

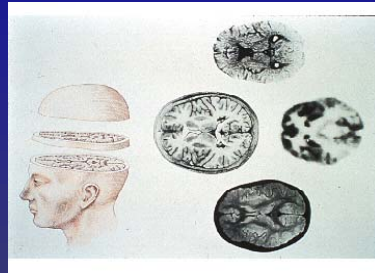
ATTENTION AS AN ORGAN SYSTEM:
Implications for education, training and
rehabilitation

MICHAEL I. POSNER
UNIVERSITY OF OREGON

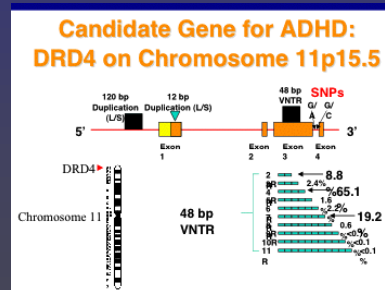
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MARCH 31, 2010

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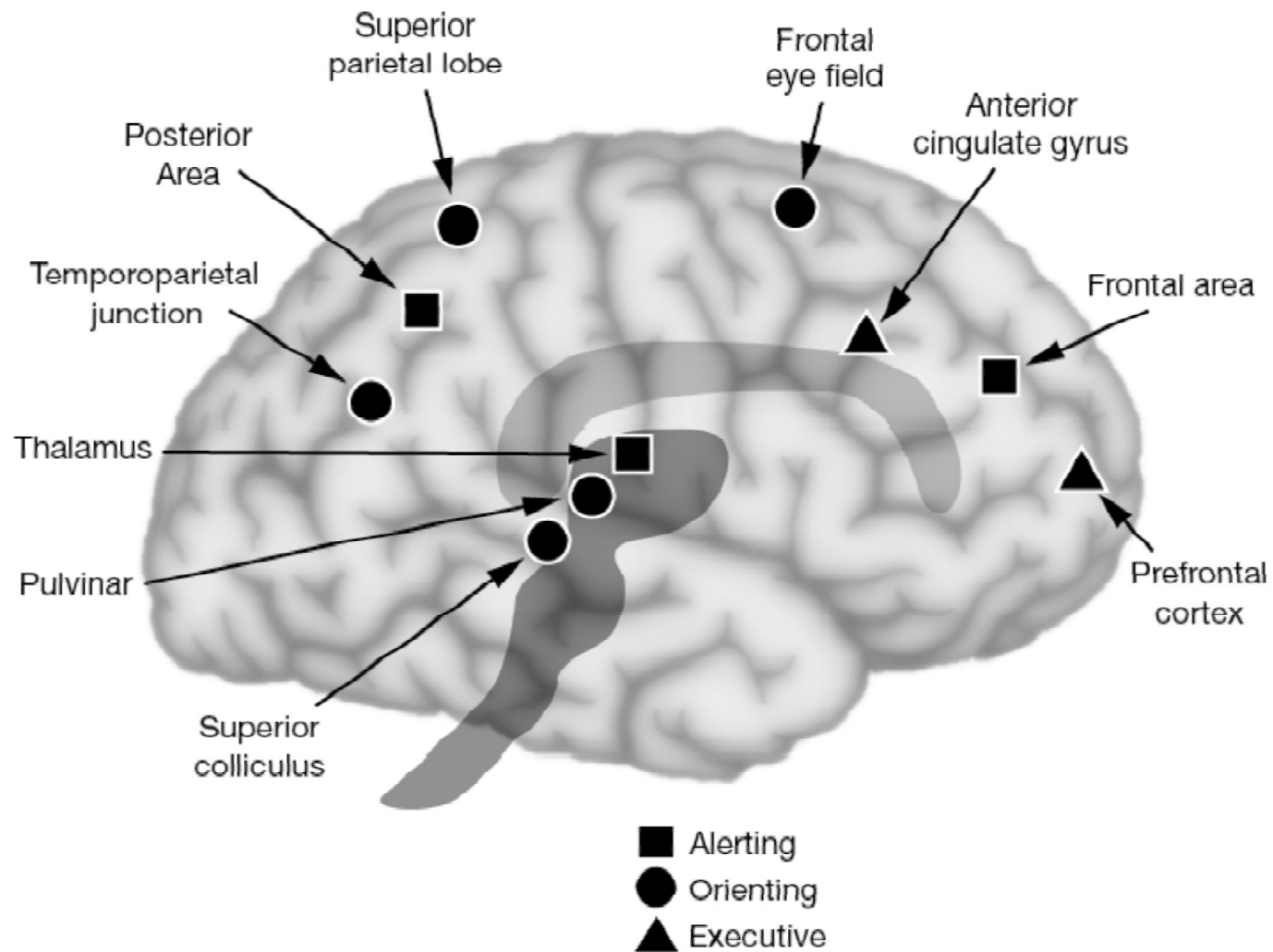
BRAIN IMAGING



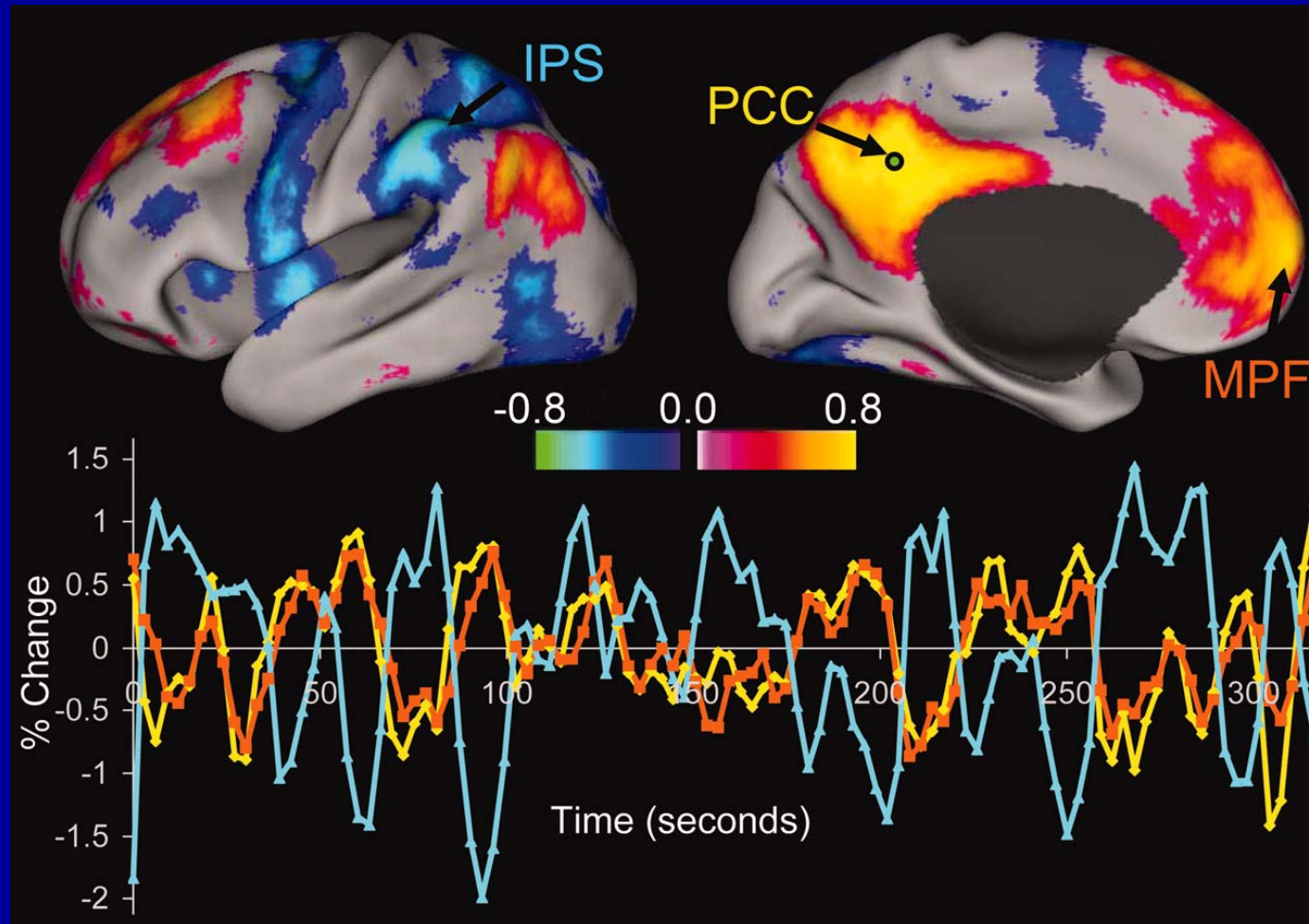
GENOMICS



ELECTRICAL RECORDING



ALERTING AND BRAIN STATES



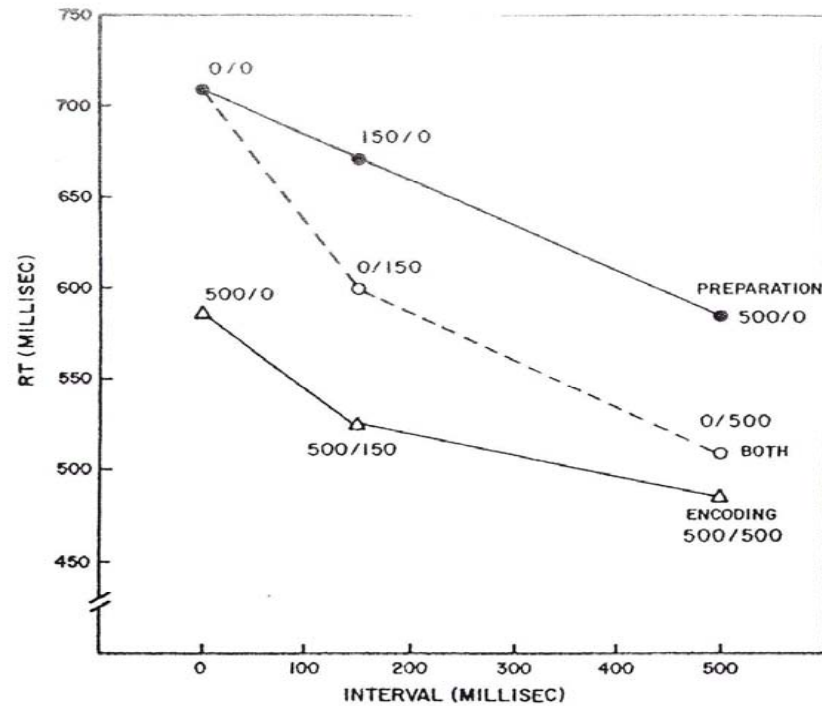


FIG. 5. Preparation, encoding, and "both" functions for name matching task. (Values of WI/ISI are shown for each point.)

TABLE 2
AMOUNT OF IMPROVEMENT IN REACTION TIME
FROM PREPARATION, ENCODING, AND BOTH

Match	Interval*	
	150	500
Physical		
Preparation	58	122
Encoding	53	73
Both	101	195
Name		
Preparation	42	127
Encoding	58	98
Both	111	201
Vowel-Consonant		
Preparation	71	170
Encoding	124	150
Both	157	296

Note.—Improvement is measured by subtracting RT at specified interval from RT at 0/0 for preparation and "both" function and 500/0 for encoding.

* In milliseconds.

Time Line

Enc Warn Both

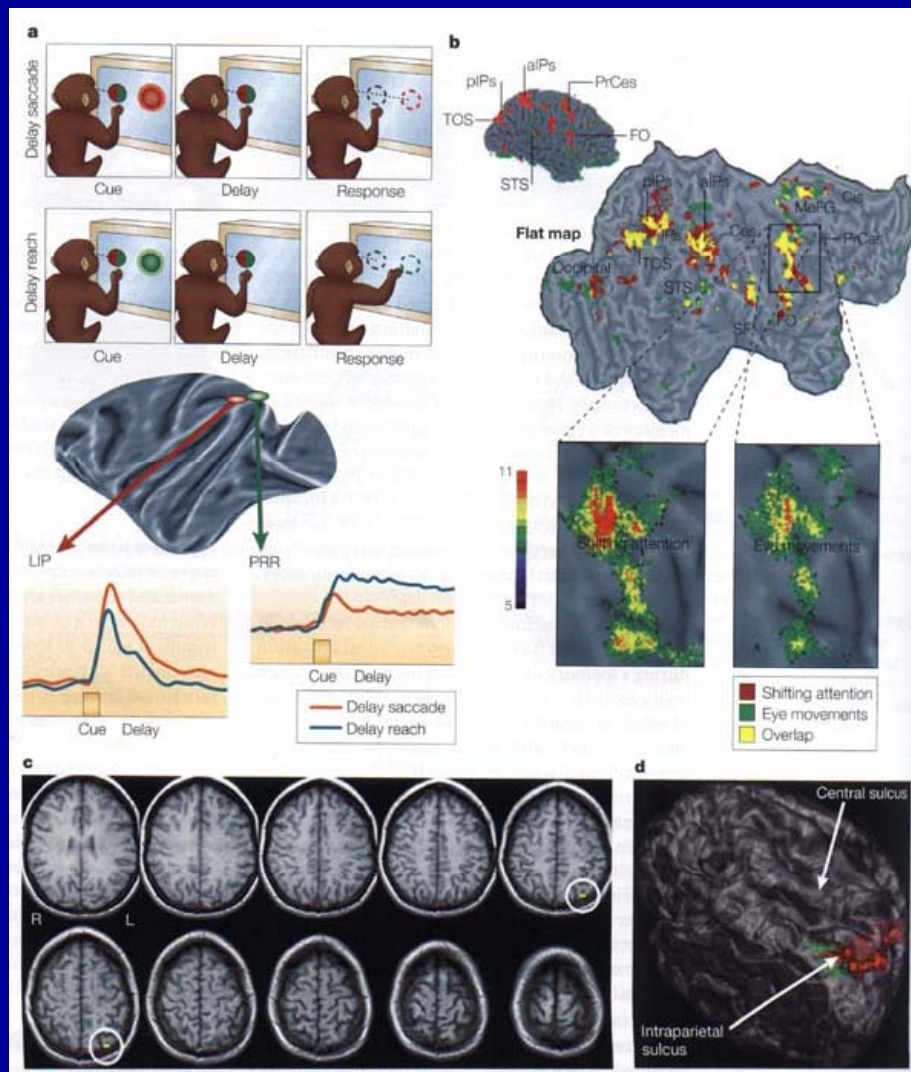
+ + A

A Aa

a a

ADHD AND ALERTING

Corbetta & Shulman, 2002



Degree of Dependence of Eye Movements
and Spatial Attention

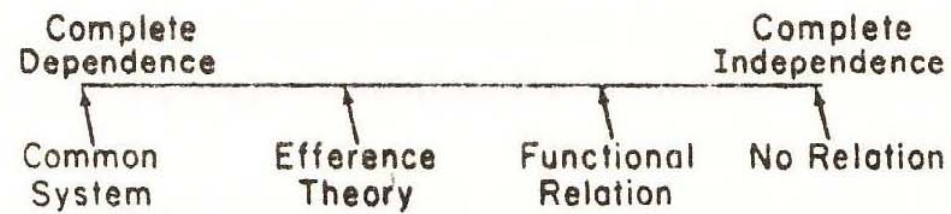


FIGURE 6. Logical relationships between overt and covert orienting of attention.

Posner, 1980

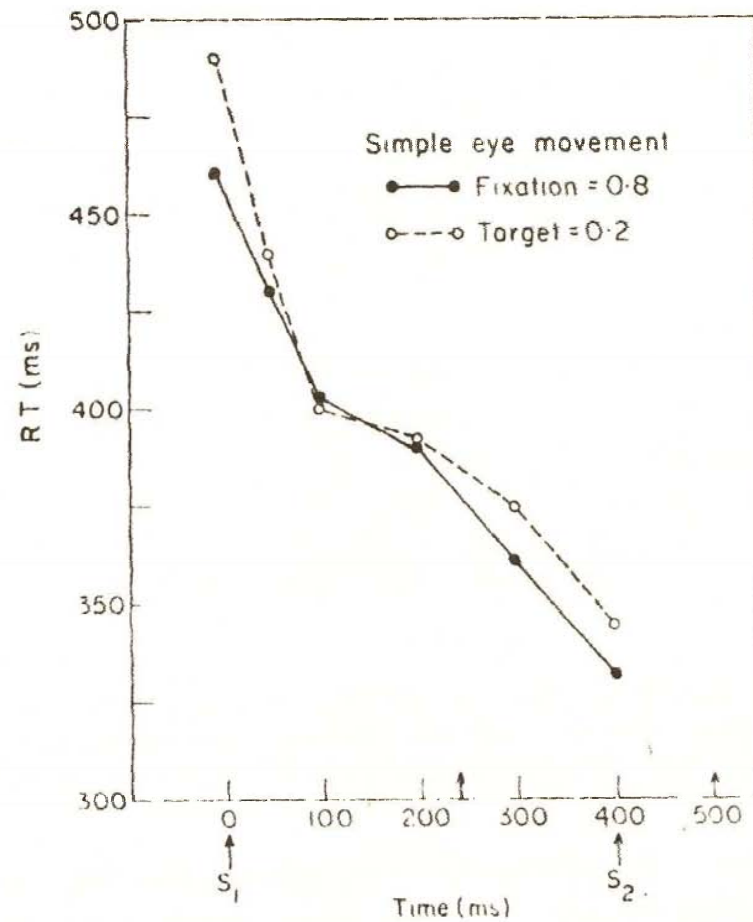
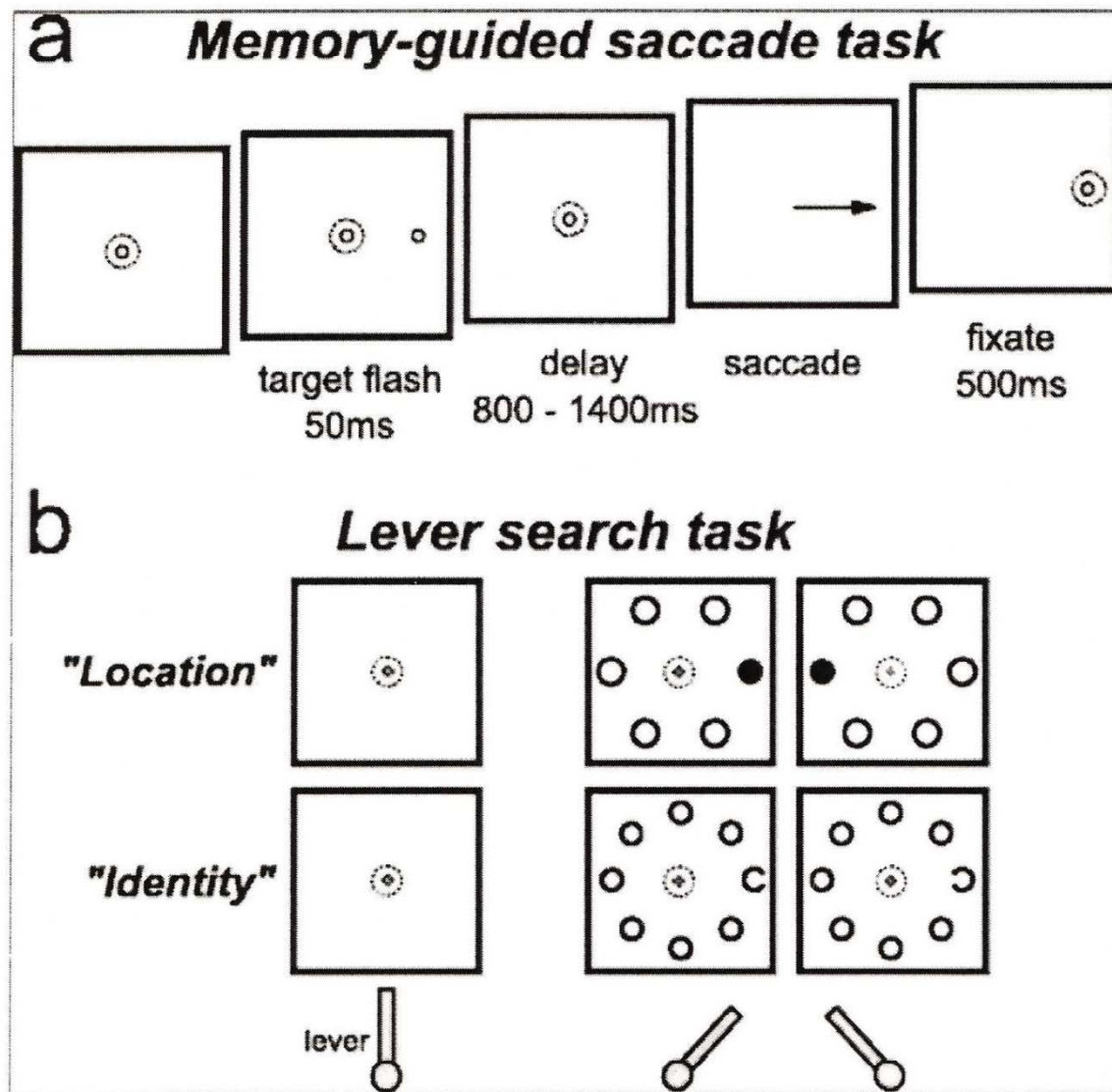
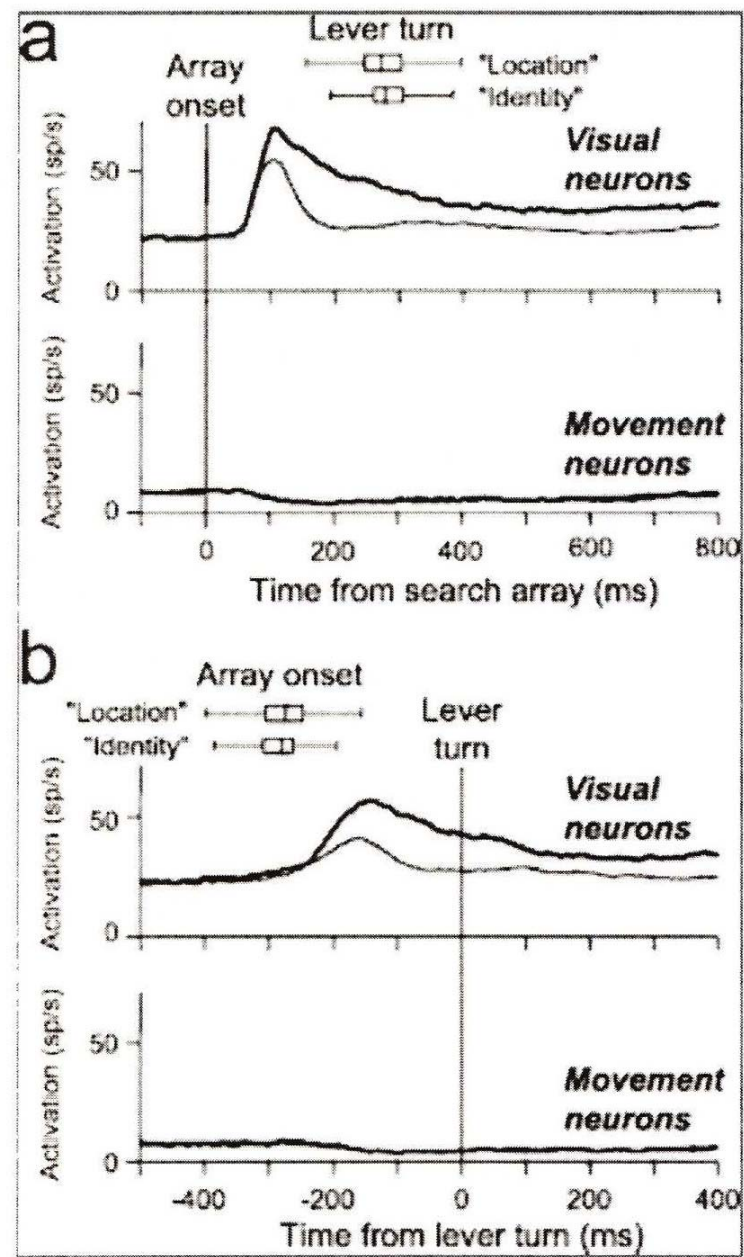


FIGURE 11. Reaction time to the detection stimulus when embedded in a double eye movement experiment. Command for the first eye movement occurs at S_1 and the second at S_2 . Arrows indicate mean RT for each movement (see text).

Posner, 1980



Thompson et al
2005



AUTISM AND ORIENTING

EXECUTIVE NETWORK

CONFLICT

SELF REGULATION

STROOP EFFECT

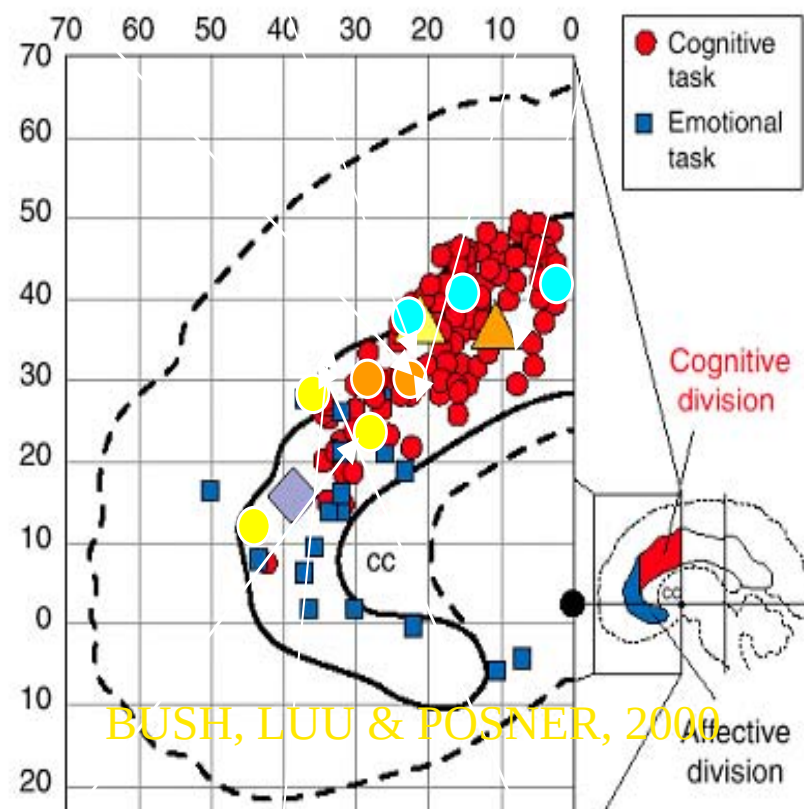
BLUE

GREEN

Yellow

Red

COGNITION AND EMOTIONAL CONTROL IN THE CINGULATE CORTEX



Linking Self-Regulation and Attention: Effortful Control

Effortful Control

Construct that consistently emerges from factorial analysis of temperament questionnaires.

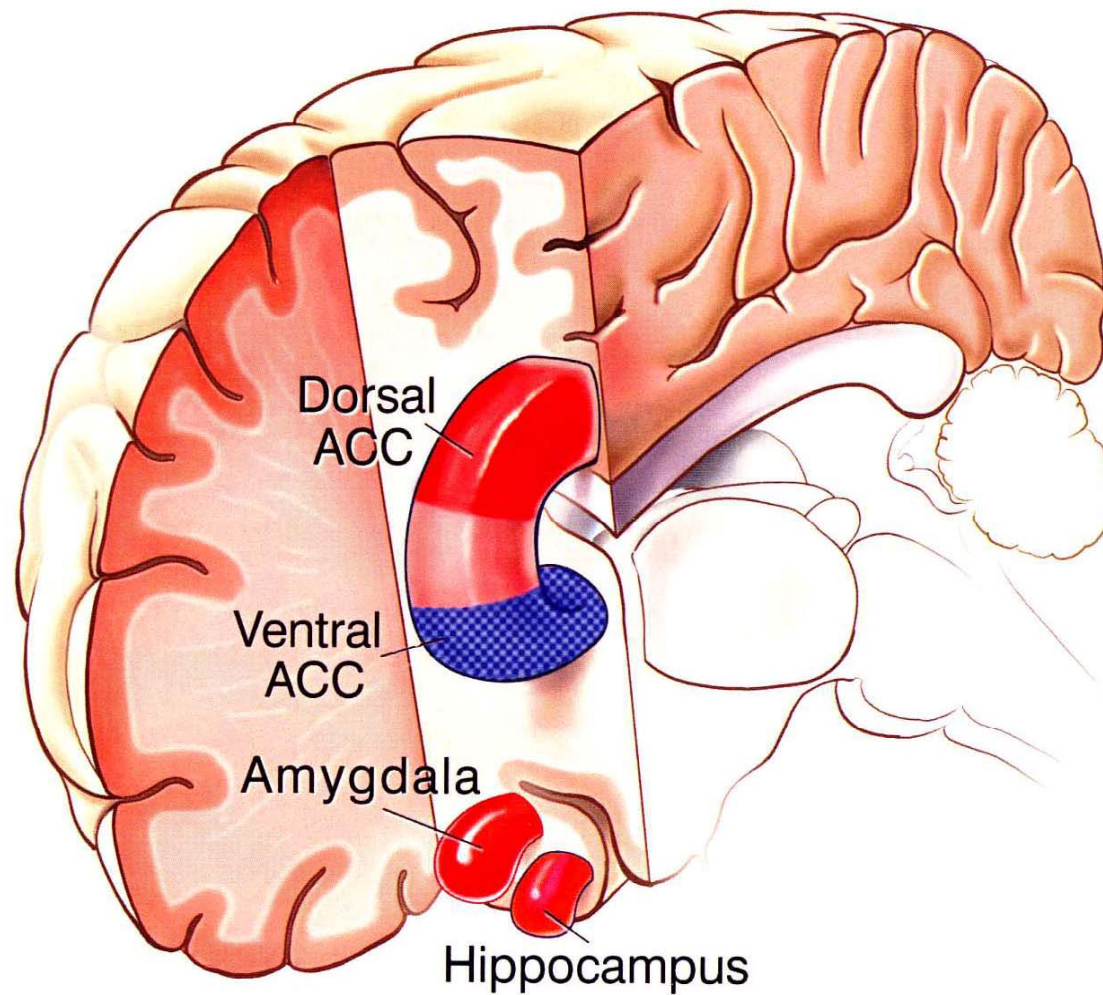
Loading scales: ATTENTIONAL SHIFTING
 ATTENTIONAL FOCUSSING
 INHIBITORY CONTROL
 PERCEPTUAL SENSITIVITY

Effortful Control and Self-Regulation

Systems of effortful control allow the individual to approach situations in the face of immediate cues for punishment and to avoid situations in the face of immediate cues for reward

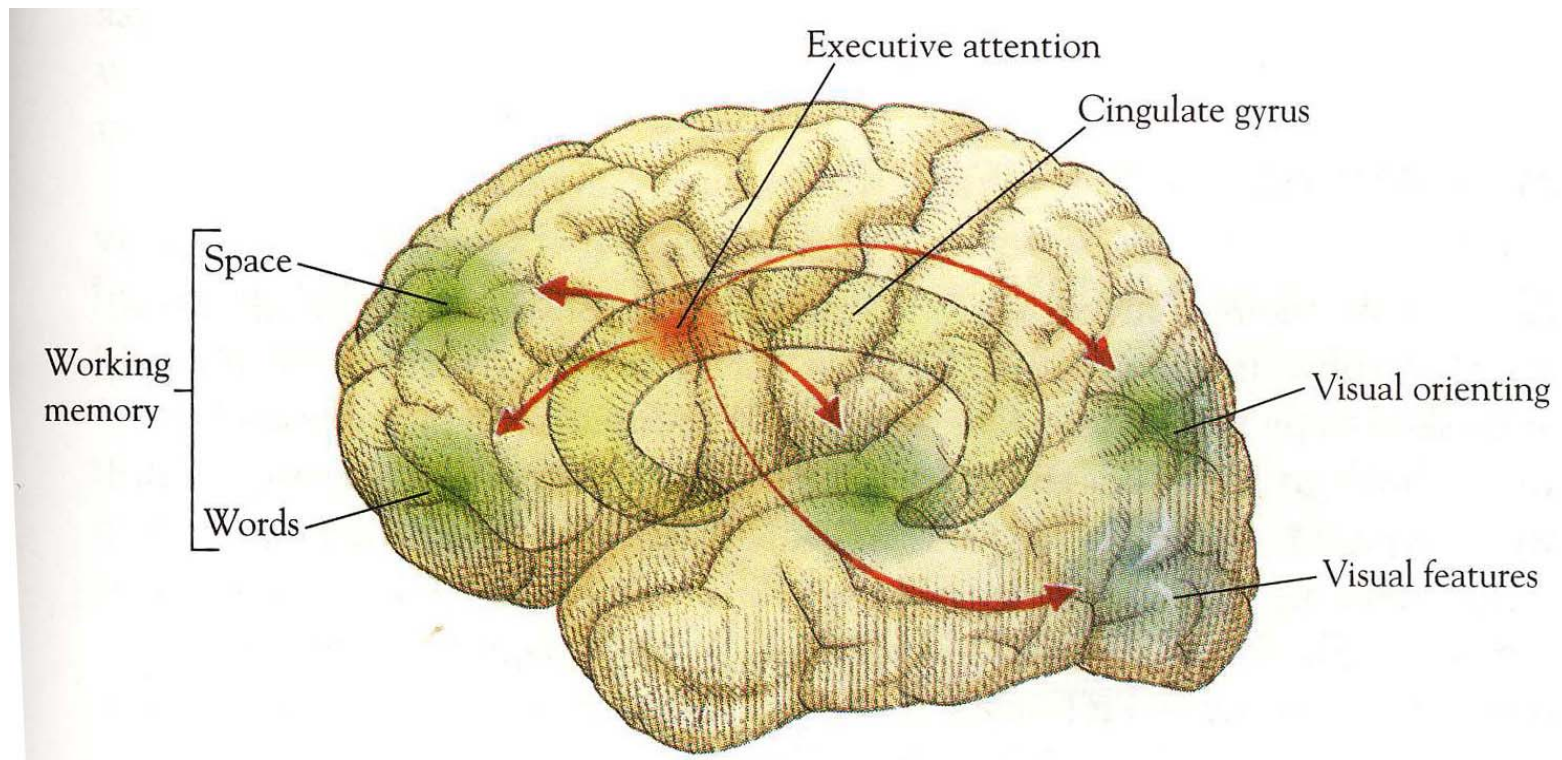
Key temperamental dimension on the basis of the development from more reactive to more self-regulative behavior in children

Effortful control is a construct situated at the intersection of the temperament and behavioral regulation literatures (Kochanska et al., 2000)



(b) Effortful Control

SOLID COLOR = STRUCTURAL
HATCHED COLOR = RESTING BOLD SIGNAL
RED = POSITIVE CORRELATED WITH EC
BLUE = NEGATIVELY CORRELATED WITH EC



EXECUTIVE NETWORK

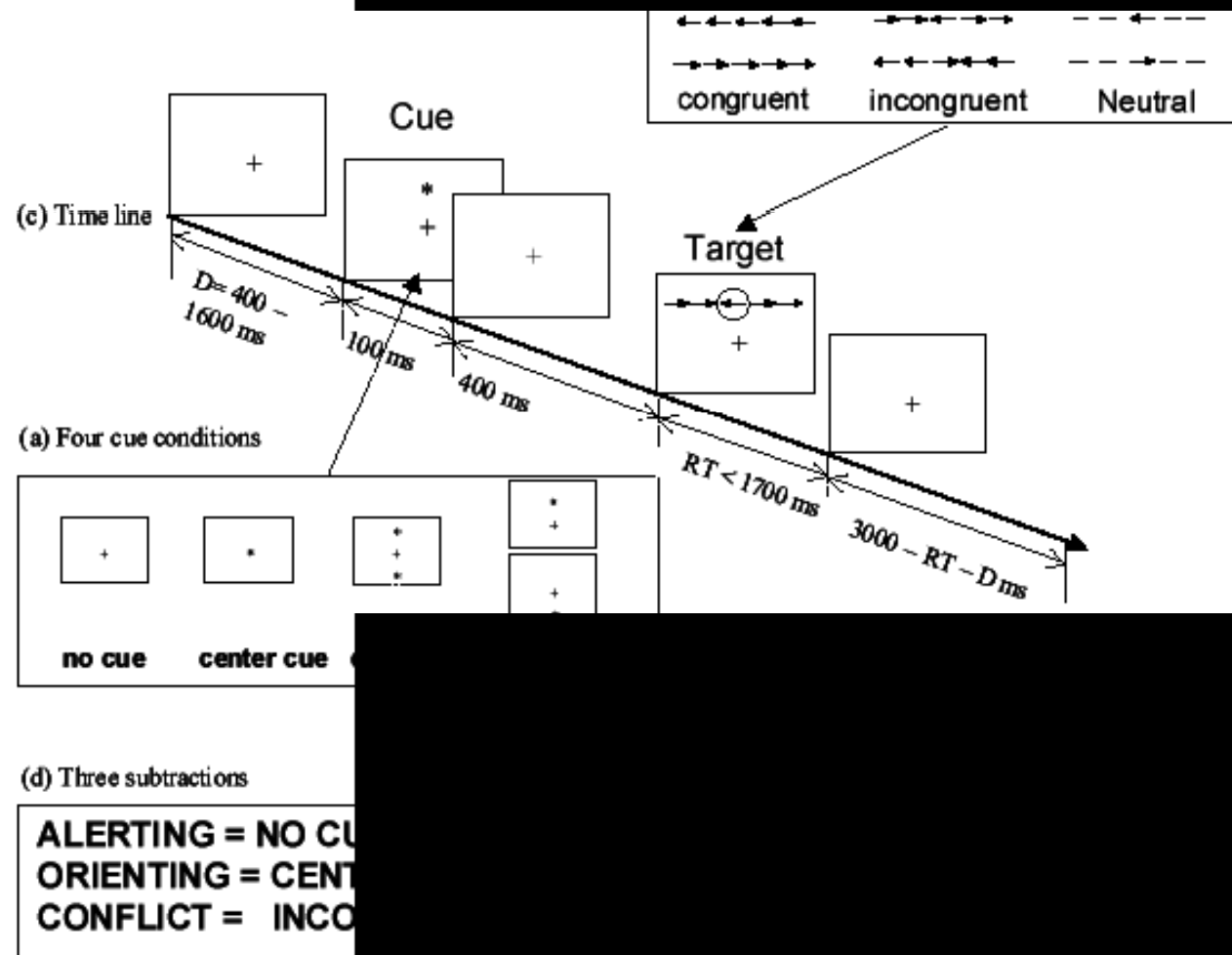
ADDICTION

ALZHEIMER

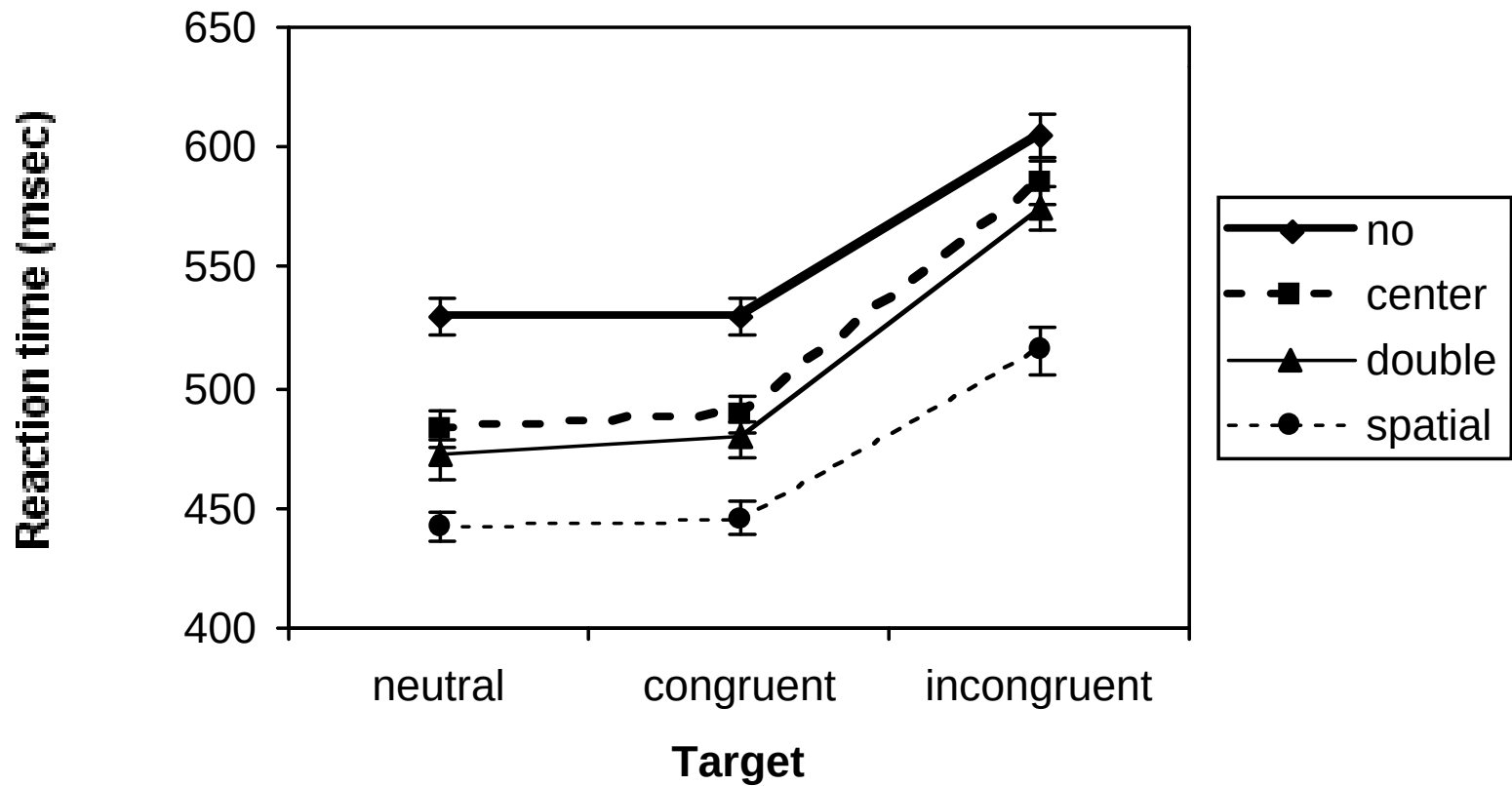
BORDERLINE PERSONALITY

SCHIZOPHRENIA

INDIVIDUALITY



Attention Network Test ANT RESULTS

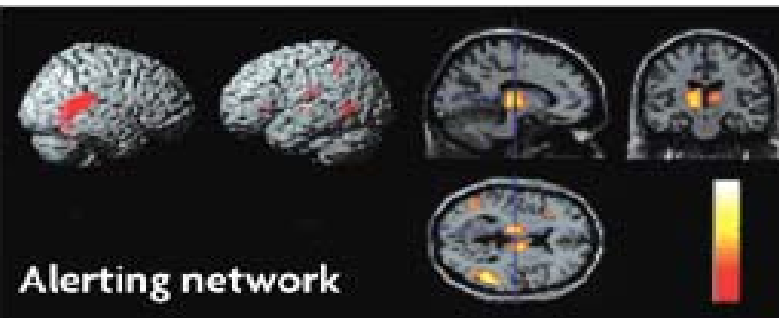


Attentional functions

Attentional networks

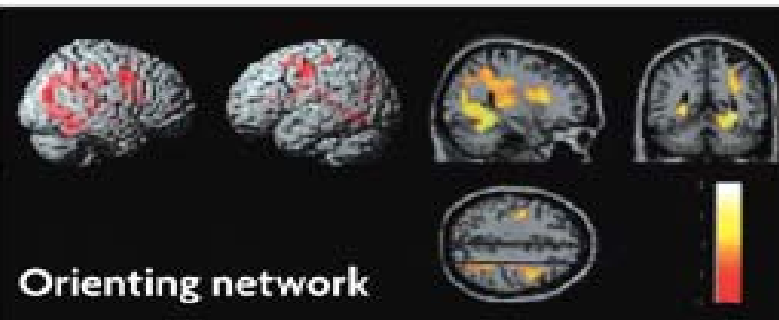
Transmitters and genes

Alerting



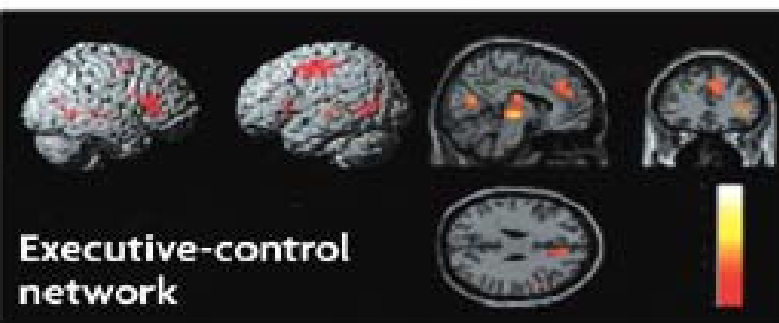
Noradrenaline
ADRA2A
NET

Orienting



Acetylcholine
CHRNA4
CHRNA7

Executive control



Dopamine
COMT
DAT1
DRD4
DBH



TRENDSⁱⁿ **Cognitive Sciences**



Cognitive genomics

Core systems of number

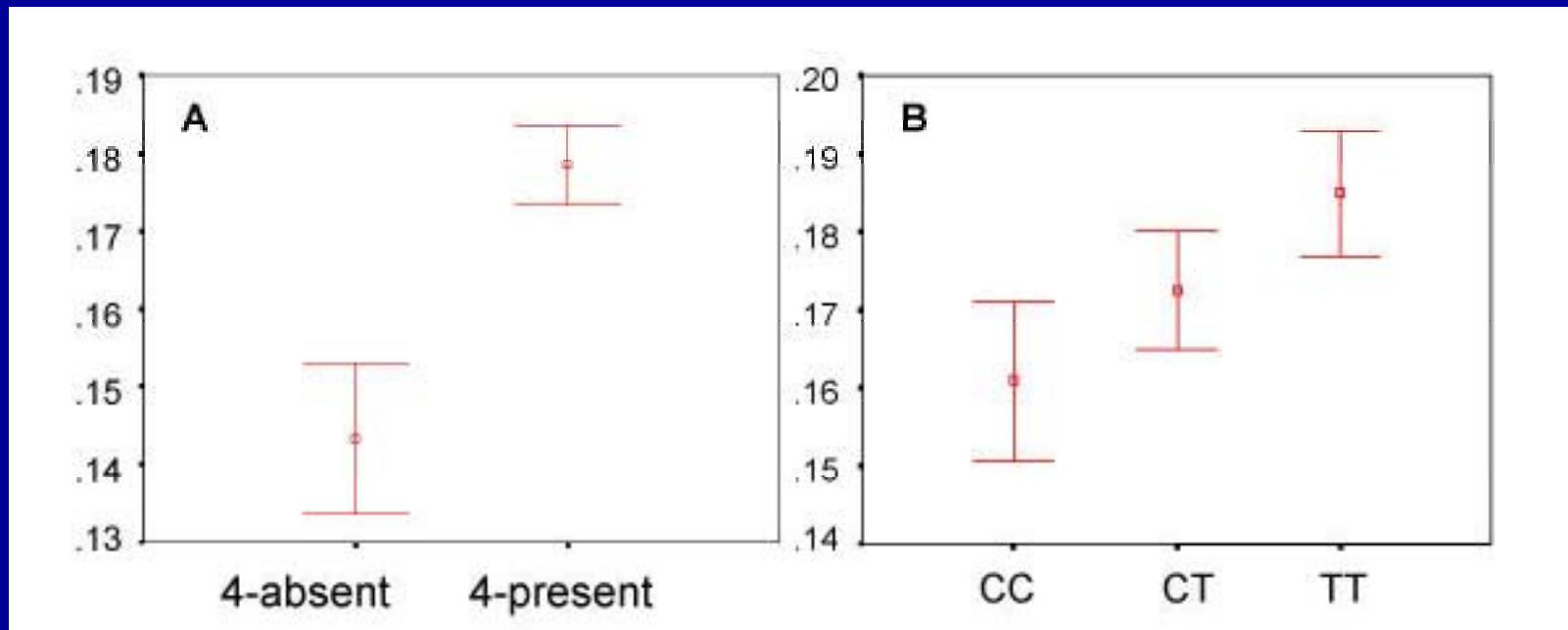
Mapping visual areas in monkeys and humans

Physical and social pain: a common neural system?

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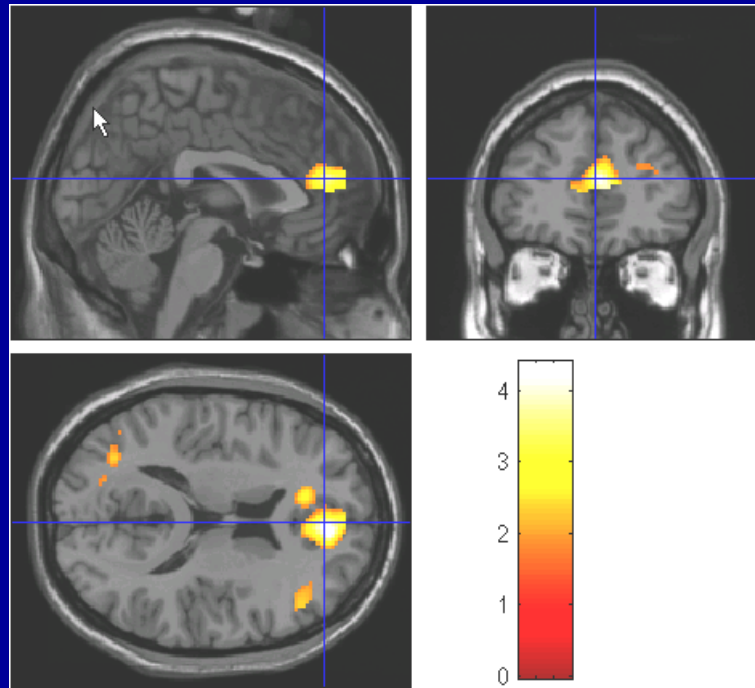
Figure 1



DRD4 and executive attention The Y-axis shows normalized executive attention scores (mean $\pm$ SE). The X-axis shows distributions for each genotypic class. Panel A shows the distribution of executive attention score as a function of exon III VNTR genotype in the 4-repeat absent vs. 4-repeat present groups. Panel B shows distribution of executive attention score as a function of a single nucleotide genotype (CC, CT and TT) at position -521.

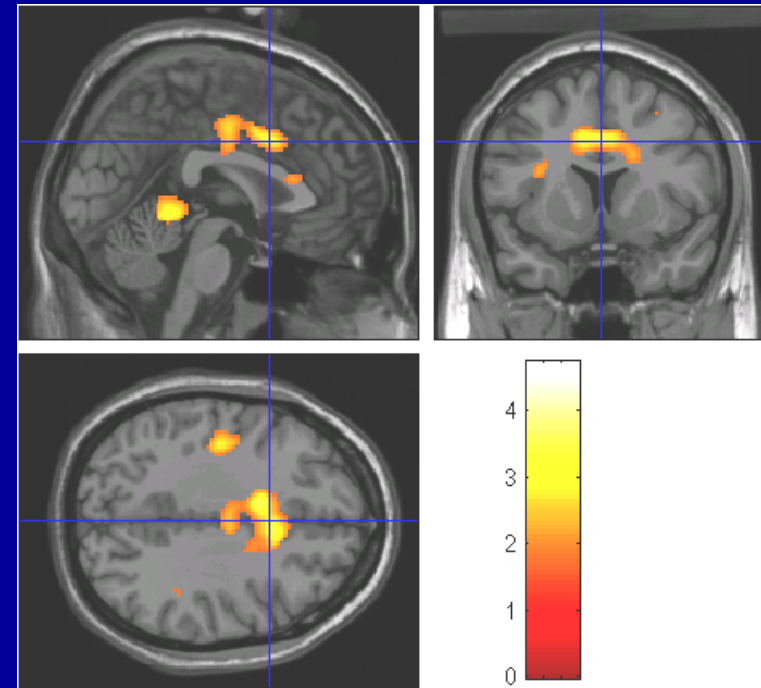
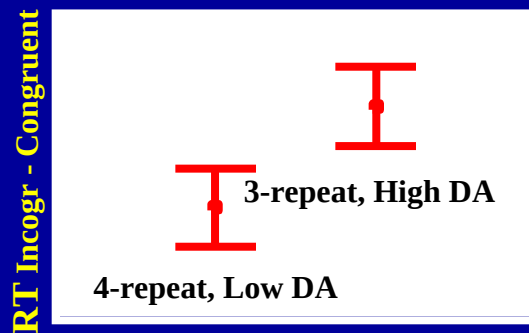
Mapping the genetic variation of executive attention onto brain activity

fMRI results: N=16

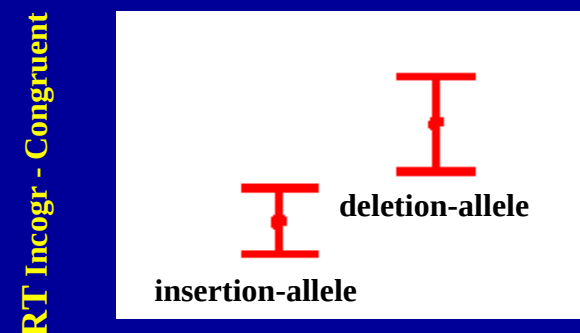


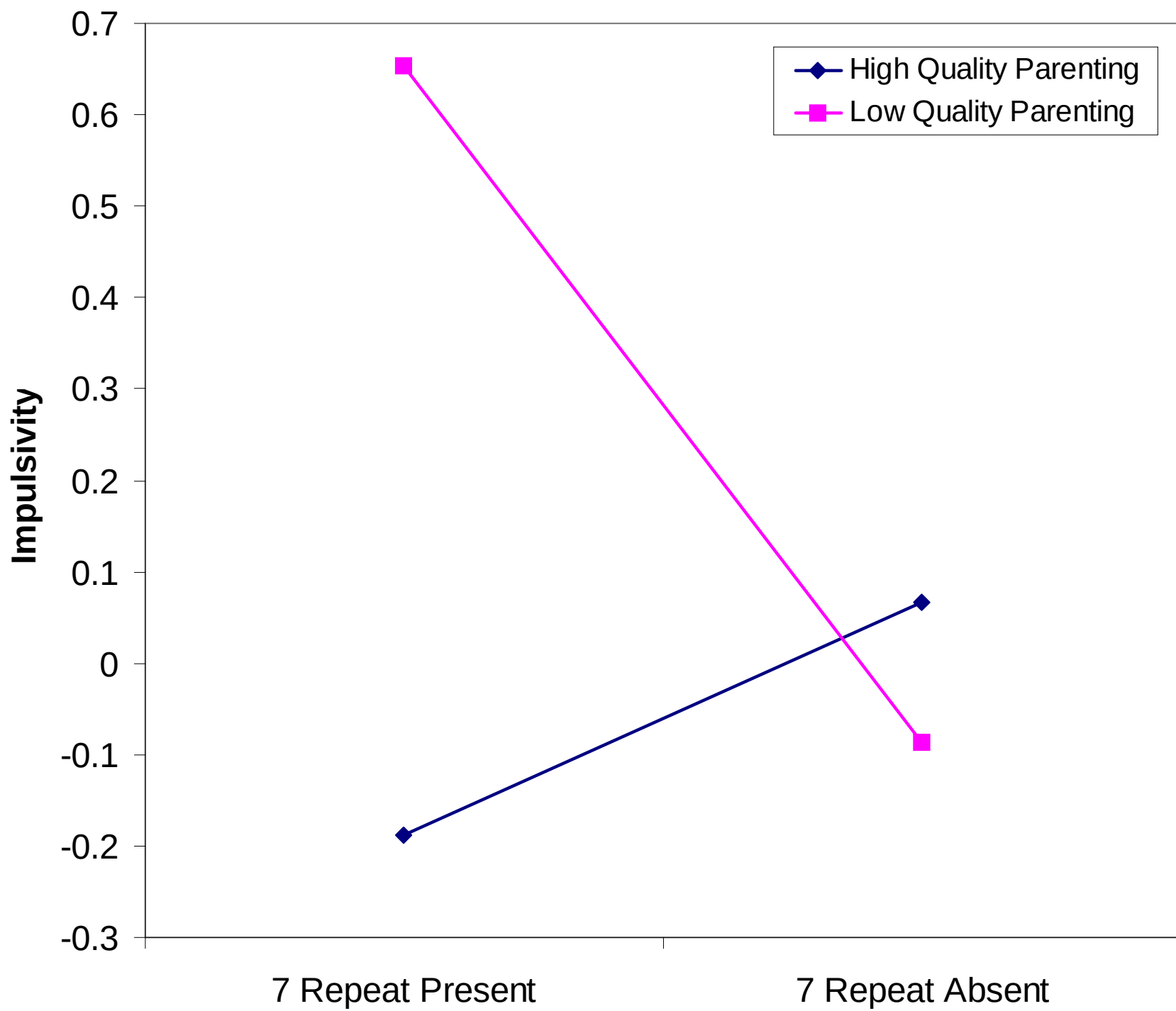
MAOA promoter (4-repeat) > (3-repeat)

Behavioral results: N=200

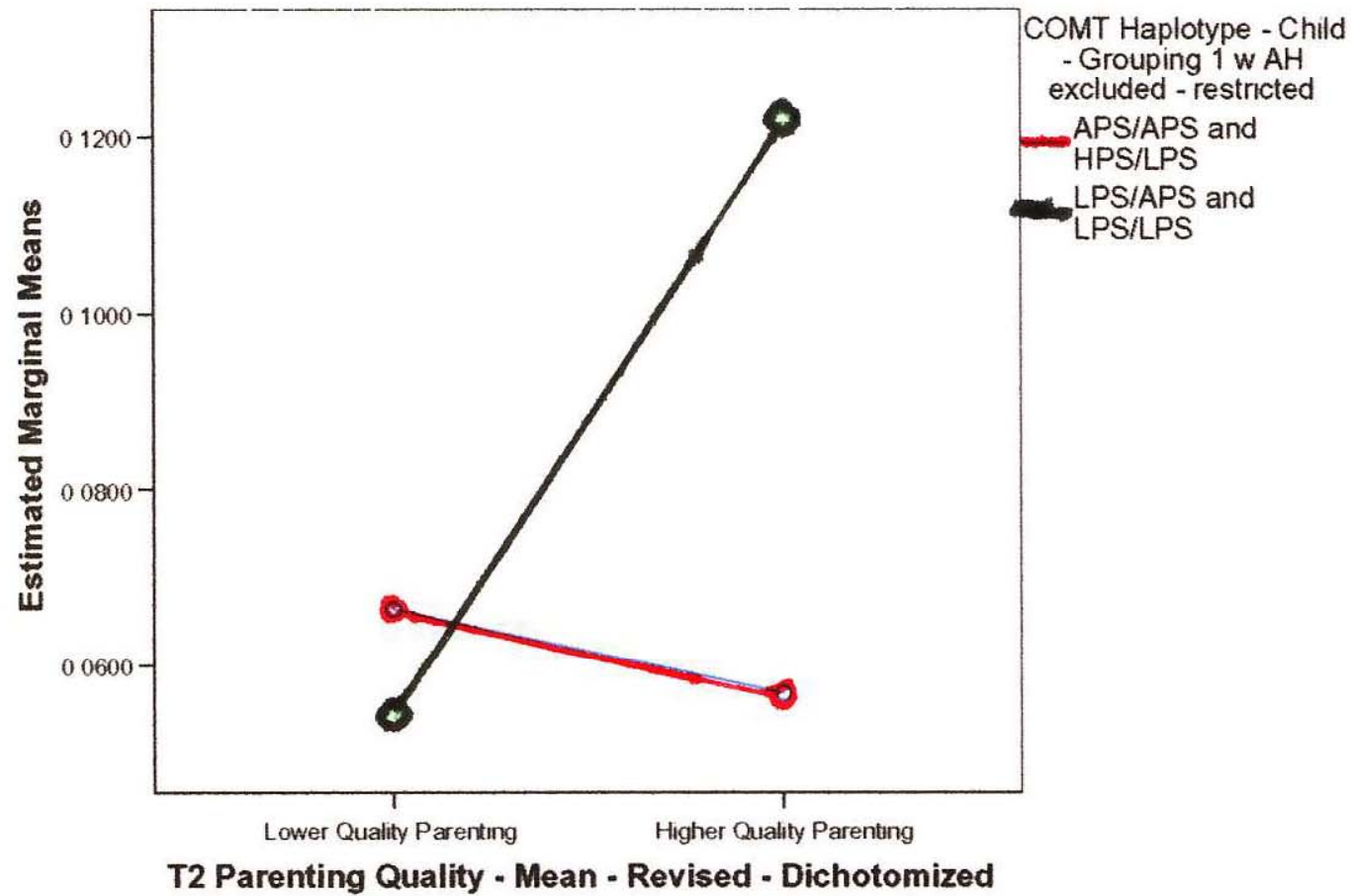


DRD4 promoter (insertion-allele) > (deletion-alleles)





Estimated Marginal Means of T2 VisSeq - Ant Look Correct Binary - Percentage



TRAINING

TICS Review

Review

Cel
PRESS

Attention training and attention state training

Yi-Yuan Tang^{1,2} and Michael I. Posner²

¹ Institute of Neuroinformatics, Dalian University of Technology, Dalian 116024, China

² Department of Psychology, University of Oregon, Eugene, OR 97403, USA

The ability to attend and to exercise cognitive control are vital aspects of human adaptability. Several studies indicate that attention training using computer based exercises can lead to improved attention in children and adults. Randomized control studies of exposure to nature, mindfulness and integrative body-mind training (IBMT) yield improved attention and self-regulation. Here, we ask how attention training and attention state training might be similar and different in their training methods, neural mechanisms and behavioral outcomes. Together these various methods lead to practical ways of improving attention and self-regulation.

Improving attention

A very diverse set of training methods have been shown to

closely related to the training and to more general cognitive abilities [1–4]. All of these methods involve practice in some cognitive skill by repetitive trials on tasks similar to those used in schools or cognitive psychology laboratories. All of these studies aim for long term improvement in attention, but in most cases only short term improvements close to the training have been well studied.

On the surface, these AT methods differ considerably from mindfulness training, exposure to nature settings or IBMT, which we group as AST. Recently, both IBMT (emphasizing body-mind balance) and nature exposure (using attention restoration theory) have used randomized designs with attention measures similar to those used with AT and have also shown significantly greater improvements in attention following training than those from

ATTENTION TRAINING



PNAS Report

Short-term meditation training improves attention and self-regulation

Yi-Yuan Tang^{*†§¶}, Yinghua Ma^{*}, Junhong Wang^{*}, Yaxin Fan^{*}, Shigang Feng^{*}, Qilin Lu^{*}, Qingbao Yu^{*}, Danni Sui^{*}, Mary K. Rothbart[†], Ming Fan[¶], and Michael I. Posner^{†¶}

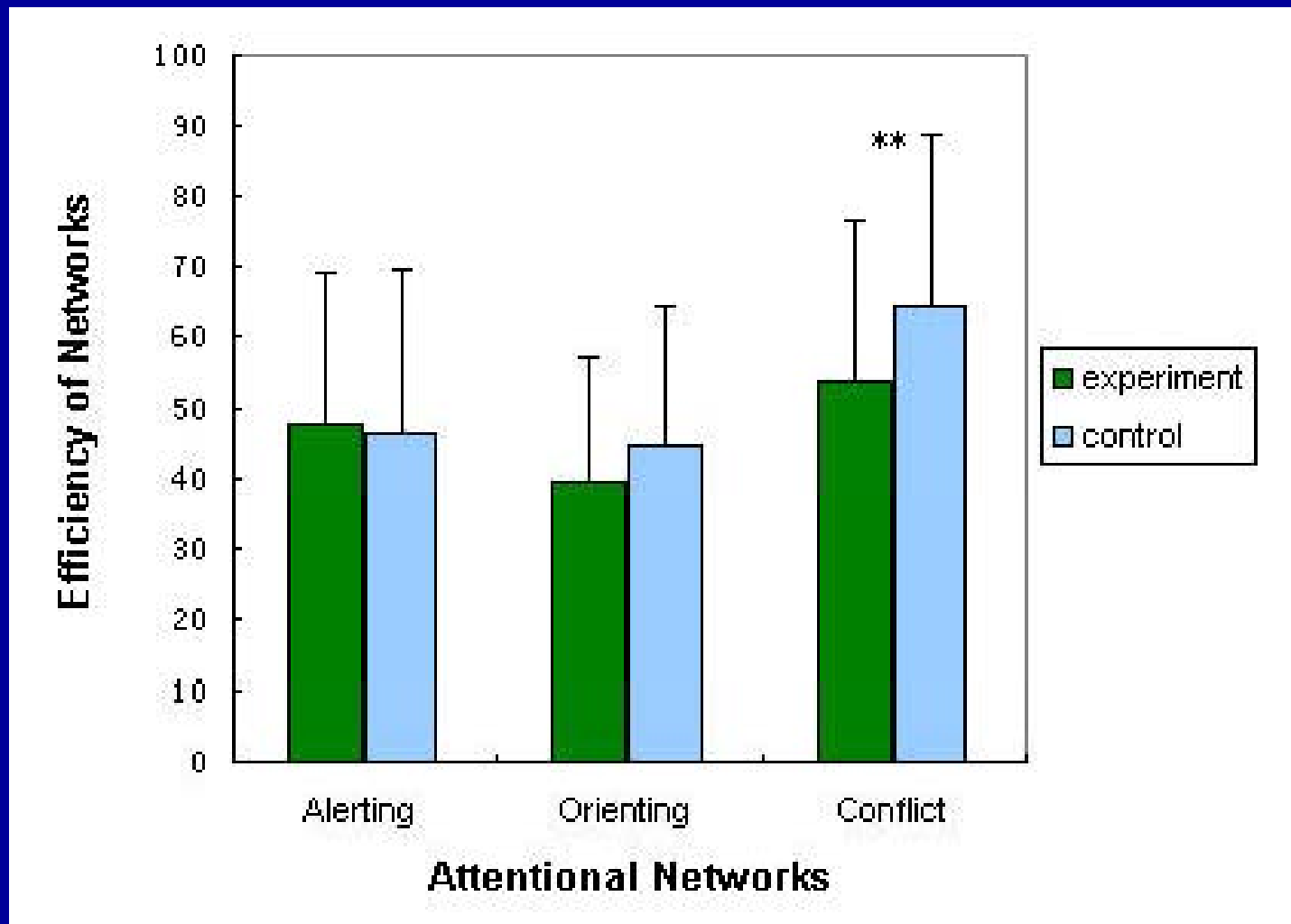
^{*}Institute of Neuroinformatics and Laboratory for Body and Mind, Dalian University of Technology, Dalian 116023, China; [†]Department of Psychology, University of Oregon, Eugene, OR 97403; [‡]Key Laboratory for Mental Health, Chinese Academy of Sciences, Beijing 100101, China; [§]Center for Social and Organizational Behavior, Graduate University of Chinese Academy of Sciences, Beijing 100080, China; and [¶]Institute of Basic Medical Sciences, Beijing 100850, China

Contributed by Michael I. Posner, August 16, 2007 (sent for review July 26, 2007)

Recent studies suggest that months to years of intensive and systematic meditation training can improve attention. However, the lengthy training required has made it difficult to use random assignment of participants to conditions to confirm these findings. This article shows that a group randomly assigned to 5 days of meditation practice with the integrative body-mind training method shows significantly better attention and control of stress than a similarly chosen control group given relaxation training. The training method comes from traditional Chinese medicine and incorporates aspects of other meditation and mindfulness training. Compared with the control group, the experimental group of 40 undergraduate Chinese students given 5 days of 20-min integrative training showed greater improvement in conflict scores on the Attention Network Test, lower anxiety, depression, anger, and

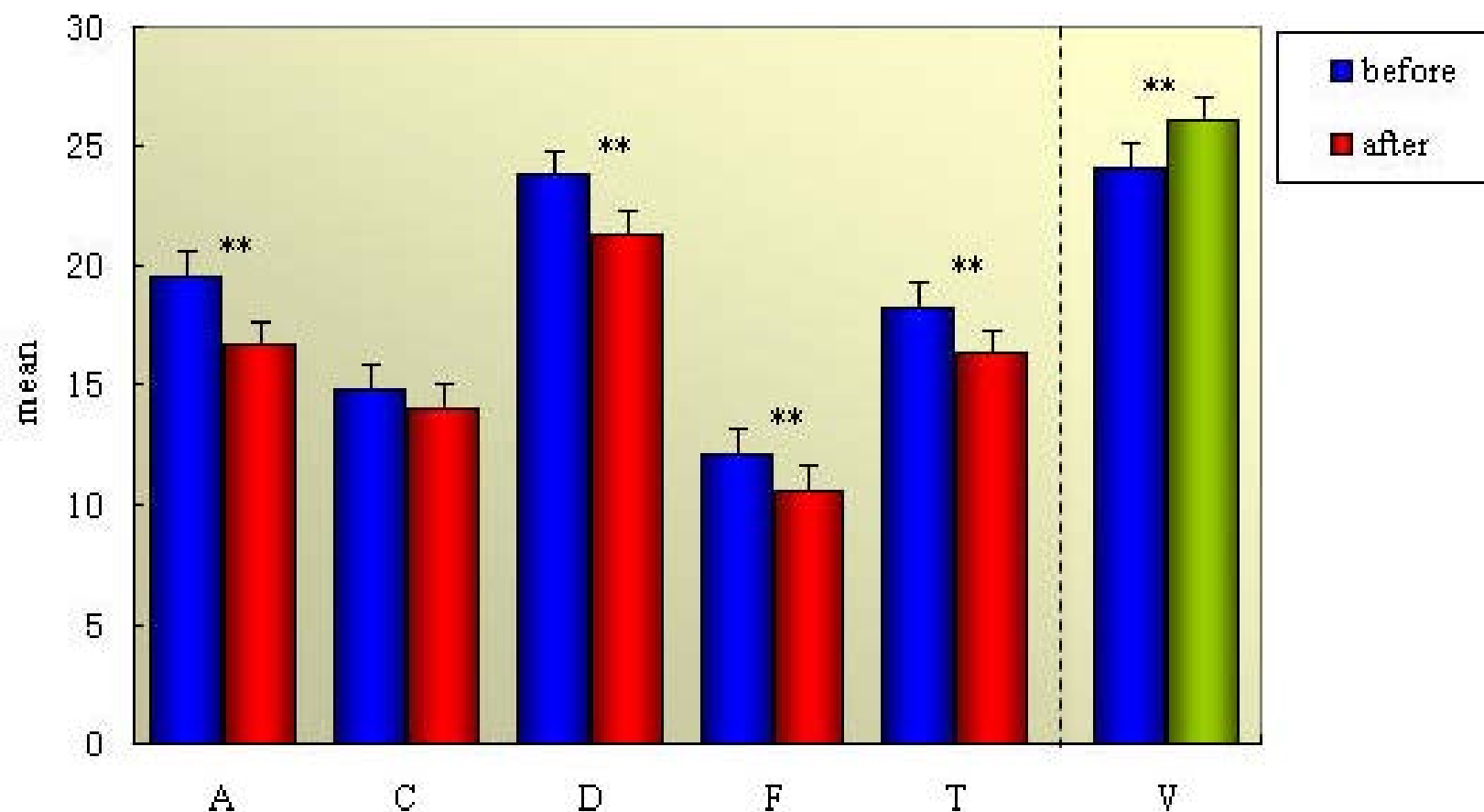
attention to the present moment, etc. (2, 12–15). Mental training methods also share several key components, such as body relaxation, breathing practice, mental imagery, and mindfulness, etc., which can help and accelerate practitioner access to meditative states (3, 8, 16–19). This background raises the possibility that combining several key components of body and mind techniques with features of meditation and mindfulness traditions, while reducing reliance on control of thoughts, may be easier to teach to novices because they would not have to struggle so hard to control their thoughts. Therefore, integrative body-mind training (IBMT; or simply integrative meditation) was developed in the 1990s, and its effects have been studied in China since 1995. Based on the results from hundreds of adults and children ranging from 4 to 90 years old in China, IBMT practice improves emotional and cogni-

Effect of five days of training on ANT performance to measure the conflict resolution ability



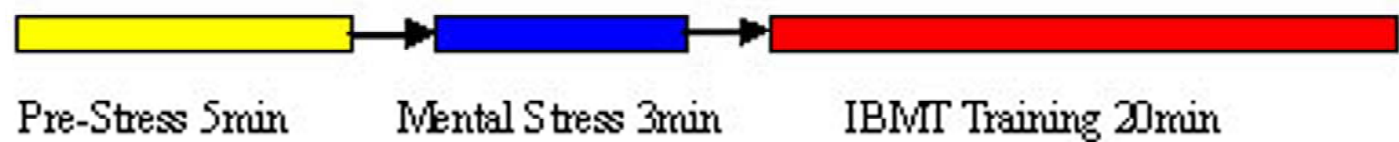
Tang *et al*, PNAS, 2007

Comparison of Scales of POMS pre- and post-training

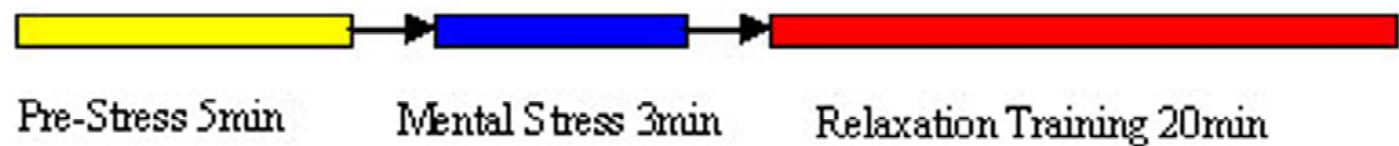


A (anger—hostility); C (confusion—bewilderment); D (depression—dejection); F (fatigue—inertia); T (tension—anxiety); V (Vigor-Activity).

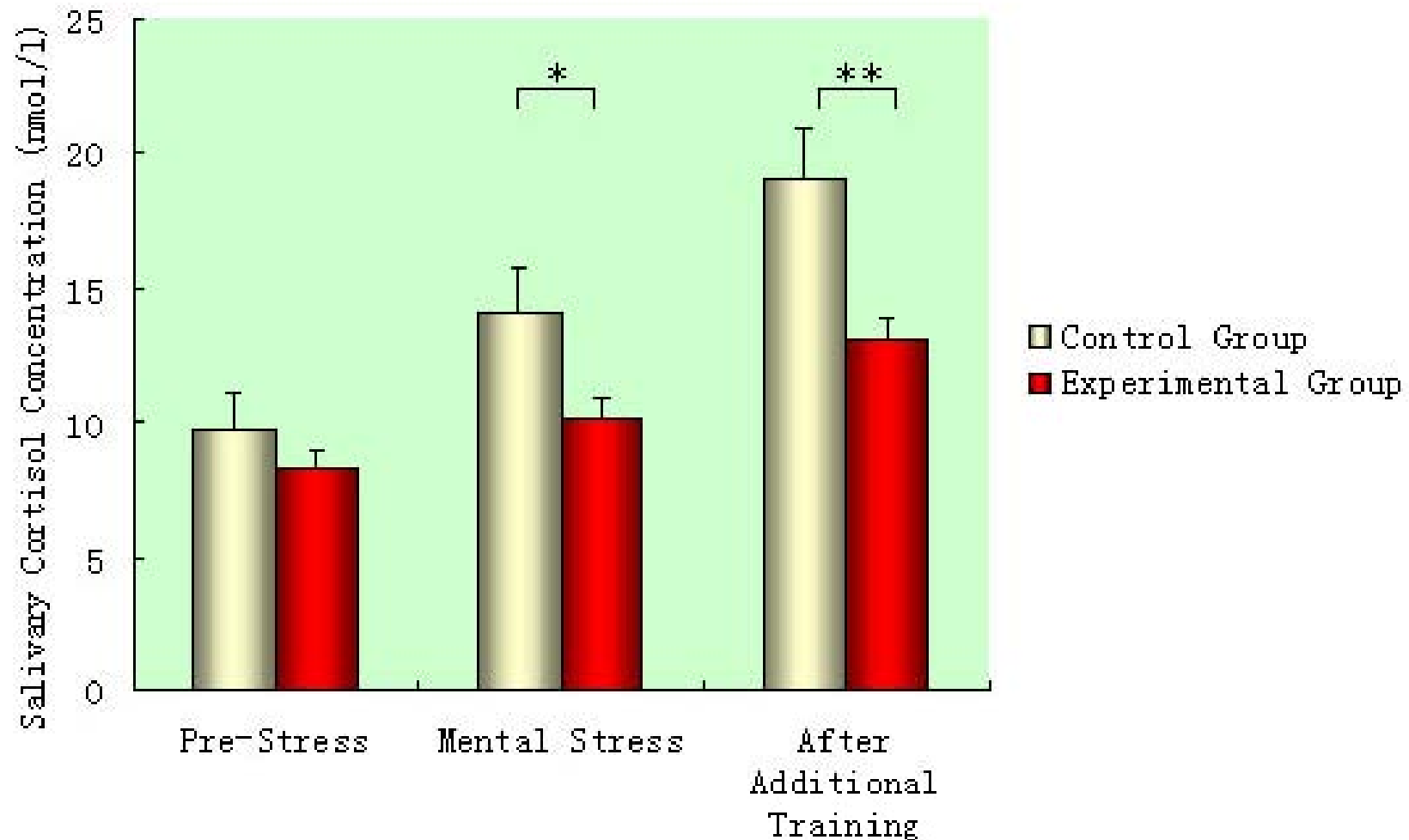
Experimental group



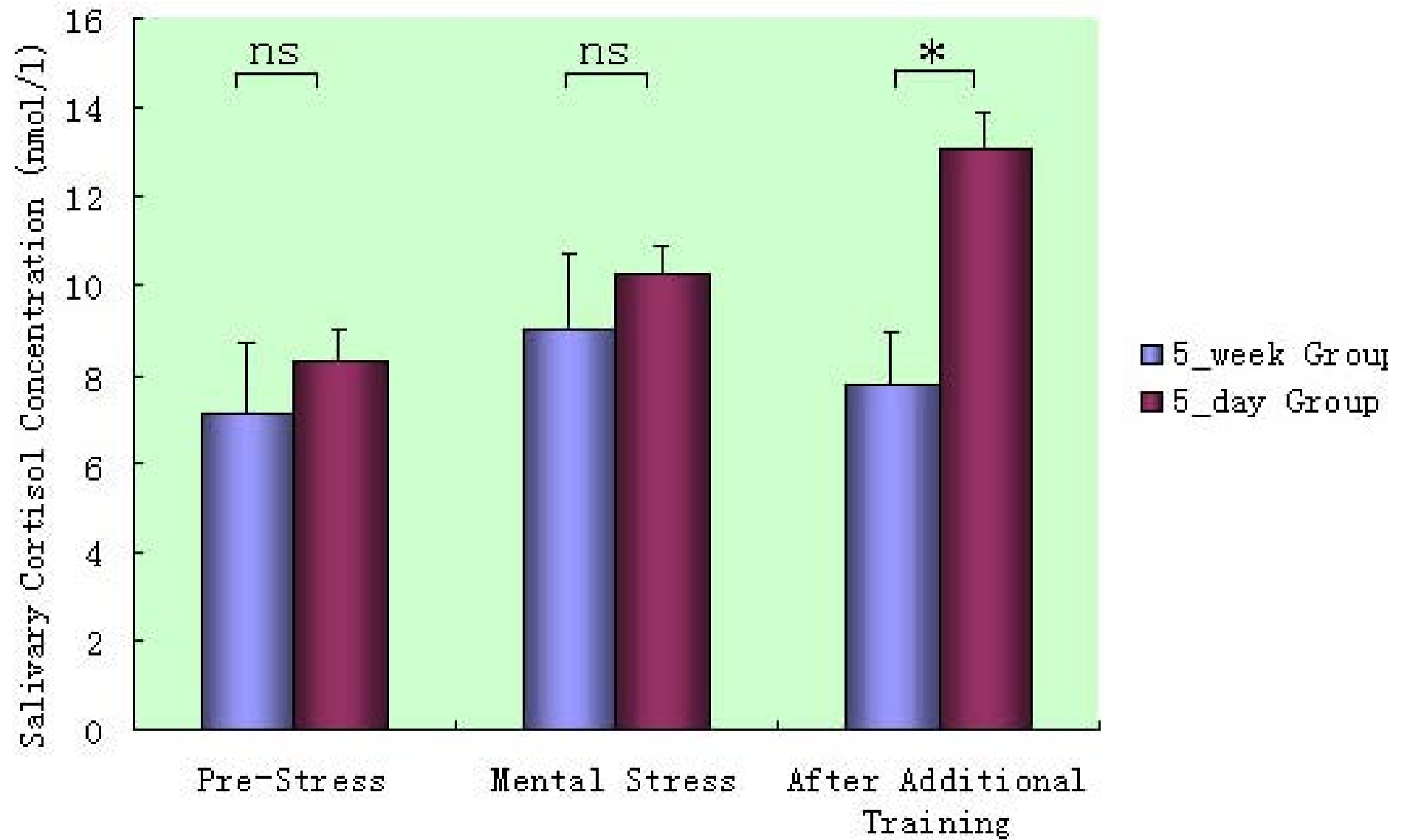
Control group



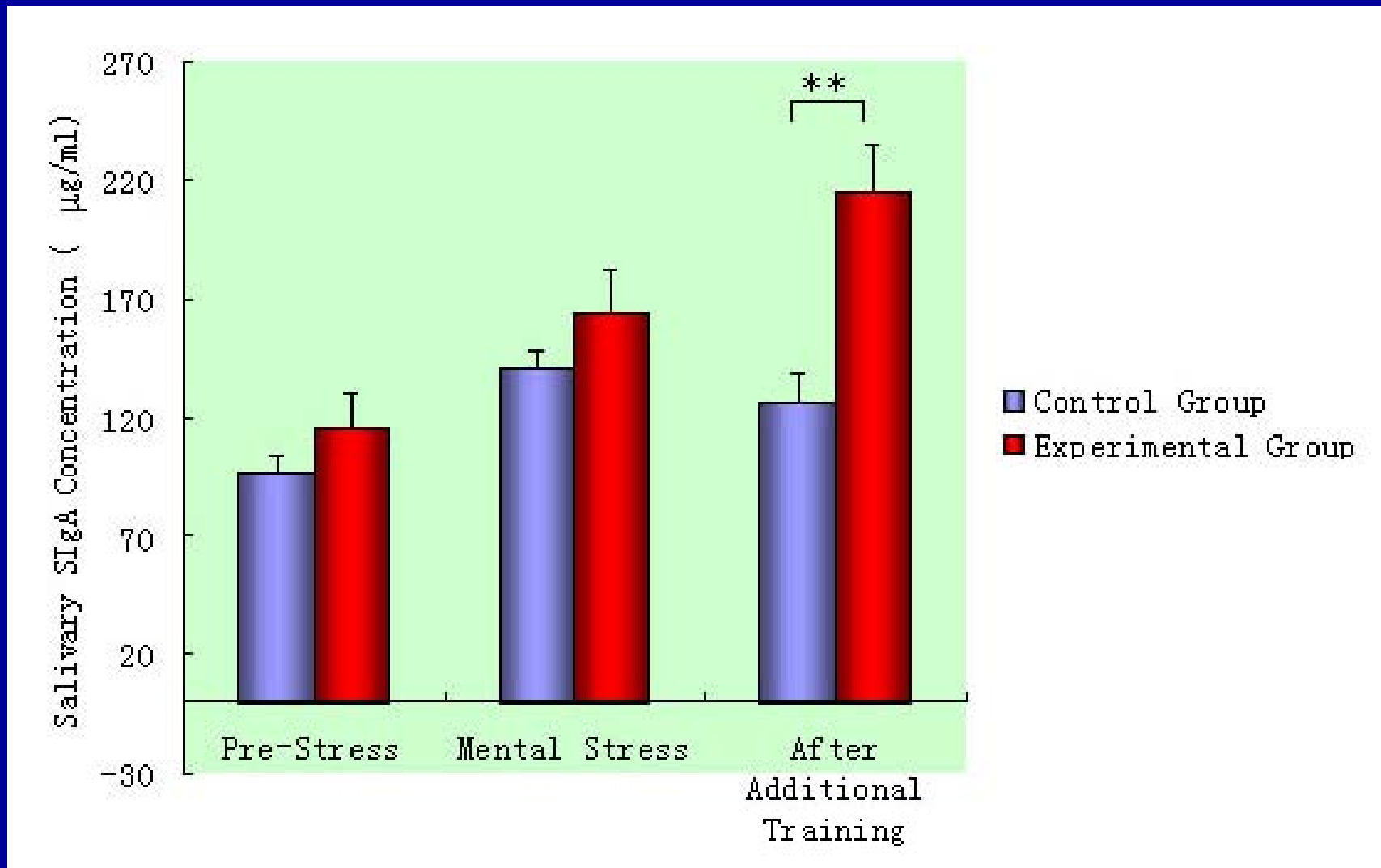
Comparison of Cortisol concentration in three different stages (stress management)



Tang *et al*, PNAS, 2007



Comparison of sIgA concentration in three different stages (immunoactivity)



Tang *et al*, PNAS, 2007

PNAS Report

Central and autonomic nervous system interaction is altered by short-term meditation

Yi-Yuan Tang^{a,b,1}, Yinghua Ma^a, Yaxin Fan^a, Hongbo Feng^a, Junhong Wang^a, Shigang Feng^a, Qilin Lu^a, Bing Hu^a, Yao Lin^a, Jian Li^a, Ye Zhang^a, Yan Wang^a, Li Zhou^a, and Ming Fan^c

^aInstitute of Neuroinformatics and Laboratory for Body and Mind, Dalian University of Technology, Dalian 116024, China; ^bDepartment of Psychology, University of Oregon, Eugene, OR 97403; and ^cInstitute of Basic Medical Sciences, Beijing 100850, China

Communicated by Michael I. Posner, University of Oregon, Eugene, OR, April 12, 2009 (received for review February 18, 2009)

Five days of integrative body–mind training (IBMT) improves attention and self-regulation in comparison with the same amount of relaxation training. This paper explores the underlying mechanisms of this finding. We measured the physiological and brain changes at rest before, during, and after 5 days of IBMT and relaxation training. During and after training, the IBMT group showed significantly better physiological reactions in heart rate, respiratory amplitude and rate, and skin conductance response (SCR) than the relaxation control. Differences in heart rate variability (HRV) and EEG power suggested greater involvement of the autonomic nervous system (ANS) in the IBMT group during and after training. Imaging data demonstrated stronger subgenual and adjacent ventral anterior cingulate cortex (ACC) activity in the IBMT group. Frontal midline ACC theta was correlated with high-frequency HRV, suggesting control by the ACC over parasympathetic activity. These results indicate that after 5 days of training, the IBMT group shows better regulation of the ANS by a ventral midfrontal brain system than does the relaxation group. This changed state probably reflects training in the coordination of body and mind given in the IBMT but not in the control group. These results could be useful in the design of further specific interventions.

anterior cingulate cortex | body–mind interaction | IBMT

In a previous study (1, 2), 80 Chinese undergraduates were randomly assigned to an experimental group (integrative body–mind training, IBMT) or to a control group (relaxation training) for 5 days of short-term training (20 min per day). Before training, no differences were found for behavioral, endocrine, and immune measures between the 2 groups. After 5 days of training, the IBMT group showed significantly greater

ical measures included heart rate, skin conductance response (SCR), and respiratory amplitude and rate, to monitor autonomic nervous system activity. These measures allowed evaluation of the training stages in the 2 parallel experiments to make sure all subjects attained similar meditative or relaxation states during and after training.

This design allowed us to apply random assignment using participants without any previous meditation or relaxation experience, given the same amount of training to detect the relationship between the brain networks and the autonomic nervous system (ANS) during training (see *Materials and Methods*).

A brain network including anterior cingulate cortex (ACC) and prefrontal cortex (PFC) has been shown to be an important mechanism for self-regulation of cognition and emotion (10–13). The sensitivity of the ACC to both reward and pain (14, 15) and evidence for ACC coupling to cognitive and emotional areas during task performance (16, 17) support the idea that the role of this brain region is to regulate the processing of information from other networks. The ACC thus serves as part of an executive attention network involved in the control of both cognition and emotion (18). Because the IBMT group showed higher levels of self-regulation than the relaxation group following training (1, 2), we hypothesized that activity in the ACC will be increased more by IBMT than by relaxation training.

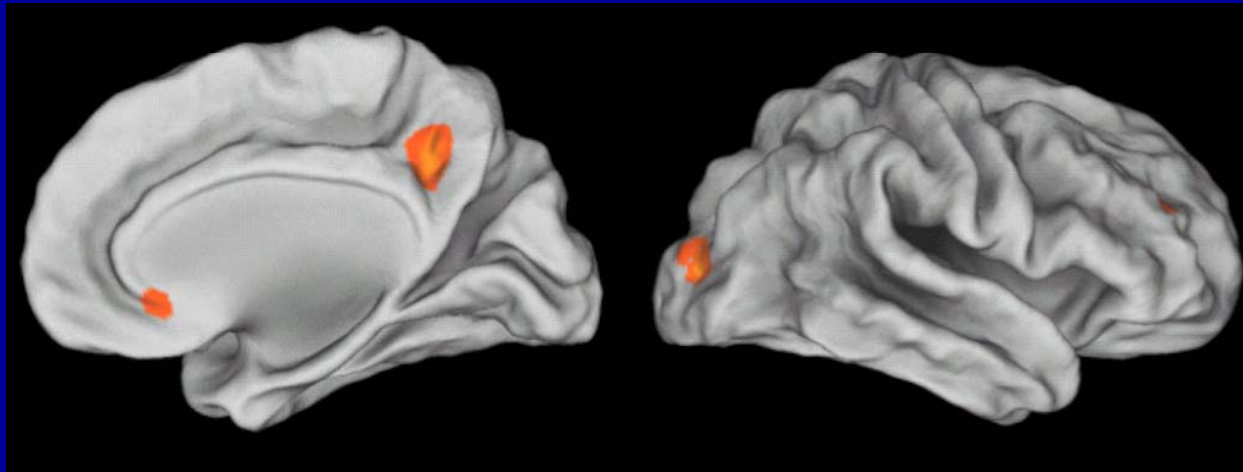
Meditation is accompanied by physiological changes. Wallace (19) first reported that transcendental meditation induced physiological changes in oxygen consumption, heart rate, skin resistance, and certain EEG frequencies. Indexes of ANS function including heart rate/heart rate variability (HRV), skin conductance/resistance response, respiratory amplitude/rate, and EEG frequencies have become biomarkers for monitoring

PSYCHOLOGY

NEUROSCIENCE

Brain imaging

- vACC plays an important role after 5 days of IBMT than relaxation in Chinese

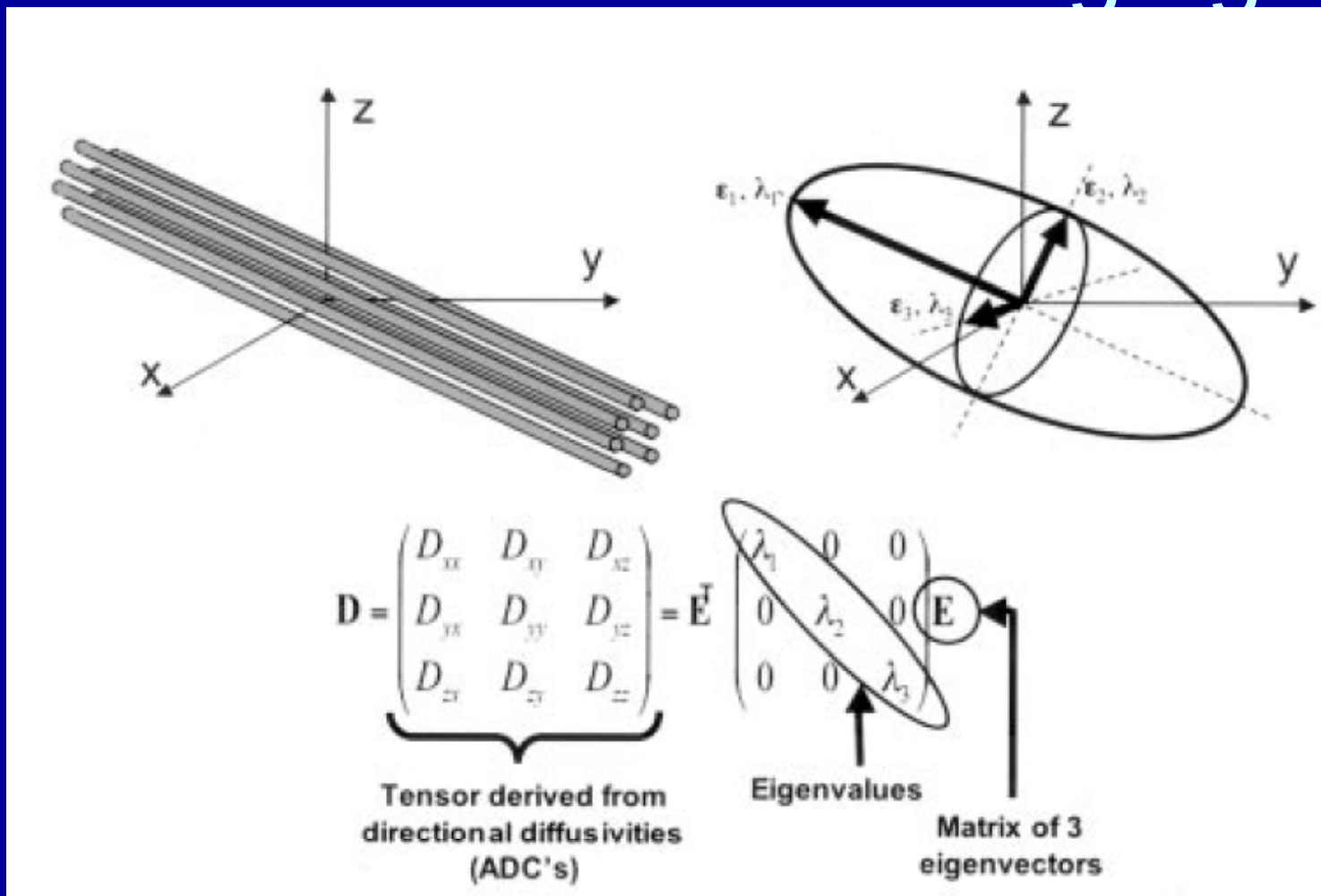


N=10, $P < 0.05$

Differences

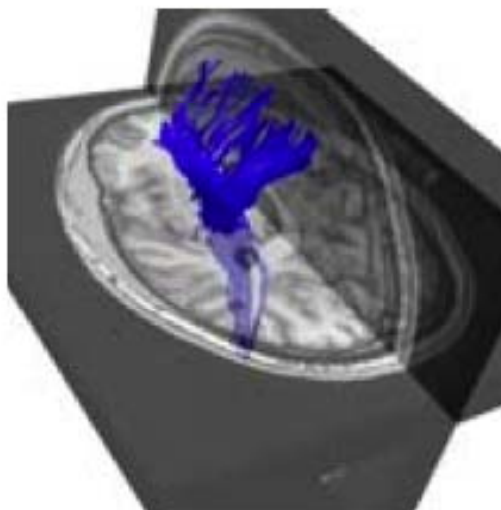
- American uses more language strategy to enter the meditation state compared to Chinese
- Chinese uses more inner experiences to enter the state
- More conscious control and effort associated to dorsal ACC activity in American
- Less control and effort associated to ventral ACC activity in Chinese
- Better compliance in Chinese compared to American
- Others

Diffusion Tensor Imaging





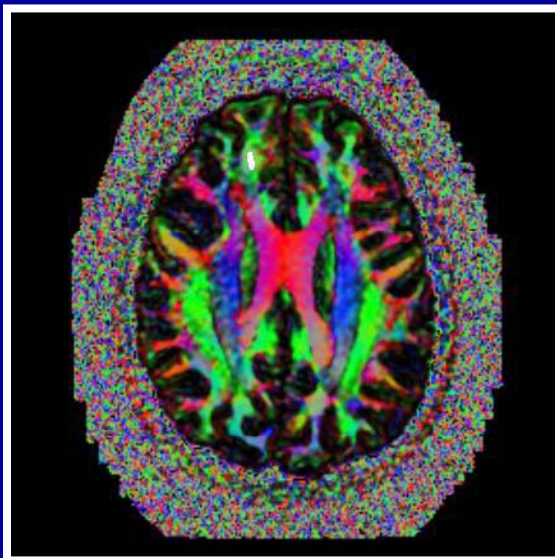
Anterior Corona Radiata



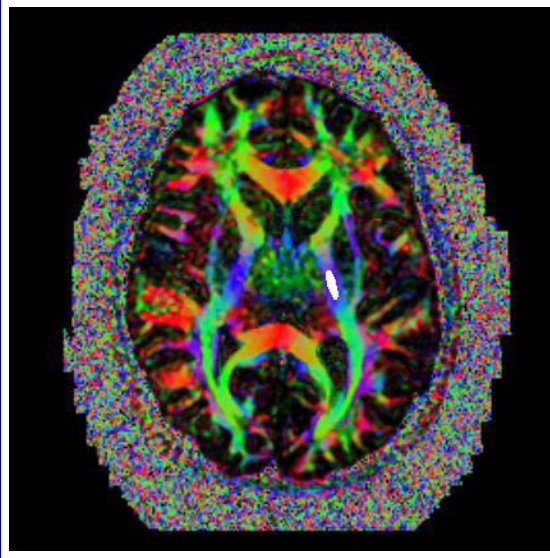
P. Limb of Internal Capsule



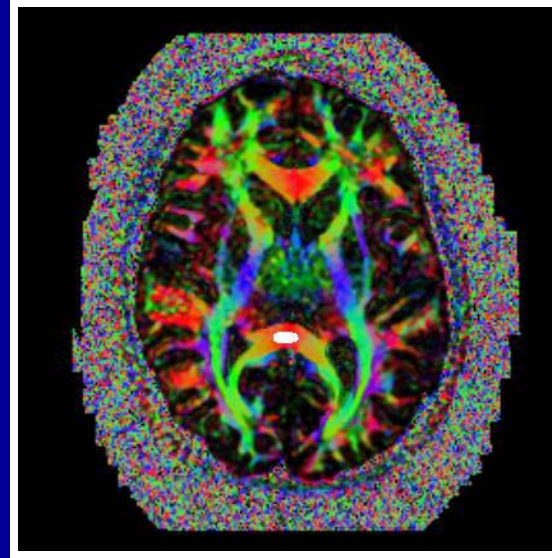
Splenium of Corpus Callosum



ACR left



PLIC right

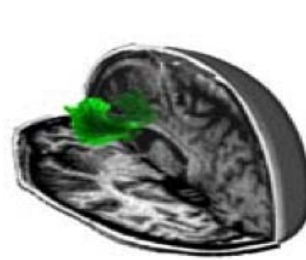


splenium

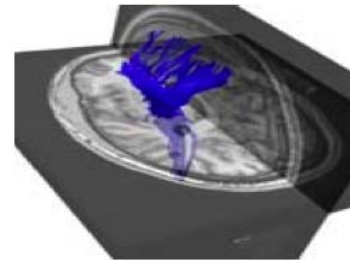
Conflict:
Incongruent RT -
Congruent RT

Alerting:
Uncued RT -
Alerting Cue RT

Orienting:
Spatial cue RT -
Alerting cue RT



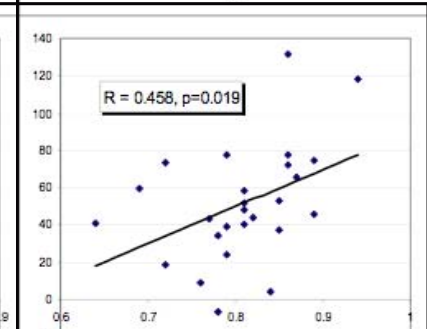
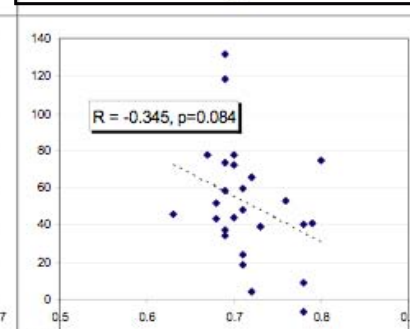
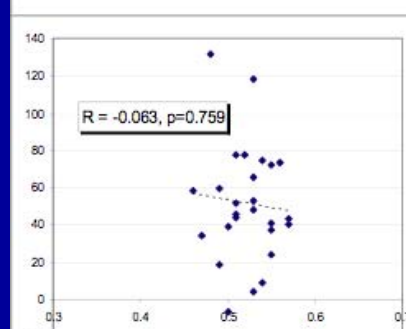
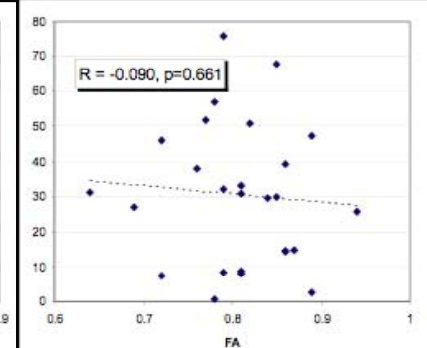
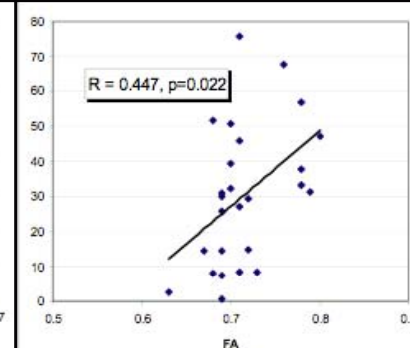
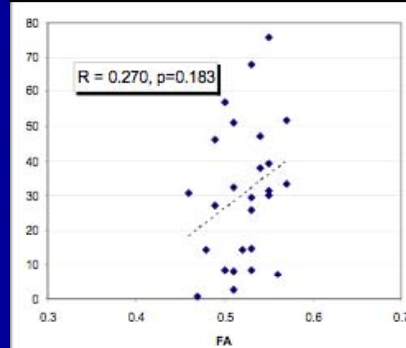
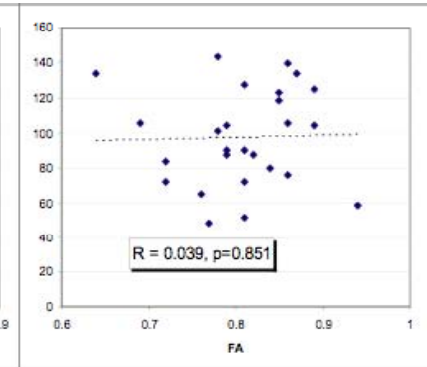
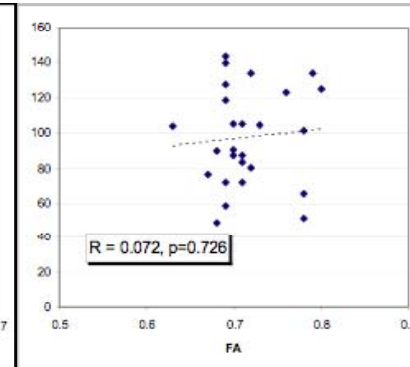
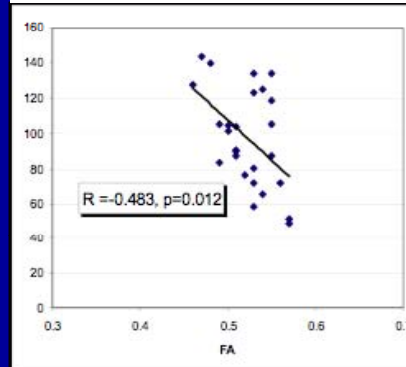
Anterior Corona Radiata

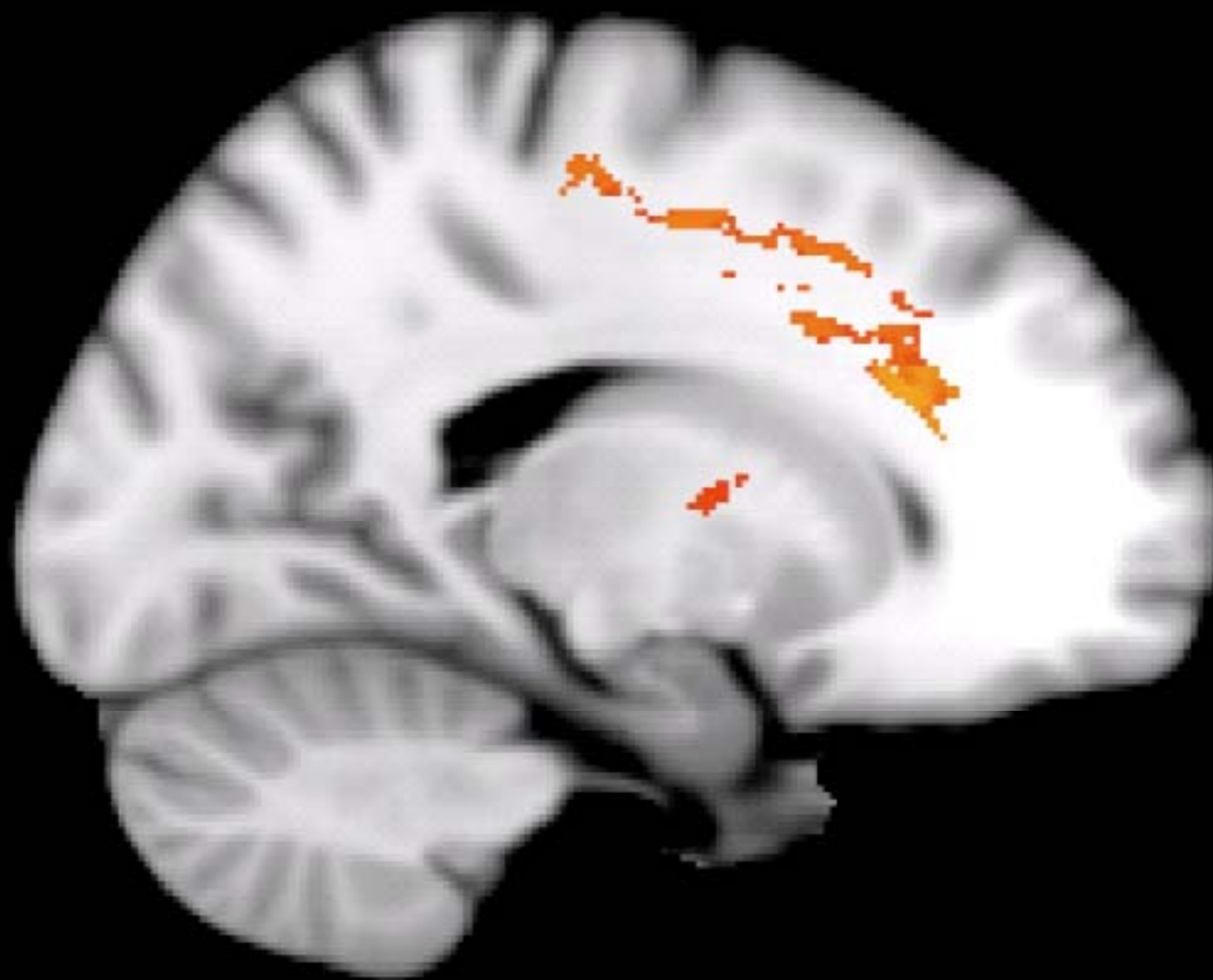


P. Limb of Internal Capsule

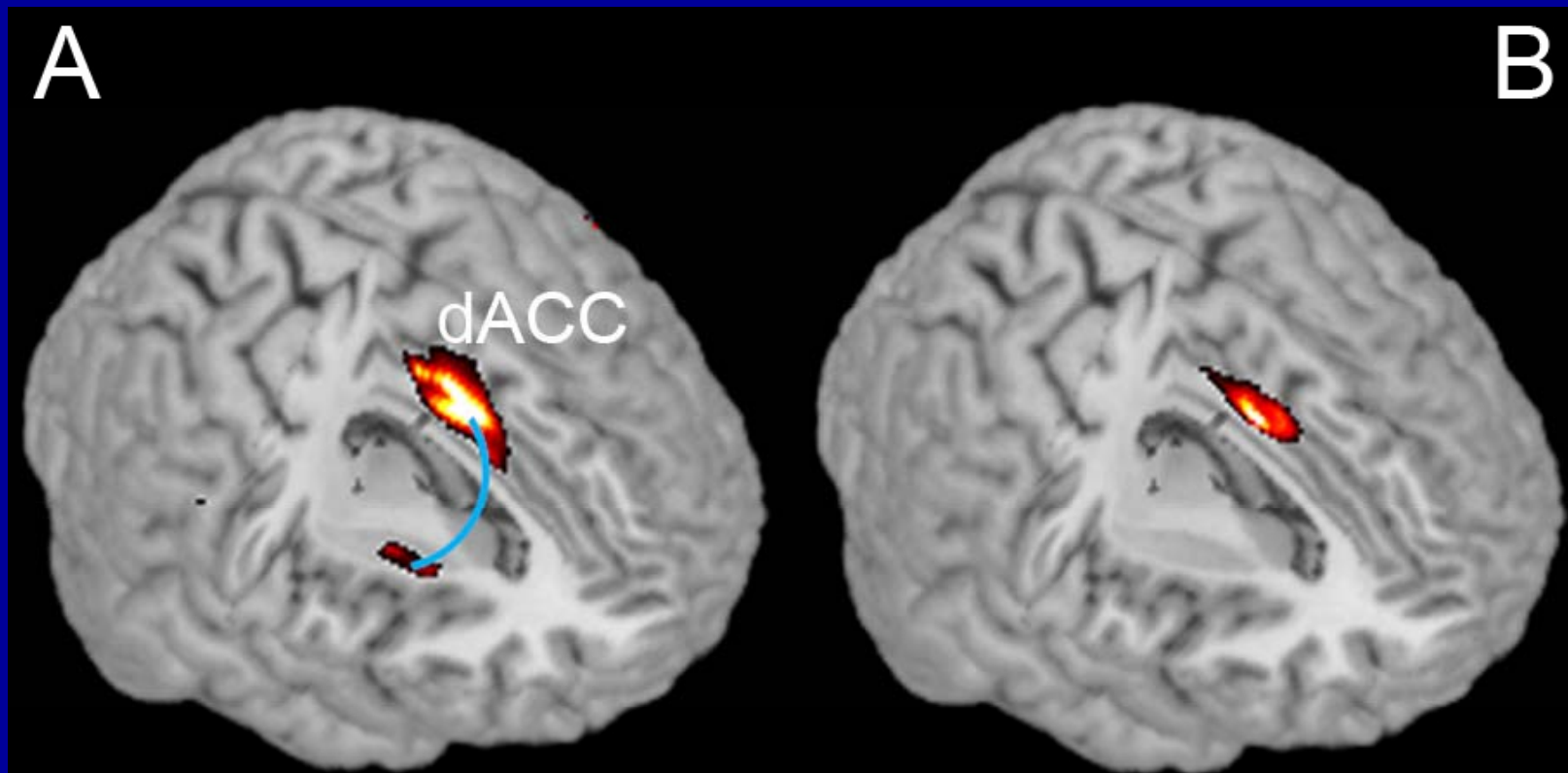


Splenium of Corpus Callosum





AGING STUDY



PATHOLOGY

ALERTING

AGING

ADHD

ORIENTING

AUTISM

NEGLECT

EXECUTIVE

ALZHEIMER

SCHIZOPHRENIA

BORDERLINE PERSONALITY

22q11

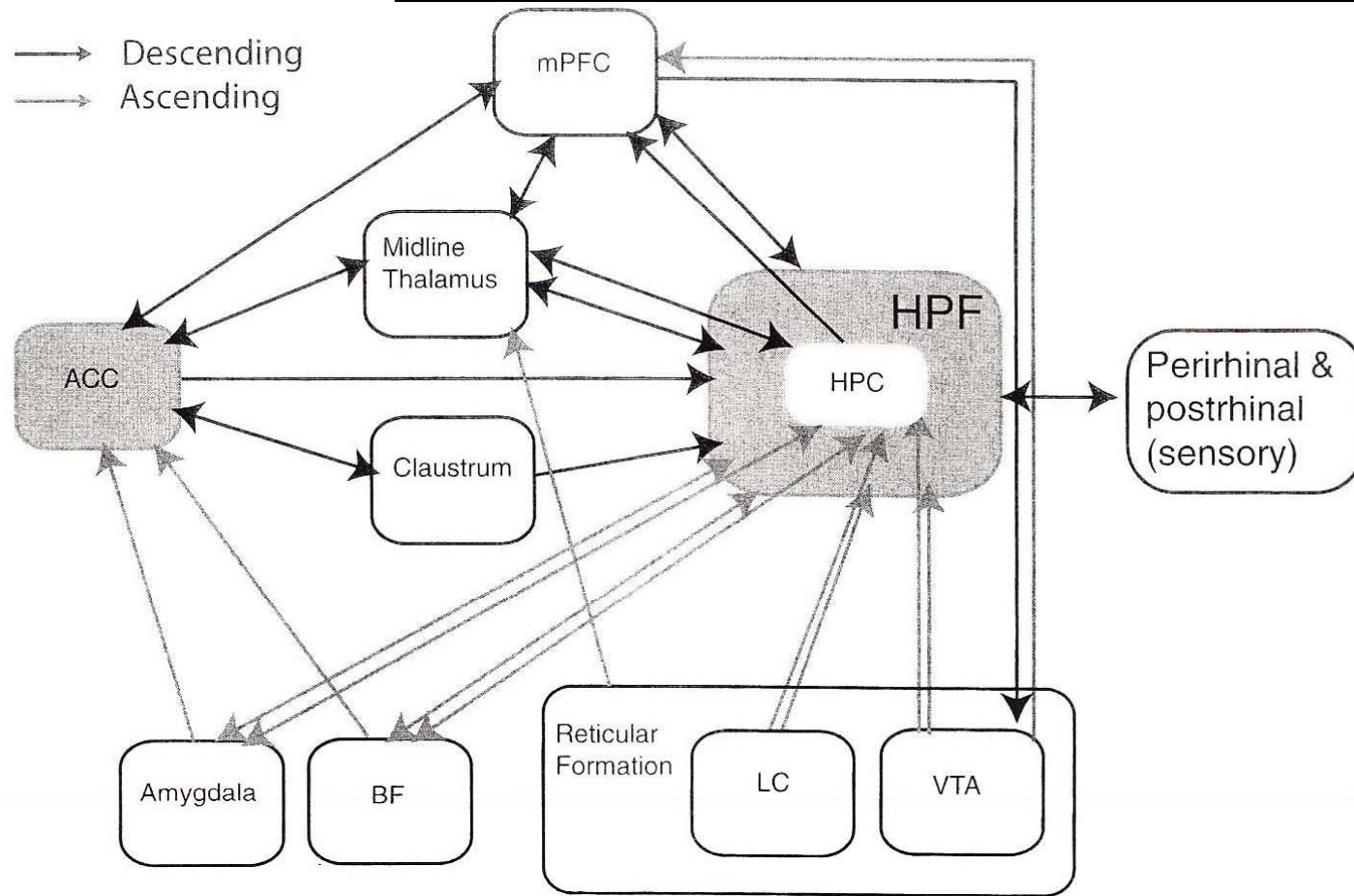
EXTERNALIZING BEHAVIOR

ADDICTONS

EDUCATION

AND

EXPERTISE



SUMMARY

Attention
System

Alert

Orient

Executive

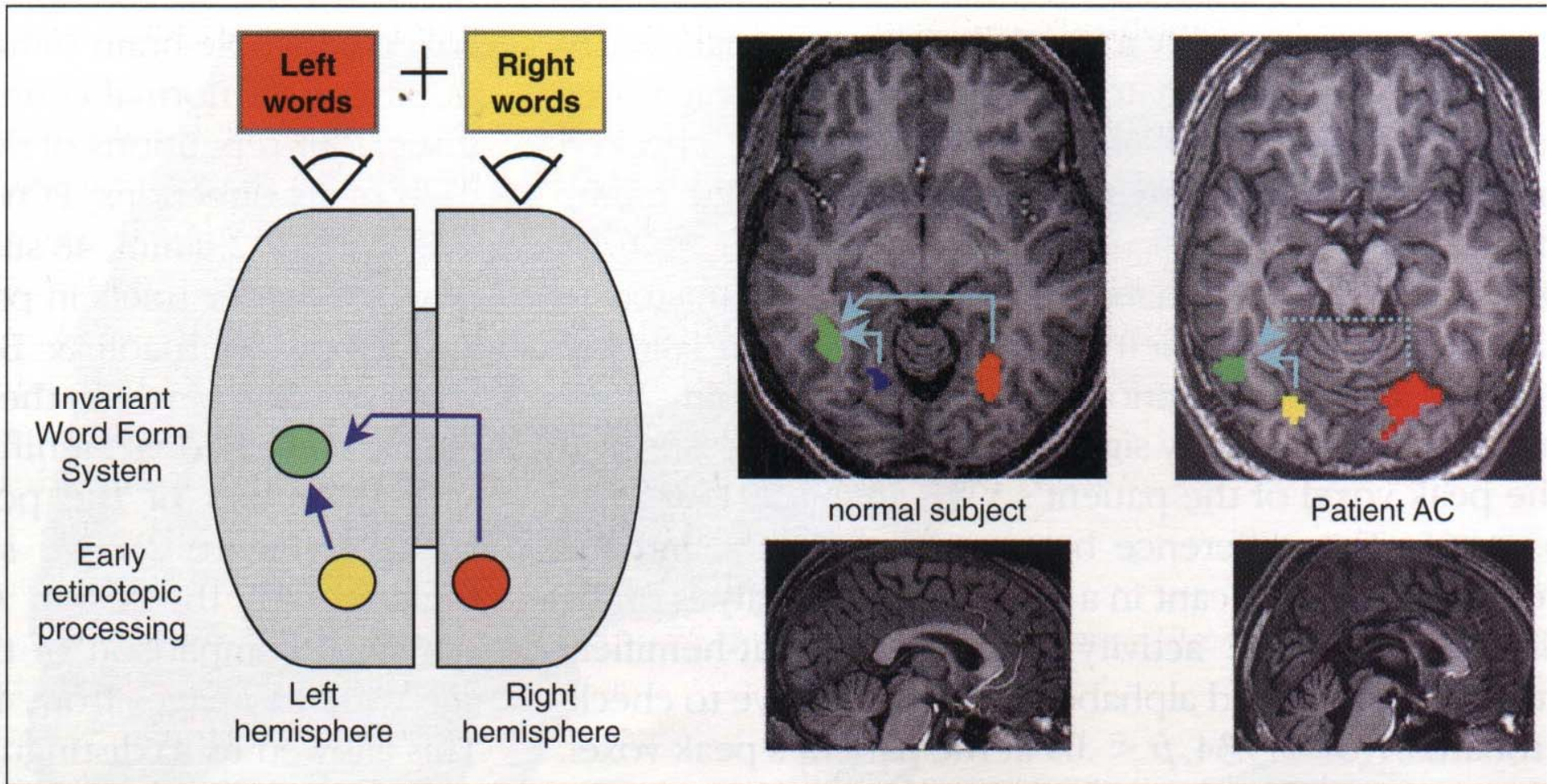
Individuality

Genes
Implications for Training,
Expertise, Pathology and
Rehabilitation

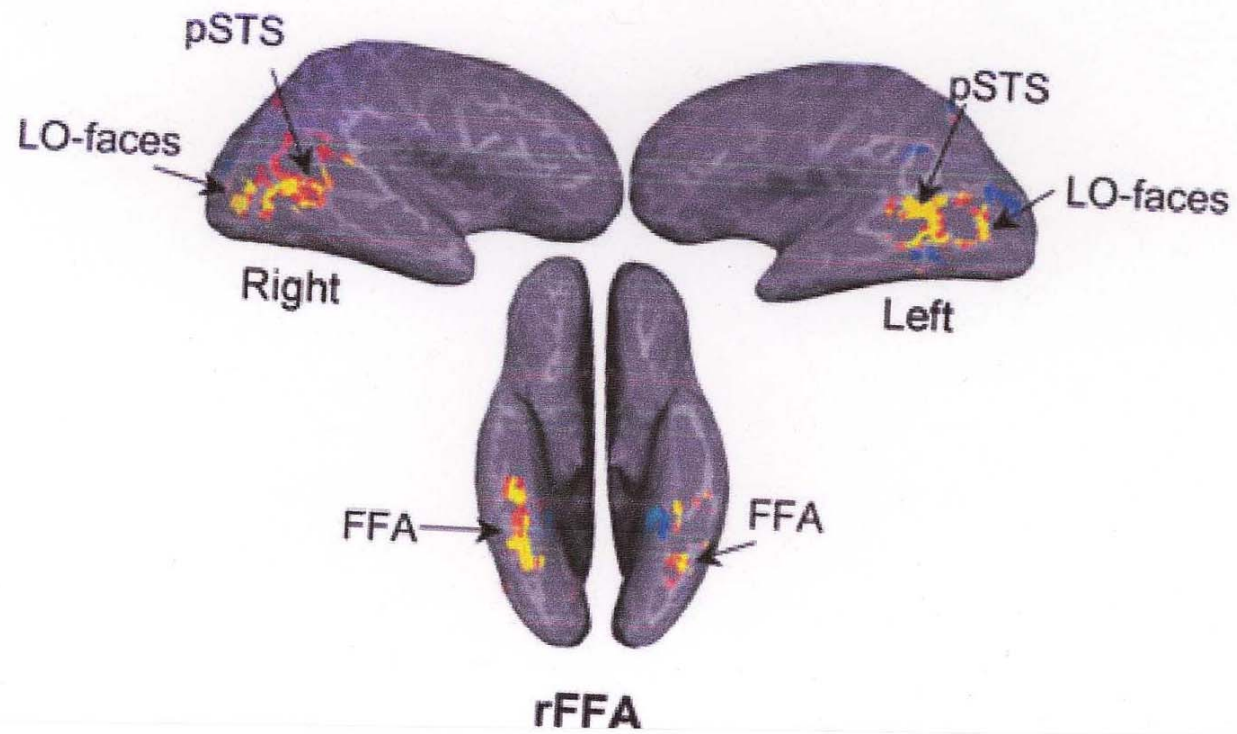


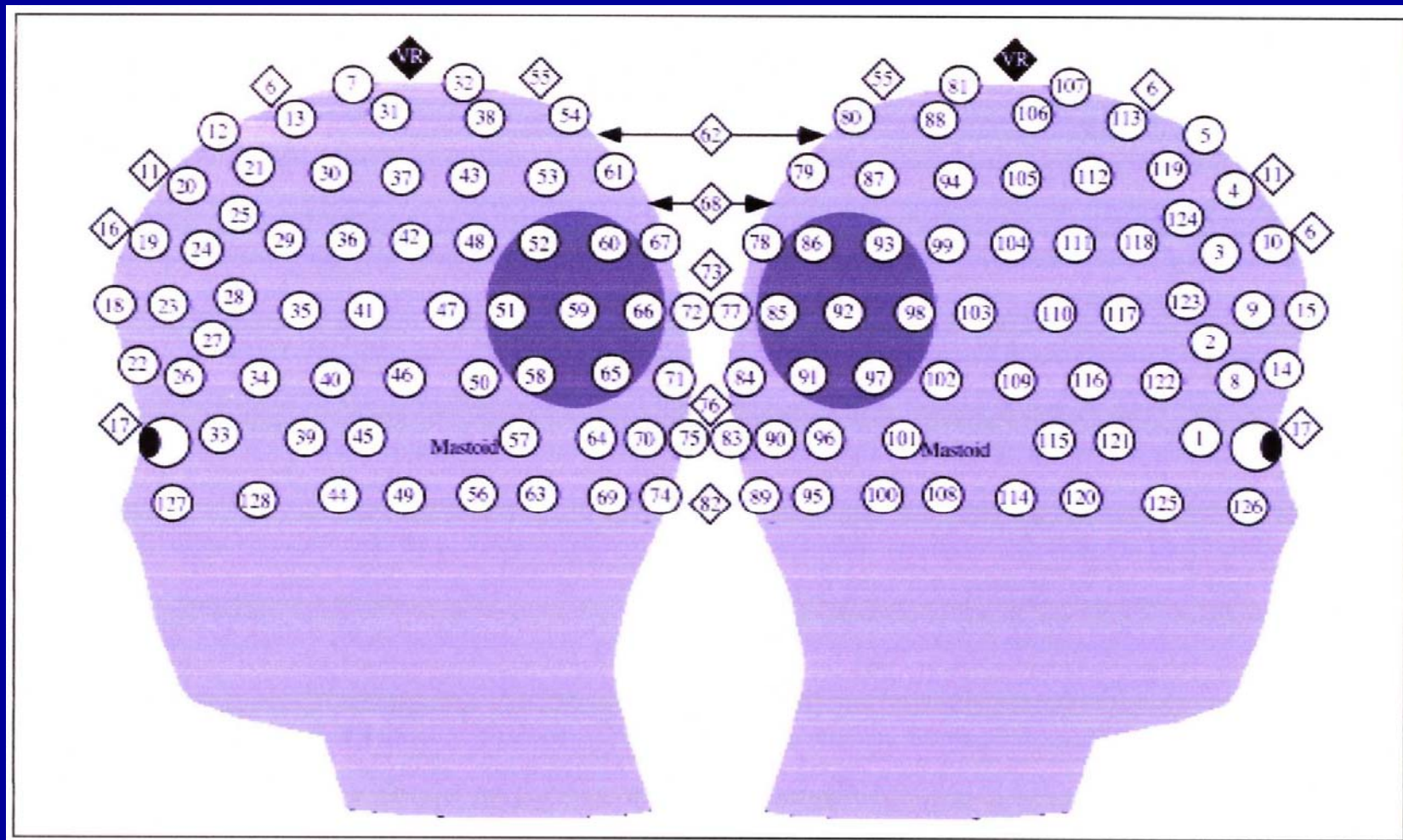
QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Chase & Simon , 1973

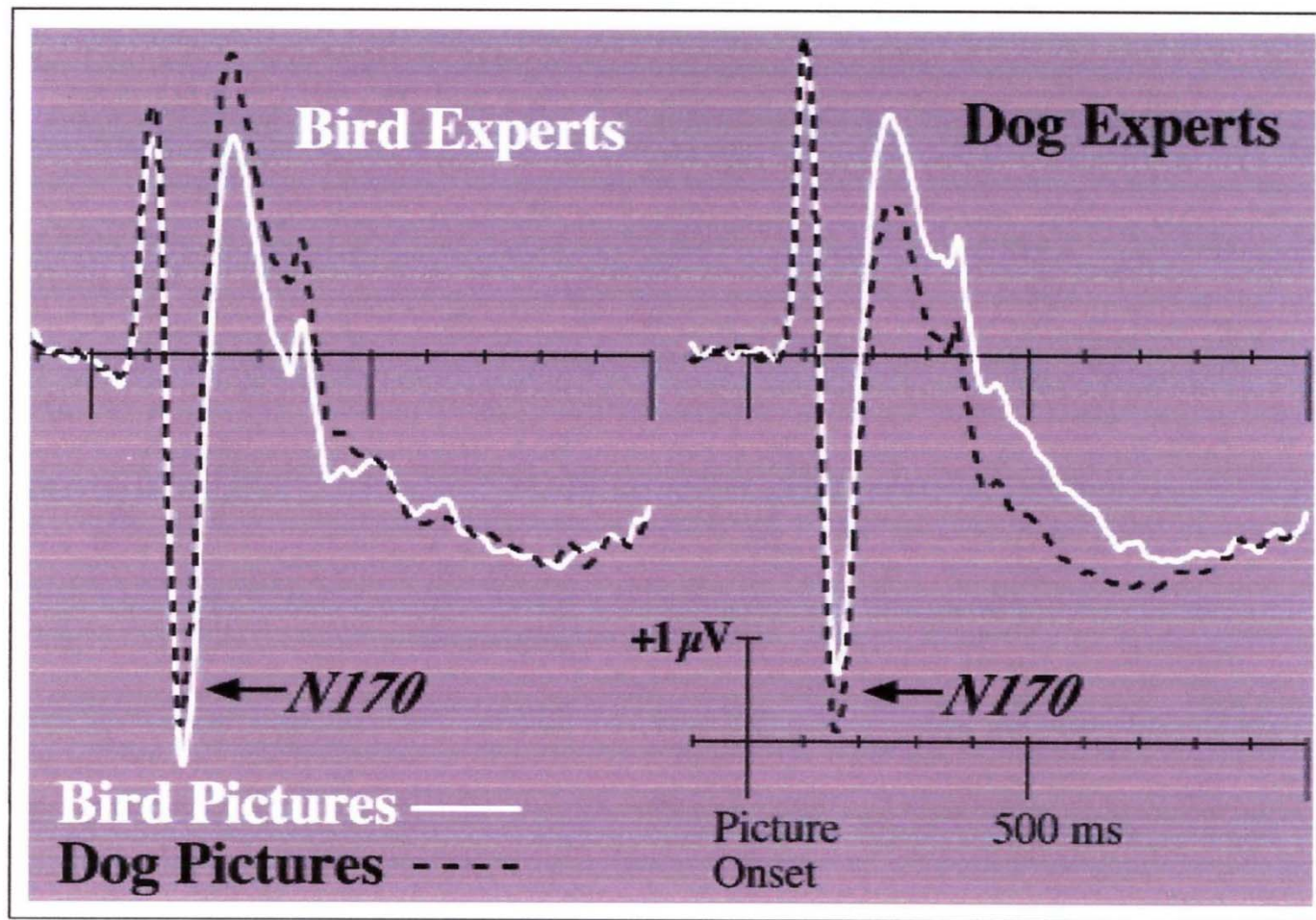


Subject 1





Tanaka & Curran 2001



(Tanaka & Curran, 2001)

SUMMARY

Attention
System

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Expertise, Pathology and
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