For Display Design" presented at the Sonic Information Design Workshop. Held in conjunction with the annual meeting of the International Community of Auditory Display. (June, 2014, New York City).
- Baldwin, C. L. (2013). Individual Differences in Auditory Spatial Perception. Invited Colloquium presented at University of Pennsylvania, Computer Science Laboratory. (March 2013: Philadelphia, PA).
- Baldwin, C. L., Roberts, D. M., Buzzell, G. A., Sin, B. M.*, Jesso, M., Simpson, B. D., & Iyer, N. (2014). Individual Differences in Change Deafness: Verbal Cognitive Style Aids Detection. Proceedings of the Cognitive Neuroscience Society. (April, 2014: Boston, MS).
- Baldwin, C.L., Spence, C., Wogalter, M., Ferris, T., et.al. (2012, October). Multimodal cueing: The relative benefits of the auditory, visual, and tactile channels in complex environments. Paper to be presented at the Human Factors and Ergonomics Society Annual Meeting, Boston, MA.
- Barrow, J. H., and Baldwin, C. L. (2010). Allowing for Individual Differences in Auditory Warning Design: Who Benefits from Spatial Auditory Alerts? In Proceedings of the

Human Factors and Ergonomics Society Annual Conference. (September, 2010, San Francisco, CA).

- Barrow, J. H., and Baldwin, C. L. (2010). Spatial audio vs. verbal directional cues: an examination of salience and disruptiveness within a simulated driving context. In Proceedings of the International Community of Auditory Display. (June, 2010, Washington, D. C.).
- Barrow, J. H., Wenger, L., Bourne, J. E., Baldwin, C. L. (2012). The Effect of Musical Valence on Pseudoneglect in a Likerttype Rating Task. Proceedings of the 12th International Conference on Music Perception and Cognition (ICMPC) (Greece, July 2012).
- Barrow, J., Borne, J., Wenger, L., & Baldwin, C. L. (2011, September). Musical Valence Affects Spatial Attention in a Likert Scale Rating Task. Paper presented at the Human Factors and Ergonomics Society Annual Meeting. Las Vegas, NV.
- Boehm-Davis, D. A (2012, February). Understanding Interruptions: A Model and Data. Paper presented at the International Ergonomics Association Triennial Congress. Recife, Brazil.
- Boehm-Davis, D. A. (2011, July). Decision-making and cognitive task analysis. Lecture presented at the 51st Annual Human Factors Short Course, Ann Arbor, MI.
- Boehm-Davis, D. A. (2011, July). Decision-making and cognitive task analysis. Lecture presented at the 51st Annual Human Factors Short Course, Ann Arbor, MI. Also presented in 2012, 2013, 2014, 2015 and 2016
- Boehm-Davis, D. A. (2011, July). Experimental design, analysis, and presentation. Lecture presented at the 51st Annual Human Factors Short Course, Ann Arbor, MI. Also presented in 2012, 2013, 2014, 2015 and 2016
- Boehm-Davis, D. A. (2011, July). Experimental design, analysis, and presentation. Lecture presented at the 51st Annual Human Factors Short Course, Ann Arbor, MI..
- Boehm-Davis, D. A. (2011, July). Fundamentals of speaking. Presented to the APA Summer Science Fellowship students. George Mason University, Fairfax, VA.
- Boehm-Davis, D. A. (2011, July). Perception, Memory & Cognition. Lecture presented at the 51st Annual Human Factors Short Course, Ann Arbor, MI.
- Boehm-Davis, D. A. (2011, July). Perception, Memory & Cognition. Lecture presented at the 51st Annual Human Factors Short Course, Ann Arbor, MI. Also presented in 2012, 2013, 2014, 2015 and 2016
- Boehm-Davis, D. A. (2012). Mentoring HF/E: Knowing my students. In Teaching Human Factors and Ergonomics, Beth Blickensderfer (Chair). Proceedings of the Human Factors & Ergonomics Society 56th Annual Meeting. Santa Monica, CA: The Human Factors & Ergonomics Society.

- Boehm-Davis, D. A. (2012, April). Can you control your bias? Subliminal actions of the brain that can affect your case work. Lecture presented at the Chesapeake Bay Division of the International Association for Identification Meeting, Cambridge, MD.
- Boehm-Davis, D. A. (2012, February). Can you control your bias? Subliminal actions of the brain that can affect your case work. Lecture presented at the American Academy of Forensic Science Meeting. Atlanta, GA.
- Boehm-Davis, D. A. (2012, February). Can you control your bias? Subliminal actions of the brain that can affect your case work. Lecture presented at the American Academy of Forensic Science Meeting. Atlanta, GA. Also presented (2012, April). At the Chesapeake Bay Division of the International Association for Identification Meeting, Cambridge, MD.
- Boehm-Davis, D. A. (2012, October). Teaching human factors and ergonomics. Panel presentation at the HFES Annual Meeting, Boston, MA.
- Boehm-Davis, D. A. (2013, September). Stop interrupting me: You're hurting my performance. Poster presented at the HFES Annual Meeting. San Diego, CA.
- Boehm-Davis, D. A. (2013, September). The future of human factors and Ergonomics: Charting a course for our profession. Panel presentation at the HFES Annual Meeting, San Diego, CA.
- C. Rees, G. Ascoli, et al. (2013). Neuron types to parse the function of connectomes. SfN13, San Diego CA.
- C. Rees, G. Ascoli, et al.: (2011, October). Interpreting the rodent hippocampal structural network at the cell-class level using graph theory. Paper presented at the 40th Society of Neuroscience Conference, Washington DC.
- C. Rees, G. Ascoli, et al.: Molecular profiling of hippocampal neurons. Society for Neuroscience, 2012.
- C. White, G. Ascoli, et al.: Molecular profiling of hippocampal neurons. Society for Neuroscience, 2012.
- Cisler, D., Jesso, M.N., Parasuraman, R. Greenwood, P.M. Attentional modulation of the contralateral delay activity CDA during working memory retention. Presented to Society for Neuroscience, Chicago, IL, 2015.
- Cisler, D., Strenziok, M., Parasuraman, R. Greenwood, P.M. (2014). Intensive working memory training transfers to everyday functioning and alters connectivity between the dorsal and ventral attention networks. Society for Neuroscience.
- Cisler, D., Strenziok, M., Parasuraman, R. Greenwood, P.M. Intensive working memory training transfers to everyday functioning and alters connectivity between the dorsal and ventral attention networks. Presented to Society for Neuroscience, Washington, D.C., 2014.

- Clarke, E. McGarry, W.R., Bickel, J., Thompson, J., Peterson, M.S., Strohl, J., Greenwood, P.M., Parasuraman, R. Cognitive training in healthy old age: Comparison of 3 training tasks on everyday cognitive functioning and white matter integrity. Presented to Society for Neuroscience, Nov. 2011.
- Clarke, E., Andrews, A., Espeseth, T., Parasuraman, R., & Greenwood, P. M. (2010). Visuospatial attention influences mental representation in working memory as reflected in the CDA. Society of Neuroscience Abstracts, 399.10/KKK66. Washington DC: Society for Neuroscience.
- Clayton, E., Cisler, D., McKinley, R., Bikson, M., Greenwood, P.M., Parasuraman, R.
- Clayton, E., Cisler, D., McKinley, R., Bikson, M., Greenwood, P.M., Parasuraman, R. (2014). Comparison of cognitive training vs transcranial Direct Current Stimulation on performance of a “Cyber Defense” multi-task. Society for Neuroscience.
- Comparison of cognitive training vs transcranial Direct Current Stimulation on performance of a “Cyber Defense” multi-task. Presented to Society for Neuroscience, Washington, D.C., 2014
- Coyne, J. T., Sibley, C., Baldwin, C. L., (2011). Ongoing Efforts Towards Developing a Physiologically Driven Training System. In Proceedings of the Human Computer Interaction Society Conference. (June, 2011: Orlando, FL).
- Coyne, J. T., Sibley, C., Baldwin, C. L., (2011, August). Ongoing Efforts Towards Developing a Physiologically Driven Training System. Paper presented at the Human Computer Interaction Society Conference, Orlando, FL.
- D. Hamilton, G. Ascoli, et al. (2013). Machine-readable hippocampal neuron properties. Neuroinformatics Conf., Stockholm, Sweden.
- D. Hamilton, G. Ascoli, et al. Neuroinformatic infrastructure for a knowledge base of hippocampus neurons. Society for Neuroscience, 2012.
- D. Marchette, G. Ascoli et al. (2012, January). Investigation of a Random Graph Model for Neuronal Connectivity. Am. Math. Soc., Boston, MA.
- D. Wheeler, G. Ascoli, et al. (2013). Morphological phenotyping of hippocampal neurons. Burroughs-Wellcome Conf., Fairfax, VA.
- D. Wheeler, G. Ascoli, et al. (2013). An open-access knowledge base of neuronal properties for the rodent hippocampus. Burroughs-Wellcome Conf., Fairfax, VA.
- D. Wheeler, G. Ascoli, et al.: (2011). Towards an unambiguous identification of the known neuronal classes of the rodent hippocampus. Paper presented at the 40th Society of Neuroscience Conference, Washington DC.

- D. Wheeler, G. Ascoli, et al.: Hippocampal neuron classification. Society for Neuroscience, 2012.
- D. Wheeler, G. Ascoli, et al.: Hippocampome alpha release. Society for Neuroscience, 2012.
- De Visser, E. J., Krueger, F., McKnight, P., Chalk, S., & Parasuraman, R. (2012, October). The world is not enough: Trust in cognitive agents. Proceedings of the Human Factors and Ergonomics Society, Boston, MA.
- Dziura, S., Baccus, W., Thompson, J.C. (2012, May). The effects of stimulus contrast on action discrimination. Annual Meeting of the Vision Sciences Society, Naples, FL.
- Eisert, J., & Baldwin, C. L. (2012, May). Vibrotactile Signals Effectively Convey Collision Avoidance Information With Less Annoyance. Paper presented at the Intelligent Transportation Society Annual Conference. Washington, D.C.
- Eisert, J., Garcia, A., Payne, J. J., & Baldwin, C. L. (2013). Tactile Route Guidance Performance and Preference. Proceedings of the Human Factors and Ergonomics Society 57th Annual Meeting. Santa Monica, CA: Human Factors and Ergonomics Society.
- Eisert, J., Garcia, A., Payne, J. J., Baldwin, C. L. (2013, in press). Tactile Route Guidance Performance and Preference. Proceedings of the Human Factors and
- Falcone, B., & Parasuraman, R. (2012, October). Comparative effects of first-person shooter video game experience and brain stimulation on threat detection learning. Proceedings of the Human Factors and Ergonomics Society, Boston, MA.
- Falcone, B., McKendrick, R., & Falcone, B., McKendrick, R., & Parasuraman, R. (2013, April). Enhancing verbal and spatial working memory with non-invasive direct current stimulation of left dorsolateral prefrontal cortex. Proceedings of the Annual Meeting of the Cognitive Neuroscience Society, San Francisco, CA.
- Falcone, B., Wada, A., Parasuraman, R., & Callan D. (2015). Direct Current Brain Stimulation Induces Changes in Cortical Activation Mediating Visual Search: A Concurrent tDCS and fMRI Study. Presented at the Cognitive Neuroscience Society Conference. San Francisco, CA
- Fedota, J., McDonald, C. G., & Parasuraman, R. (2010). Modulation of conflict monitoring processes by stimulus ambiguity in an Eriksen flanker task: An event-related potential study. Society of Neuroscience Abstracts, 699.5/JJJ35. Washington DC: Society for Neuroscience.
- Finomore, V., Rahill, K.M., Satterfield, K., & Shaw, T. H. (2014). Best of Both Worlds: Evaluation of Multi-Modal Communication Management Suite. Proceedings of the Human Factors and Ergonomic Society, USA, 58.
- Fong, A., Sibley, C., Coyne, J., Baldwin, C. (2011). Method for Characterizing and Identifying Task Evoked Pupillary Responses During Varying Workload Levels. Proceedings of the

- Human Factors and Ergonomics Society Annual Meeting. (September, 2011, Las Vegas, NV).
- Fong, A., Sibley, C., Coyne, J., Baldwin, C. (2011, September). Method for Characterizing and Identifying Task Evoked Pupillary Responses During Varying Workload Levels. In Paper presented at the Human Factors and Ergonomics Society Annual Meeting. Las Vegas, NV.
- Foroughi, C. F., Werner, N. E., Nelson, E. T., Boehm-Davis, D. A. (2013). Do interruptions affect quality of work? Proceedings of the Human Factors and Ergonomics Society 57th Annual Meeting.
- Foroughi, C. K., (2014). Suppressing the Thought Process. Presentation at the George Mason University Human Factors and Applied Cognition Brown Bag, Fairfax, VA.
- Foroughi, C. K., Blumberg, E. J., Scheldrup, M. R., Peterson, M. S., Parasuraman, R., & Boehm-Davis, D. A. (2014). Reducing the Decrement: Transcranial Direct Current Stimulation Reduces Resumption Time Post-Interruption. Poster presented at the 21st Annual Meeting of the Cognitive Neuroscience Society, Boston, MA.
- Foroughi, C. K., Werner, N. E., & Boehm-Davis, D. A. (2016). Are Individuals Sensitive to Changes in Performance when Interrupted? In Proceedings of the 60th Human Factors and Ergonomics Society 60th Annual Meeting.
- Foroughi, C. K., Werner, N. E., Hatcher, M. C., Lopez, A. J., Zafar, T. W., & Boehm-Davis, D. A. (2014). Do Interruptions Affect Content Production? In Proceedings of the 58th Human Factors and Ergonomics Society 58th Annual Meeting.
- Foroughi, C. K., Werner, N. E., Hatcher, M. C., Lopez, A. J., Zafar, T. W., & Boehm-Davis, D. A. (2014). Do Interruptions Affect Content Production? In Proceedings of the 58th Human Factors and Ergonomics Society Annual Meeting.
- Foroughi, C. K., Werner, N. E., Nelson, E. T., Boehm-Davis, D. A. (2013). Do Interruptions Affect Quality of Work? In Proceedings of the Human Factors and Ergonomics Society 57th Annual Meeting. 57, 154-157.
- Foroughi, C. K., Werner, N. E., Nelson, E. T., Boehm-Davis, D. A. (2013). Do Interruptions Affect Quality of Work? In Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 57, 154-157.
- Foroughi, C. K., Wren, W. C., Barragan, D., Mead, P., & Boehm-Davis, D. A. (2015). Assessing mental rotation ability in a virtual environment with an Oculus Rift. In Proceedings of the 59th Human Factors and Ergonomics Society Annual Meeting, 59, 1849-1852.
- Fu, S., Greenwood, P. M., Lin, M.-K., Wang, Y., Fryxell, K., & Parasuraman, R. (2010, November). CHRNA4 genotypes and visuospatial attention: An event-related potential study. Society of Neuroscience Abstracts, 198.9/III33. Washington DC: Society for Neuroscience.

- Funke, G., Dillard, M., Funke, M., Warm, R., & Parasuraman, R. (2012, February). The SART does not promote mindlessness in vigilance. Paper presented in the Symposium on Neuroergonomics, Technology, and Cognition, International Ergonomics Association Conference, Recife, Brazil.
- Funke, G., Funke, M., Dillard, M., Finomore, V., Shaw, T., Epling, S., Warm, J. S., & Parasuraman, R. (2012, October). Proceedings of the Human Factors and Ergonomics Society, Boston, MA.
- G. Ascoli (2011, December). Molecular phenotyping of hippocampal neurons. Neurodevelopmental Gene Expression Workshop, Allen Brain Institute, Seattle, WA.
- G. Ascoli (2014). Digital neuroanatomy. Symp. Adapting Brain, Keystone, CO.
- G. Ascoli (2014). Minimum metadata standards for neuromorphology. AAAS Symp. Data Sharing, Washington DC, March 2014.
- G. Ascoli (2014). Neuroscience data sharing. BRAIN Mtg, US Presidential Bioethics Commission, Atlanta, GA, June 2014.
- G. Ascoli, & M. Mainetti. (2014). Much ADO about BIG learning. HHMI Neural Maps, JFRC, April 2014.
- G. Ascoli. (2013). Hippocampus: from neurons to function. Sapienza Univ. Rome, Italy, June 2013.
- G. Ascoli. (2013). Much ADO about BIG learning. HRL Colloquium, Malibu, CA, July 2013.
- G. Ascoli. (2013). Neuroinformatics challenges (Symp. Brain Aging). SfN13, San Diego CA, November 2013.
- G. Ascoli. (2014). Computing with a Periodic Table of the Neurons. Joint Symp. Neur. Comp., Irvine, CA, May 2014.
- G. Ascoli. (2014). Data sharing as a foundation of reproducible science. NSF Workshop, Arlington, VA, February 2014.
- G. Ascoli. (2014). Neurocognitive models of training. ONR mtg, Arlington, VA, February 2014.
- G. Ascoli: A knowledge base of hippocampus neuron types. HHMI Neuron Types, JFRC, Nov. 2012.
- G. Ascoli: Architects or botanists? The relevance of (neuronal) trees to model cognition. BICA Conf., Palermo (Italy), Oct. 2012.
- G. Ascoli: Hippocampus: from neurons to function. AFOSR Cognition & Comput Intell. Conf. Washington DC, January 2013.
- G. Ascoli: Neuronal Morphology goes Digital. Eur. Inst. Oncol., Milan, Italy, July 2012.

- G. Ascoli: Neuroscience Big Data. AAAS Colloquium, Washington DC, May 2013.
- G. Ascoli: Reconstructing the hippocampus from potential synapses to synaptic potentials. HHMI Light Circuit Reconstruction, JFRC, Oct. 2012
- G. Ascoli: The potential of brain connectivity. NAFKI conf. Irvine, CA, Nov. 2012.
- Garcia, A, Baldwin, C., Funke, M., Funke, G., Finomore, V., Dukes, A., Knott, B., Warm, J., (2011, May). The Effects of Co-Action on Workload and Stress in Team Vigilance. Paper presented at the 16th International Symposium on Aviation Psychology, Dayton, Ohio.
- Garcia, A. J., Baldwin, C. L., Funke, M., Funke, G., Knott, B., Finomore, V., Warm, J. (2011). Team Vigilance: The Effects of Co-Action on Workload in Vigilance. Proceeding of the Human Factors and Ergonomics Society Annual Meeting. (September, 2011, Las Vegas, NV).
- Garcia, A. J., Baldwin, C. L., Funke, M., Funke, G., Knott, B., Finomore, V., Warm, J. (2011, September). Team Vigilance: The Effects of Co-Action on Workload in Vigilance. In Paper presented at the Human Factors and Ergonomics Society Annual Meeting. Las Vegas, NV.
- Garcia, A., Baldwin, C. L., & Dworsky, M. (2010). Gender Differences in Simulator Sickness In Fixed- versus Rotating-Base Driving Simulator. In Proceedings of the Human Factors and Ergonomics Society Annual Conference. (September, 2010, San Francisco, CA).
- Garcia, A., Baldwin, C., Funke, M., Funke, G., Finomore, V., Dukes, A., Knott, B., & Warm, J., (2011, May). The effects of co-action on workload and stress in team vigilance.
- Garcia, A., Baldwin, C., Funke, M., Funke, G., Finomore, V., Dukes, A., Knott, B., Warm, J. (2011). The Effects of Co-Action on Workload and Stress in Team Vigilance. Proceedings of the 16th International Symposium on Aviation Psychology (May, 2011, Dayton, Ohio).
- Garcia, A., Baldwin, C., Funke, M., Funke, G., Finomore, V., Dukes, A., Knott, B., Warm, J., (2011, May). The Effects of Co-Action on Workload and Stress in Team Vigilance. Paper presented at the 16th International Symposium on Aviation Psychology, Dayton, OH.
- Garcia, A., Eisert, J., Finomore, V., & Baldwin, C. L. (2013). Comprehension of vibrotactile route guidance cues. Proceedings of the Human Computer Interaction International conference. (July 2013, Las Vegas, NV).
- Garcia, A., Eisert, J., Finomore, V., & Baldwin, C. L. (2013). Comprehension of vibrotactile route guidance cues. Proceedings of the Human Computer Interaction International conference. (July 2013, Las Vegas, NV).
- Garcia, A., Eisert, J., Payne, J., Baldwin, C. L., & Finomore, V. (2013). Individual differences in perception of advanced navigation systems and their influence on route learning.

- Proceedings of the International Symposium of Aviation Psychology. (May, 2013: Dayton, OH).
- Garcia, A., Finomore, V., Burnett, G., Baldwin, C., Brill, C. (2012, October). Individual differences in multimodal waypoint navigation. Paper to be presented at the Human Factors and Ergonomics Society Annual Meeting, Boston, MA.
- Gardner, R., & Ascoli, G. (2011, May). Quantitative characterization of autobiographical and prospective memory. Presented at the Association for Psychological Science Conference, Washington DC, 2011.
- Gartenberg, D., Veksler, B., Gunzelmann, G., & Trafton, J. G. (2014). An ACT-R process model of the signal duration phenomenon of vigilance. In Proceedings of 58th annual meeting of the Human Factors and Ergonomics Society.
- Gonzalez, C. A., & Baldwin, C. L. (2013). Effects of Pulse rate, Fundamental Frequency, and Burst Density on Auditory Similarity. Proceedings of the Human Factors and Ergonomics Society 57th Annual Meeting. Santa Monica, CA: Human Factors and Ergonomics Society.
- Gonzalez, C. A., & Baldwin, C. L. (2013, in press). Effects of Pulse rate, Fundamental Frequency, and Burst Density on Auditory Similarity. Proceedings of the Human Factors and Ergonomics Society 57th Annual Meeting. Santa Monica, CA.
- Gonzalez, C., Lewis, B. A., Baldwin, C. L. (2012). Revisiting pulse rate, frequency and perceived urgency: Have relationships changed and why? Proceedings of the 18th International Conference on Auditory Display (June 2012, Atlanta Georgia).
- Gonzalez, C., Lewis, B. A., Baldwin, C. L. (2012, June). Revisiting pulse rate, frequency and perceived urgency: Have relationships changed and why? Paper presented at the 18th International Conference on Auditory Display, Atlanta GA.
- Gonzalez, C., Lewis, B. A., Pratt, S., Baldwin, C. L. (2012, October). Perceived Urgency and Annoyance of Auditory Alerts in a Driving Context. Paper presented at the Human Factors and Ergonomics Society Annual Meeting, Boston, MA.
- Greenwood, P. M., Strenziok, M., Clarke, E., McGarry, W. R., Bickel, J., Thompson, J. C., & Parasuraman, R. (2012, March). Cerebral White Matter Integrity and Everyday Problem Solving Changes after Cognitive Training with Video Games in Healthy Old Age. Paper presented at the Annual Meeting of the Cognitive Neuroscience Society, Chicago, IL.
- Greenwood, P. M., Strenziok, M., Clarke, E., McGarry, W. R., Bickel, J., Thompson, J.C., & Parasuraman, R. Cerebral White Matter Integrity and Everyday Problem Solving Changes after Cognitive Training with Video Games in Healthy Old Age. Paper presented at the Annual Meeting of the Cognitive Neuroscience Society, Chicago, IL, March 2012.

- Greenwood, P., Clarke, E., Strenziok, M., Bickel, J., McGarry, R., Strohl, J., Thompson, J., & Parasuraman, R. (2012, March). Cognitive training in healthy old age: Comparison of 3 training tasks on cognitive functioning and white matter integrity. Paper presented the Annual Meeting of the Cognitive Neuroscience Society, Chicago, IL
- Greenwood, P., Clarke, E., Strenziok, M., Bickel, J., McGarry, R., Strohl, J., Thompson, J., & Parasuraman, R. Cognitive training in healthy old age: Comparison of 3 training tasks on cognitive functioning and white matter integrity. Paper presented the Annual Meeting of the Cognitive Neuroscience Society, Chicago, IL, March 2012.
- Greenwood, P.M. Invited “State of the Science” talk at Cognitive Aging Conference, April 6, 2014, in Atlanta Georgia. Title of talk was “Heterogeneity in cognitive aging: genetics and epigenetics.”
- Harwood, A. Greenwood, P.M., Shaw, T. Increased Cerebral Blood Flow in Older Adults during Vigilance, Presented at the Cognitive Neuroscience Society, April, 2016.
- Harwood, A.E., Cisler, D., Parasuraman, R. Greenwood, P.M. Distraction suppression and video game training: far transfer effects to fluid intelligence. Presented to Society for Neuroscience, Chicago, IL, 2015.
- Howard M., Bhattacharyya R., O’Reilly R., Ascoli G., Fellous J. (2011). Adaptive Recall in Hippocampus. In A. Samsonovich & K. Johansson, Eds., BICA Proceedings, IOS Press, pp. 151-7.
- Iyer, N., Thompson, E., Romigh, G., Baldwin, C. L. & Simpson, B. (2013). Spatial attention in an auditory dual task. (June, 2013: Sweden). Proceedings of the Cognitive Hearing Sciences Conference.
- Iyer, N., Thompson, E., Romigh, G., Baldwin, C. L. & Simpson, B. (2013). Spatial attention in an auditory dual task. Published Abstract in the Proceedings of the Cognitive Hearing Sciences Conference. (June, 2013: Sweden).
- Kennedy, W. G. (2010). Towards understanding trust through computational cognitive modeling. In Proceedings of the First International Conference on Biologically Inspired Cognitive Architectures. November 13-14. Arlington, VA: American Association for Artificial Intelligence.
- Kennedy, W. G., & Krueger, F. (2013) Building a Cognitive Model of Trust Within ACT-R To Match Functional Neuroimaging Data. (May, 2013: Stanford, CA). Association for the Advancement of Artificial Intelligence (AAAI) Spring Symposium.
- Kennedy, W.G., & Patterson, R.E. (2012, April). Modeling Intuitive Decision Making in ACT-R. Paper presented at the International Conference on Cognitive Modeling, Berlin.
- Kidd, D. G., Nelson, E. K., & Baldwin, C. L. (2010). The effects of repeated exposures to collision warnings on driving and secondary task performance. In Proceedings of the

- Human Factors and Ergonomics Society Annual Conference. (September, 2010, San Francisco, CA).
- Kidwell, B., Calhoun, G., Ruff, R., & Parasuraman, R. (2012, October). Adaptable and adaptive automation for supervisory control of multiple autonomous vehicles. Proceedings of the Human Factors and Ergonomics Society, Boston, MA.
- Kidwell, B., Miller, W., & Parasuraman, R. (2014). Automation complacency: Using non-invasive brain stimulation to change attention allocation. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 58, 27 October-31 October.
- Kidwell, B., Miller, W., Parasuraman, R. (2014). Automation complacency: Using non-invasive brain stimulation to change attention allocation. In Proceedings of the Human Factors and Ergonomics Society 58th Annual Meeting, 58, 27 October-31 October.
- Komendantov, G. Ascoli, et al.: Electrophysiological phenotyping of hippocampal neurons. Society for Neuroscience 2013.
- Lewis, B. A., Penaranda, B. N., Roberts, D. M., & Baldwin, C. L. (2013). Max brake force as a measure of perceived urgency in a driving context. Proceedings of the Human Factors and Ergonomics Society 57th Annual Meeting. Santa Monica, CA: Human Factors and Ergonomics Society.
- Lewis, B. A., Penaranda, B. N., Roberts, D. M., & Baldwin, C. L. (2013, in press). Max brake force as a measure of perceived urgency in a driving context. Proceedings of the Human Factors and Ergonomics Society 57th Annual Meeting. Santa Monica, CA.
- Lewis, B. A., Penaranda, B. N., Roberts, D. M., & Baldwin, C. L. (2013). Effectiveness of Bimodal Versus Unimodal Alerts for Distracted Drivers. (June 2013, Bolton Landing, NY). Proceedings of the Driving Assessment Conference.
- Lewis, B. A., Penaranda, B. N., Roberts, D. M., & Baldwin, C. L. (2013). Effectiveness of Bimodal Versus Unimodal Alerts for Distracted Drivers. (June 2013, Bolton Landing, NY). Proceedings of the Driving Assessment Conference.
- Lewis, B., & Baldwin, C. L. (2012, October). Perceived urgency across auditory, visual, and vibrotactile signals: An examination and validation. Paper to be presented at the Human Factors and Ergonomics Society Annual Meeting, Boston, MA.
- Mandell, A., Becker, A., & Shaw, T.H. (2014). The effect of neuroticism on vigilance performance: A Transcranial Doppler investigation. Proceedings of the Human Factors and Ergonomic Society, USA, 58.
- McCorry, D., & Thompson, J.C. (Nov 2010). Decoding covert speech states using functional magnetic resonance imaging and multi-voxel pattern analysis. Society for Neuroscience Abstracts. San Diego, CA: Society for Neuroscience.

- McGarry, R., Strenziok, M., Cisler, D.S., Clarke, E., Santa Cruz, S.A., Thompson, J.C., Parasuraman, R., & Greenwood, P.M. Real-Time Strategy Video Game Training Increases Fronto-Parietal Cortical Thickness, Default Mode Network Connectivity, and Reasoning Ability in Healthy Older Adults. Cognitive Neuroscience Society 2013 Meeting, April 13-16, 2013, San Francisco, CA.
- McGarry, W., Strenziok, M., Cisler, D., Clarke, E., Santa Cruz, S., Thompson, J., Parasuraman, R., & Greenwood, P. (2013, April). Real-time strategy video game training increases fronto-parietal cortical thickness, default mode network connectivity, and reasoning ability in healthy older adults. Proceedings of the Annual Meeting of the Cognitive Neuroscience Society, San Francisco, CA.
- McKendrick, R., & Parasuraman, R. (2012, October). Effects of different types of variable priority and adaptive training on skill acquisition in dual verbal-spatial working memory tasks. Proceedings of the Human Factors and Ergonomics Society, Boston, MA.
- McKendrick, R., Shaw, T., Saqer, H., de Visser, E., & Parasuraman, R. (2011, September). Team performance and communication within networked supervisory control human-machine systems. Paper presented at the Annual Conference of the Human Factors and Ergonomics Society, Las Vegas, NV.
- Melissa Scheldrup, Jon Strohl, Jessica Vance, Danielle Walker, Pamela Greenwood & Raja Parasuraman. Transcranial direct current stimulation exerts selective benefits on executive control in a complex task whether prefrontal or motor cortex is stimulated. Cognitive Neuroscience Society 2013 Meeting, April 13-16, 2013, San Francisco, CA.
- Miller, W. D. & Boehm-Davis, D. A. (2013). Age-Related Differences in Positional Dispersion of Fixations in a Multitask Environment. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 57, 104-108.
- Miller, W. D. & Boehm-Davis, D. A., & Stanard, T. (2014). What Happens When You Can't Press Pause? The Effect Of Interruptions On Detecting Threats In A Simulated Closed-Circuit Television Surveillance Feed. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 58, 27 October-31 October.
- Miller, W. D. & Boehm-Davis, D. A., & Stanard, T. (2014). What Happens When You Can't Press Pause? The Effect Of Interruptions On Detecting Threats In A Simulated Closed-Circuit Television Surveillance Feed. In Proceedings of the Human Factors and Ergonomics Society 58th Annual Meeting, 58, 27 October-31 October.
- Miller, W.D. & Boehm-Davis, D.A. (2013). Age-Related Differences in Positional Dispersion of Fixations in a Multitask Environment. Proceedings of the Human Factors & Ergonomics Society 57th Annual Meeting. (October, 2013, San Diego, CA).
- Miller, W.D. & Boehm-Davis, D.A. (2013). Age-Related Differences in Positional Dispersion of Fixations in a Multitask Environment. Proceedings of the Human Factors & Ergonomics Society Annual Meeting. (October, 2013, San Diego, CA).

- Nadler, E., Traube, E., Lerner, N., Jenness, J., Brown, T., Baldwin, C., Chiang, D., Forkenbrock, G. (2013). Development of Crash Warning Interface Metrics (CWIM). Proceedings of the 23rd Enhanced Safety in Vehicles conference. (May 27-30, Seoul, Korea).
- Nadler, E., Traube, E., Lerner, N., Jenness, J., Brown, T., Baldwin, C., Chiang, D., Forkenbrock, G. (in press). Development of Crash Warning Interface Metrics (CWIM). Proceedings of the 23rd Enhanced Safety in Vehicles conference. (May 27-30, Seoul, Korea).
- Nguyen, C., Satterfield, K., Bellows, B., McKnight, P., & Shaw, T.H. (2013). Assessing resource utilization during vigilance using Transcranial Doppler: The effects of extraversion. Proceedings of the Human Factors and Ergonomics Society, 57.
- Paper presented at the 16th International Symposium on Aviation Psychology, Dayton, OH.
- Parasuraman, R. & Greenwood, P.M. Video Game Training and Transcranial Direct Current Brain Stimulation Enhance Human Learning and Brain Function. Symposium presented at APA Convention, Honolulu, 7/31-8/4, 2013.
- Parasuraman, R. (2011, August). Neurogenetics of individual differences in working memory and decision making: Implications for selection and training. Paper presented at the Annual Meeting of the American Psychological Association, Washington DC.
- Parasuraman, R. (2011, June). Neuroergonomics research at CENTEC. Invited Lecture, Institute for Aerospace Engineering, Technical University of Berlin, Berlin, Germany.
- Parasuraman, R. (2011, September). Can behavioral, neuroimaging, and molecular genetic studies of “cognitive superstars” tell us how to augment cognition? Paper presented at the Annual Conference of the Human Factors and Ergonomics Society, Las Vegas, NV.
- Parasuraman, R. (2011, September). Neuroergonomics: Theory and methods. Invited Webinar, Human Factors and Ergonomics Society, Santa Monica, CA.
- Parasuraman, R. (2012, February). Neurogenetics of individual differences in complex decision making. Paper presented in the Symposium on Neuroergonomics, Technology, and Cognition, International Ergonomics Association Conference, Recife, Brazil.
- Parasuraman, R. (2012, June). Supercharging cognition: Neuroimaging, genetic, and brain stimulation studies. Invited Lectures given at: (1), Key Laboratory of the Cognitive Neuroscience of Learning, Beijing Normal University, Beijing, China; (2) Department of Psychology, Tsinghua University Beijing, China; (3) Department of Kinesiology, Shanghai University of Sport, Shanghai, China; and (4) Laboratory of Brain and Cognitive Disorders, Hangzhou Normal University, Beijing, China.
- Parasuraman, R. (2012, October). Applications of NIRS in ergonomics and human factors. Invited Panel, Proceeding of the Human Factors and Ergonomics Society, Boston, MA.

- Parasuraman, R. (2012, October). Reducing major rule violations in commuter rail operations: The role of distractions and attentional errors. Invited Panel, Proceedings of the Human Factors and Ergonomics Society, Boston, MA.
- Parasuraman, R. (2012, October). Our future HF/E professors and researchers: Is anyone in the pipeline? Invited Panel, Past President's Forum, Proceedings of the Human Factors and Ergonomics Society, Boston, MA.
- Parasuraman, R. (2012, October). Paul M. Fitts Education Award winners: Teaching human factors and ergonomics. Invited Panel, Proceedings of the Human Factors and Ergonomics Society, Boston, MA.
- Parasuraman, R., & Galster, S. (2012, March). Invited Chair, Panel on Sensing, Workshop on Human Performance Augmentation, Arizona State University, Tempe, AZ.
- Penaranda, B., & Baldwin, C. L. (2012). Temporal factors of EEG and Artificial Neural Network Classifiers of Mental Workload. Proceedings of the Human Factors and Ergonomics Society. (October, 2012, Boston).
- Penaranda, B., & Baldwin, C. L. (2012, October). Temporal factors of EEG and Artificial Neural Network Classifiers of Mental Workload. Paper to be presented at the Human Factors and Ergonomics Society. Boston, MA.
- Pratt, S., Gonzalez, C., Lewis, B. A., & Baldwin, C. L. (2012, in press). Perceived urgency scaling of tactile alerts. Proceedings of the Human Factors and Ergonomics Society Annual Meeting. (October 2012, Boston).
- Pratt, S., Gonzalez, C., Lewis, B. A., Baldwin, C. L. (2012, October). Perceived urgency scaling of tactile alerts. Paper to be presented at the Human Factors and Ergonomics Society Annual Meeting. Boston, MA.
- R. Gardner, G. Ascoli, et al.: Place & response navigation in dual-solution task. HRL Colloquium, 2013.
- R. Goldin, G. Ascoli, et al. (2012, March). Neuron classification from network connectivity. Am. Math Soc. Mtg, Washington DC,.
- R. Goldin, G. Ascoli, et al. (2012, March). Neuron classification from network connectivity. HHMI Statistics & Neuroscience, JFRC.
- R. Goldin, G. Ascoli, et al. (2012, March). Neuron classification from network connectivity. NIST Colloquium, Gaithersburg, MD,
- Ramirez, R., Botteicher, V., Shaw, T. H., Sikdar, S., Parasuraman, R. (2014). Exploring the feasibility of using functional Tissue Pulsatility Imaging to measure cognitive load during an abbreviated vigilance task. Proceedings of the Human Factors and Ergonomic Society, USA, 58.

- Roberts, D., Fedota, J., Buzzell, G., Parasuraman, R., & McDonald, C. (2013, April). Top-down modulation of prestimulus alpha power and its relation to a stimulus discrimination process. Proceedings of the Annual Meeting of the Cognitive Neuroscience Society, San Francisco, CA.
- Robinson, E., Lerner, N., Jenness, J., Traube, E., Brown, T., Baldwin, C., Llaneras, R. (2011). Crash Warning Interface Metrics: Evaluating Driver-Vehicle Interface Characteristics for Advanced Crash Warning Systems. Proceedings of the 22nd International Technical Conference on the Enhanced Safety of Vehicles (June, 2011, Washington, DC).
- S. Larson, G. Ascoli, et al.: The NeuroLex Neuron curation project. Neuroinformatics Conf., 2013.
- Safford, A.S. Siembada, K., & Thompson, J.C. (2012, May). Object-based attentional modulation of effective connectivity in biological motion perception. Paper presented at the Annual Meeting of the Cognitive Neuroscience Society, Chicago, IL.
- Safford, A.S., Hussey, E.A., Parasuraman, R., Thompson, J.C. (2010). Object-based attentional modulation of biological motion: Spatiotemporal dynamics using fMRI and EEG. 17th Annual Meeting Human Brain Mapping Abstracts.
- Saqer, H., de Visser, E., Emfield, A., Shaw, T.H., & Parasuraman, R. (2011). Adaptive Automation to Improve Human Performance in supervision of multiple uninhabited aerial vehicles: Individual markers of performance. Paper presented at the Human Factors and Ergonomics Society Annual Meeting, Las Vegas, NV.
- Sarbone, B., Greenwood, P. M., Smelser, J., & Parasuraman, R. (2013, April). Working memory training exerts stronger effects on risk aversion than stimulation of prefrontal cortex. Proceedings of the Annual Meeting of the Cognitive Neuroscience Society, San Francisco, CA.
- Satterfield, K., Finomore, V., & Shaw, T.H. (2014). Using cerebral hemovelocity to measure workload in a complex vigilance task with display redundancy. Proceedings of the Human Factors and Ergonomic Society, USA, 58.
- Satterfield, K., Ramirez, R., Shaw, T., & Parasuraman, R. (2012, October). Measuring workload during a dynamic supervisory control task using cerebral blood flow velocity and the NASA-TLX. Proceedings of the Annual Conference of the Human Factors and Ergonomics Society, Boston, MA.
- Scheldrup, M., Strohl, J., Lindgren E., Greenwood, P., Parasuraman R. Differential effects of transcranial direct current stimulation of prefrontal and motor cortex on a complex cognitive task. Society for Neuroscience, 2012.
- Scheldrup, M., Strohl, J., Vance, J., Walker, D., Greenwood, P., McKinley, A. R., & Parasuraman, R. (2013, April). Transcranial Direct Current Stimulation exerts selective benefits on executive control in a complex task whether prefrontal or motor cortex is

- stimulated. Proceedings of the Annual Meeting of the Cognitive Neuroscience Society, San Francisco, CA.
- Scheldrup, M., Strohl, J., Vance, J., Walker, D., Greenwood, P.G., Parasuraman, R. Transcranial direct current stimulation exerts selective benefits on executive control in a complex task whether prefrontal or motor cortex is stimulated. Cognitive Neuroscience Society Annual Meeting, 2013.
- Scheldrup, M., Strohl, J., Vance, J., Walker, D., Greenwood, P.M., Parasuraman, R. (2013). Transcranial direct current stimulation exerts selective benefits on executive control in a complex task whether prefrontal or motor cortex is stimulated. Cognitive Neuroscience Society Annual Meeting.
- Scheldrup, M., Vance, J., Glazier, S., Darmini, Y., McKinley, R.A., Parasuraman, R., Greenwood, P. M. Transcranial direct current stimulation and acquisition of a complex task; effect of stimulation timing during training. Cognitive Neuroscience Society Annual Meeting, 2014.
- Scheldrup, M., Vance, J., Glazier, S., Darmini, Y., McKinley, R.A., Parasuraman, R., Greenwood, P.M. (2014). Transcranial direct current stimulation and acquisition of a complex task; effect of stimulation timing during training. Cognitive Neuroscience Society Annual Meeting.
- Scheldrup, M., Vance, J., McKinley, R.A., Bikson, M., Parasuraman, R., Greenwood, P.M. Transcranial Direct Current Stimulation differentially influences implicit and explicit memory in a multi-task. Society for Neuroscience, 2014.
- Scheldrup, M.R., Dwidevy, P., McKinley, R., Greenwood, P.M. Transcranial direct current stimulation (tDCS) affects cognitive performance in only a subset of individuals—interindividual differences in tDCS responsiveness during complex cognitive training. Presented to Society for Neuroscience, Chicago, IL, 2015.
- Scheldrup, M.R., Vance, J., Blumberg, E., McKendrick, R., McKinley, R., Parasuraman, R., Greenwood, P.M. Transcranial direct current stimulation differentially affects subtasks during simulation of a real-world multi-task. Presented at Cognitive Neuroscience Society, April, 2015.
- Scheldrup, M.R., Vance, J., McKinley, R., Bikson, M., Parasuraman, R., Greenwood, P.M. (2014). Transcranial Direct Current Stimulation differentially influences implicit and explicit memory in a multi-task. Society for Neuroscience.
- Scheldrup, M.R., Vance, J., McKinley, R., Bikson, M., Parasuraman, R., Greenwood, P.M. Transcranial Direct Current Stimulation differentially influences implicit and explicit memory in a multi-task. Presented to Society for Neuroscience, Washington, D.C., 2014
- Schmidt, K., Jankord, R., Lin, M.-K., Lipsky, R., Parasuraman, R., Greenwood, P.M. Working memory in mouse and man: novel genetic variants in the formiminotransferase

- cyclodeaminase (FTCD) gene identified in mice and assessed in humans. Presented to Society for Neuroscience, Chicago, IL, 2015.
- Shaw, T.H. (2011, August). Measuring Sustained Attention: Group-level and Individual Differences Approaches. Paper presented at the Annual Meeting of the American Psychological Association, Washington DC.
- Sibley, C., Coyne, J. T., Baldwin, C. L. (2011, September). Pupil Dilation as an Index of Learning. Paper presented at the Human Factors and Ergonomics Society Annual Meeting, Las Vegas, NV.
- Strenziok, M., Chung, M., Greenwood, P., Santacruz, S., & Parasuraman, R. (2012, March). Reduced dorsolateral prefrontal activation during attentionally guided spatial working memory processing. Paper presented the Annual Meeting of the Cognitive Neuroscience Society, Chicago, IL.
- Strenziok, M., Clarke, E., Cruz, S. A., Thompson, J. C., Parasuraman, R., & Greenwood, P. M. (2013, April). Effects of real-time strategy video game training on white matter integrity in interhemispheric posterior callosal connections of the precuneus in healthy aging. Proceedings of the Annual Meeting of the Cognitive Neuroscience Society, San Francisco, CA.
- Strenziok, M., M. Chung, S. Santacruz, P.M. Greenwood, and R. Parasuraman, Altered dorsolateral prefrontal cortex activation during attentionally-guided spatial working memory processing in young adults, in Cognitive Neuroscience Society. Chicago, March 2012.
- Strohl, J., Greenwood, P. M., Lindgren, E., & Parasuraman, R. (2012, November). Differential effects of transcranial direct current stimulation of prefrontal and motor cortex on a complex cognitive task. Paper to be presented at the Society for Neuroscience, New Orleans, LA.
- Strohl, J., Greenwood, P. M., Lindgren, E., & Parasuraman, R. Differential effects of transcranial direct current stimulation of prefrontal and motor cortex on a complex cognitive task. Paper presented at the Society for Neuroscience, New Orleans, LA. November, 2012.
- Strohl, J., Greenwood, P. M., Lindgren, E., & Parasuraman, R. Differential effects of transcranial direct current stimulation of prefrontal and motor cortex on a complex cognitive task. Society for Neuroscience, November, 2012, New Orleans, LA.
- Taylor, B. A., Roberts, D. M., & Baldwin, C. L., (2011). Age-Related Differences in IntraIndividual Speech Processing Variability. Paper presented at the Cognitive Neuroscience Society Conference. San Francisco, CA.
- Thompson, J.C. (2012, July). Form and motion cues and the processing of actions in occipitotemporal cortex. Paper presented at "The Brain in Action" Symposium at the AsiaPacific Conference on Vision (APCV2012), Incheon, Korea.

- Tsai, Y.D., Kang, S., & Peterson, M.S. (September 2010). Effects of individual differences on visual search task performance. In Proceedings of the Fifty-fourth Annual Meeting of the Human Factors and Ergonomics Society. Santa Monica, CA: Human Factors and Ergonomics Society.
- Werner, N. (2012). Interruptions in the real world: examining the role of interruption locus on resumption in a hospital pharmacy. Poster presented at the International Ergonomics Association Triennial Congress. Recife, Brazil.
- Werner, N. E., Nelson, E. T., Miller W. D. & Boehm-Davis, D. A. (2012). Interruptions in the real world: Examining the role of internal versus external interruptions in a hospital pharmacy. Proceedings of the 56th Human Factors and Ergonomics Society Annual Meeting, 56(1), 819-823.
- Werner, N., Cades, D., Boehm-Davis, D. A., Chang, J., Khan, H., Thi, G. (2011). What Makes Us Resilient to Interruptions? Understanding the Role of Individual Differences in Resumption. In Proceedings of the Human Factors & Ergonomics Society Annual Meeting. Santa Monica, CA: The Human Factors & Ergonomics Society.
- Werner, N., Nelson, E. Miller, W., & Boehm-Davis, D. A. (2012). Interruptions in the real world: Examining the role of internal versus external interruptions in a hospital pharmacy. Proceedings of the Human Factors & Ergonomics Society Annual Meeting. Santa Monica, CA: The Human Factors & Ergonomics Society.
- Werner, N.E., & Holden, R. (2014). Exploring Interruptions in the Wild: How are Interruptions Experienced in Dynamic Action Teams? In Proceedings of the Human Factors and Ergonomics Society 58th Annual Meeting, Chicago, Illinois, October 2014.
- Werner, N.E., McNaughton, C., Holden, R. (2013). Exploring interruptions in complex action teams. Presented at the 2013 International Symposium on Human Factors and Ergonomics in Healthcare, March 16-19, Baltimore, Maryland, 2013.
- Wheeler, D., Rees, C., & Ascoli, G. A. (November 2010). The "Hippocampome", a database of potential connectivity among neuronal classes in the rodent hippocampus. Society of Neuroscience Abstracts. Washington DC: Society for Neuroscience.

7.4 Books and Book Chapters

- Baldwin, C. L. (2012). Auditory Cognition and Human Performance: Research and Applications. Clermont, FL: CRC Press – Taylor & Francis.
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7.5 Tech Reports

- Miller, W.D., Estepp, J.R., Schmidt, K.D., Bowers, M., Davis, I. (2014). An Updated Version of the U.S. Air Force Multi-Attribute Task Battery (AF-MATB). Technical report submitted.

7.6 Special Issue of *NeuroImage* on “Neuroergonomics: The Brain in Action and at Work.”

This special issue represents a key development relevant both to the research and collaboration goals of CENTEC. There is a strong need for a special issue on the topic in a high impact cognitive neuroscience journal. While neuroergonomics is increasingly well known in the human factors area, it is not yet well represented in the mainstream neuroscience literature.

Accordingly, CENTEC Director Raja Parasuraman made an initial inquiry to the editors of two high profile journals in cognitive neuroscience, *The Journal of Cognitive Neuroscience* and *NeuroImage* regarding the possibility of a special issue. Both editors were positive, but the first journal declined because they no longer publish special issues. The editor of the second journal, *NeuroImage*, was enthusiastically positive.

Following initial inquiries, discussions, and a review by the editor and publishers, the special issue is now planned for 2011, with 14 invited papers to be submitted by February 2011, and a publication date of about September 2011. An exciting aspect of the special issue is the agreement of Dr. Michael Posner to write a commentary article. Dr. Posner is particularly appropriate given that he is both a highly regarded pioneer of human performance research (e.g., Fitts & Posner, *Human Performance*, 1969) and is considered a “father” of the cognitive neuroscience revolution (Posner & Raichle, 1994).

The papers of the special issue will describe how research and practice in the field of human factors and ergonomics can be enriched by consideration of theories and results from neuroscience—in particular non-invasive neuroimaging, brain stimulation, molecular genetic, and computational techniques. In turn, the papers will show how neuroergonomics offers another example of translational neuroscience—as applied to normal populations engaged in work, transportation, and other everyday activities, as opposed to applications to clinical populations and medicine.

List of Invited Authors and Topics (CENTEC and AFRL contributors shown in **bold**).

Editorial. **Parasuraman**, **Christensen**, and Grafton.

1. Attention, biological motion, and action recognition. **Thompson** and **Parasuraman**, George Mason University.
2. Decoding intention: A neuroergonomic perspective. Grafton and Tipper, University of California, Santa Barbara.
3. A selective review of simulated driving studies: Combining naturalistic and hybrid paradigms, analysis approaches, and future directions. Calhoun and Pearlson, University of New Mexico.
4. Optical brain monitoring for operator training and mental workload assessment. Ayaz et al., Drexel University.
5. EEG metrics for within and cross task workload classification with an artificial neural network. **Baldwin** and Penaranda, George Mason University,
6. The effects of day-to-day variability of physiological data on operator functional state classification. **Christensen** et al., Air Force Research Laboratory.
7. Cross-subject workload classification with a hierarchical Bayes model. Hope et al., Rensselaer Polytechnic Institute.

8. Individual differences in cognition, affect, and performance: Behavioral, neuroimaging, and molecular genetic approaches. **Parasuraman** and Jiang, George Mason University.
9. Individual differences in cognitive style and strategy predict similarities in the patterns of brain activity between individuals. Miller et al., University of California, Santa Barbara.
10. Neural decoding of collective wisdom with multi-brain computing. Eckstein et al., University of California, Santa Barbara.
11. Computational neuroergonomics. Liu et al., University of Michigan.
12. TDCS guided using fMRI significantly accelerates learning to identify concealed objects. Clark et al., University of New Mexico.
13. Modulating the brain at work using noninvasive transcranial stimulation. **McKinley** et al., Air Force Research Laboratory
14. Effects of training strategies implemented in a complex videogame on functional connectivity of attentional networks. Voss et al., University of Illinois, Urbana-Champaign.
15. Expanding horizons in ergonomics research. Posner, University of Oregon.