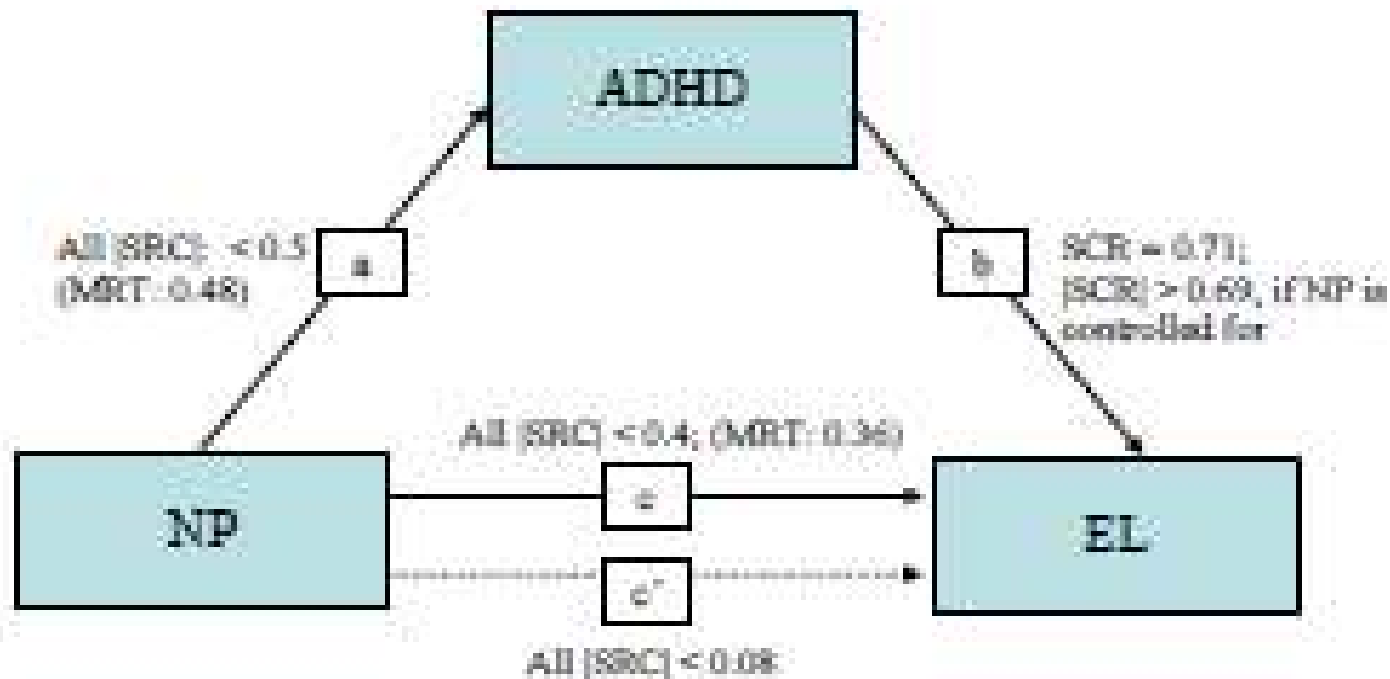


Jaap van der Meere, RUG, NL

ADHD: state regulation – motivation and
emotions

Neuropsychological correlates of emotional lability in children with ADHD

Tobias Banaschewski,¹ Christine Jennen-Steinmetz,² Daniel Brandeis,^{1,3} Jan K. Buitelaar,⁴ Jonna Kuntsi,⁵ Luise Poustka,¹ Joseph A. Sergeant,⁶ Edmund J. Sonuga-Barke,^{7,8} Alexis C. Frazier-Wood,¹⁰ Björn Albrecht,¹¹ Wai Chen,¹² Henrik Uebel,¹¹ Wolff Schlotz,^{7,9} Jaap J. van der Meere,¹³ Michael Gill,¹⁴ Iris Manor,¹⁵ Ana Miranda,¹⁶ Fernando Mulas,¹⁷ Robert D. Oades,¹⁷ Herbert Roeyers,⁸ Aribert Rothenberger,¹¹ Hans-Christoph Steinhausen,^{3,19,20} Stephen V. Faraone,²¹ and Philip Asherson⁵

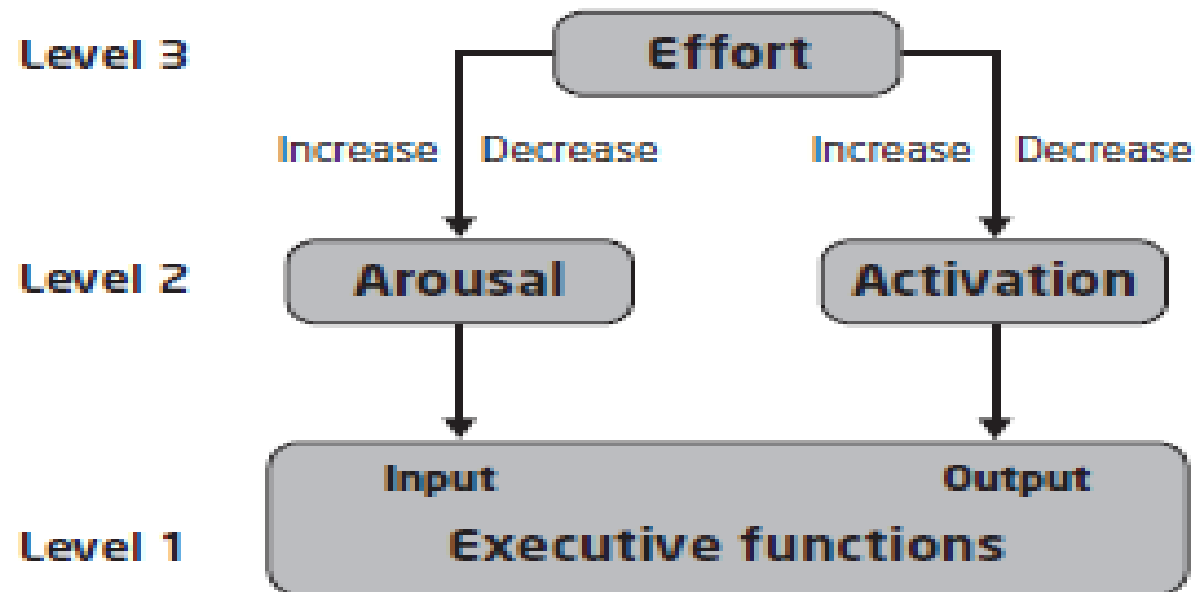


ADHD: State Regulation and Motivation

Jaap J van der Meere, Prof, PhD¹, Norbert A Börger, PhD¹, and Jan R Wiersema, PhD²
¹Department of Clinical Neuropsychology, University of Groningen, The Netherlands, and
²Department of Experimental Clinical and Health Psychology, Ghent University, Belgium

CML - Psychiatry 2010;21(1):1-7.

Figure 1. The state regulation model.



National academy of neuropsychology

- Effort/motivation indices are a medical necessity to ensure that examiners are obtaining a valid measurement of examinees' optimal performance
- Bush et al (2005). Archives of Clinical Neuropsychology, 20, 419-426

*fMRI indicates two
anticorrelational networks in the
brain*

- The task **positive** frontal parietal attention network (active task state)
- The task **negative** default mode network (passive task state)
- Raichle et al (2001). Proceedings National Academy of Science USA, 98, 676-682

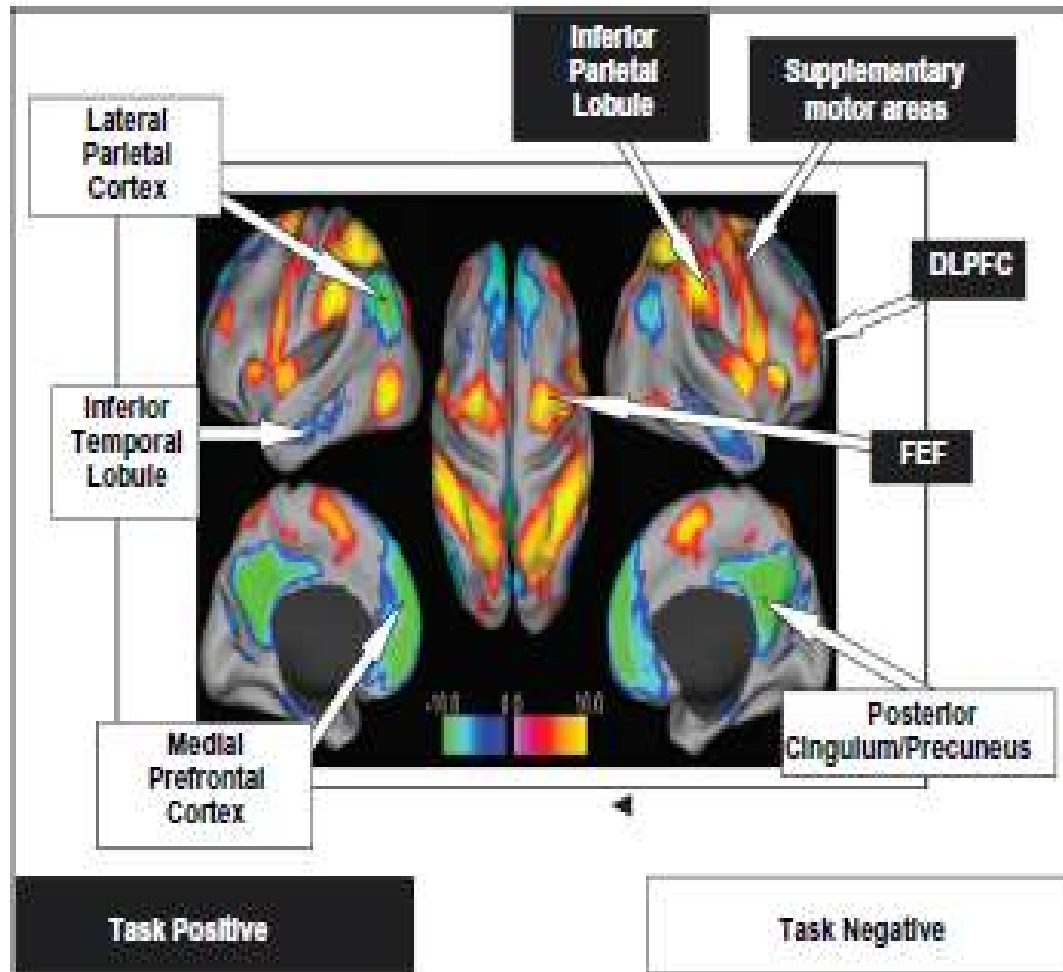


Fig. 1. Key neuroanatomical components of anti-correlated task positive and task-negative networks of the resting brain default network as illustrated by spontaneous fluctuations in the BOLD signal at rest in a study by Fox et al. (2005). FEF, frontal eye fields, DLPFC, Dorsolateral prefrontal cortex.

Task positive network

- Involved in responding to environmental events:
 - Response selection
 - Preparation
 - Planning
 - Orientation



Executive functions

Task negative network

- The wandering mind
- Day dreaming
- Internally focused tasks
- Suboptimal motivational states
- **The wandering mind uses almost as much energy as the one that makes things getting done**

Debate: the role of glucose in mental tasks

- Motivation = extra energy allocation = glucose depletion
- Fairclough & Houston (2004). *Biological Psychology*, 2, 177-190
- *against*
- Kurzban et al (2012). *Behavior and Brain science*

*Debate: glucose consumption and
effort/energy allocation*

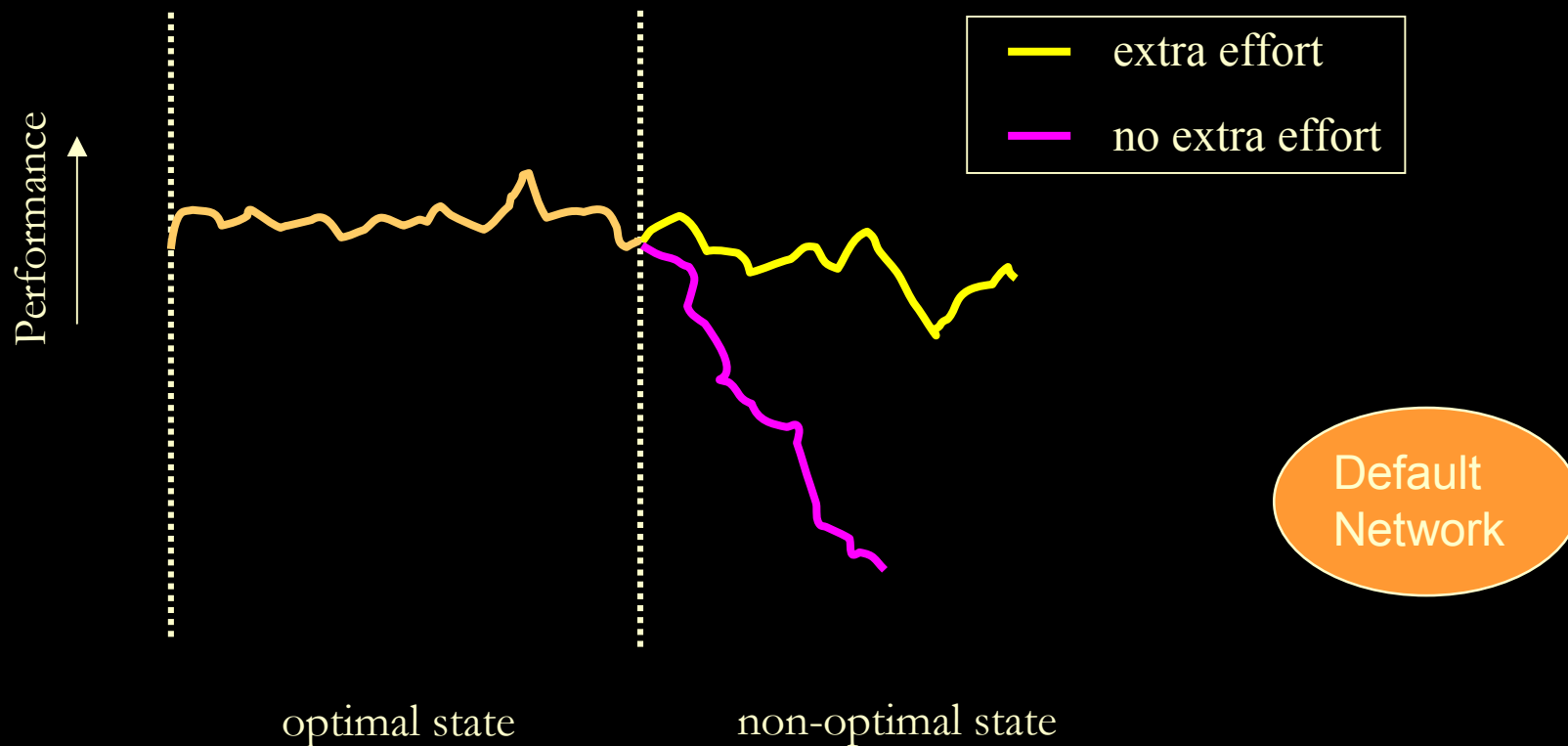
task positive network



task negative network

Theory of state regulation, Sanders 1983

- Actual state vs. required (target) state – effort allocation



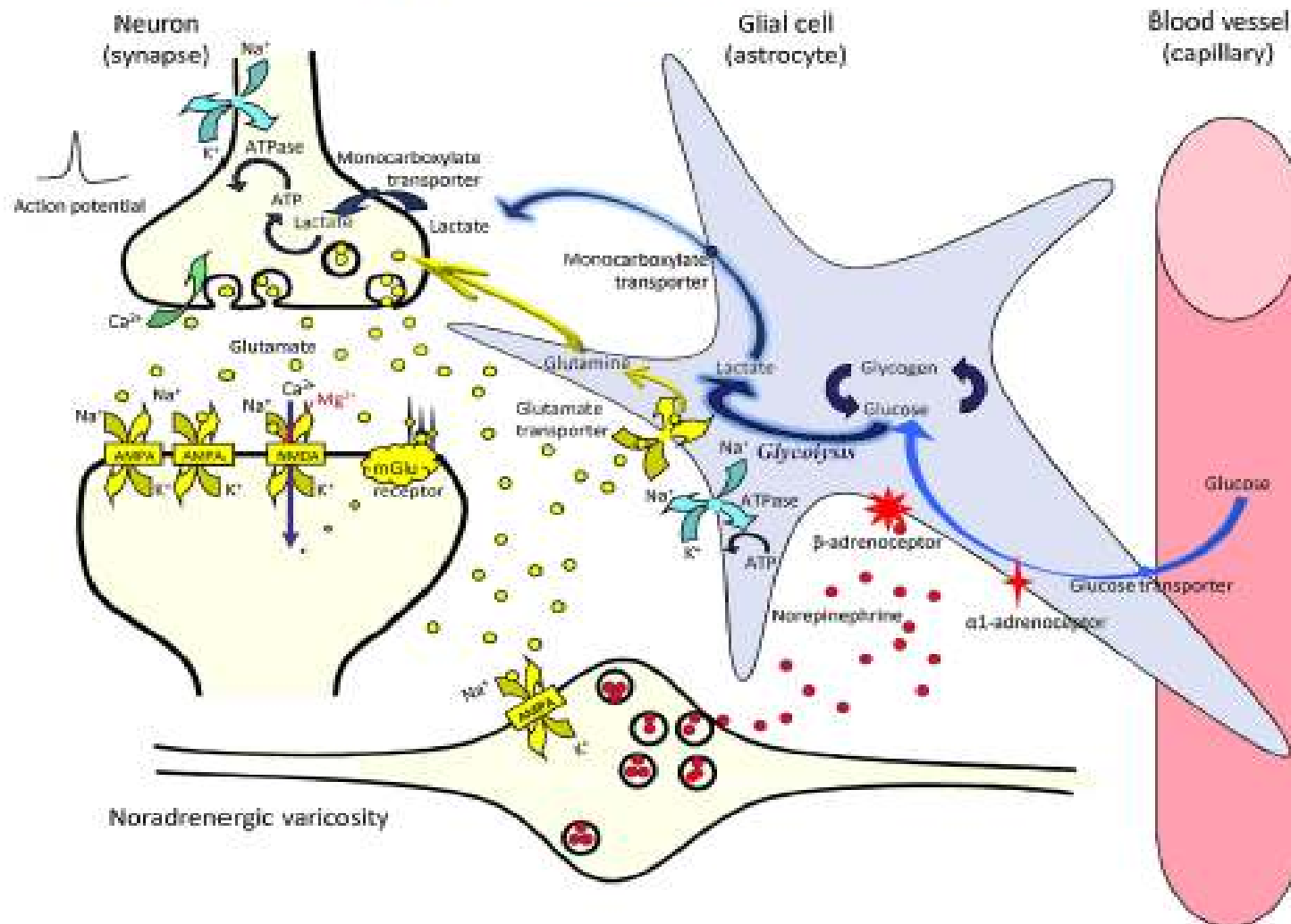
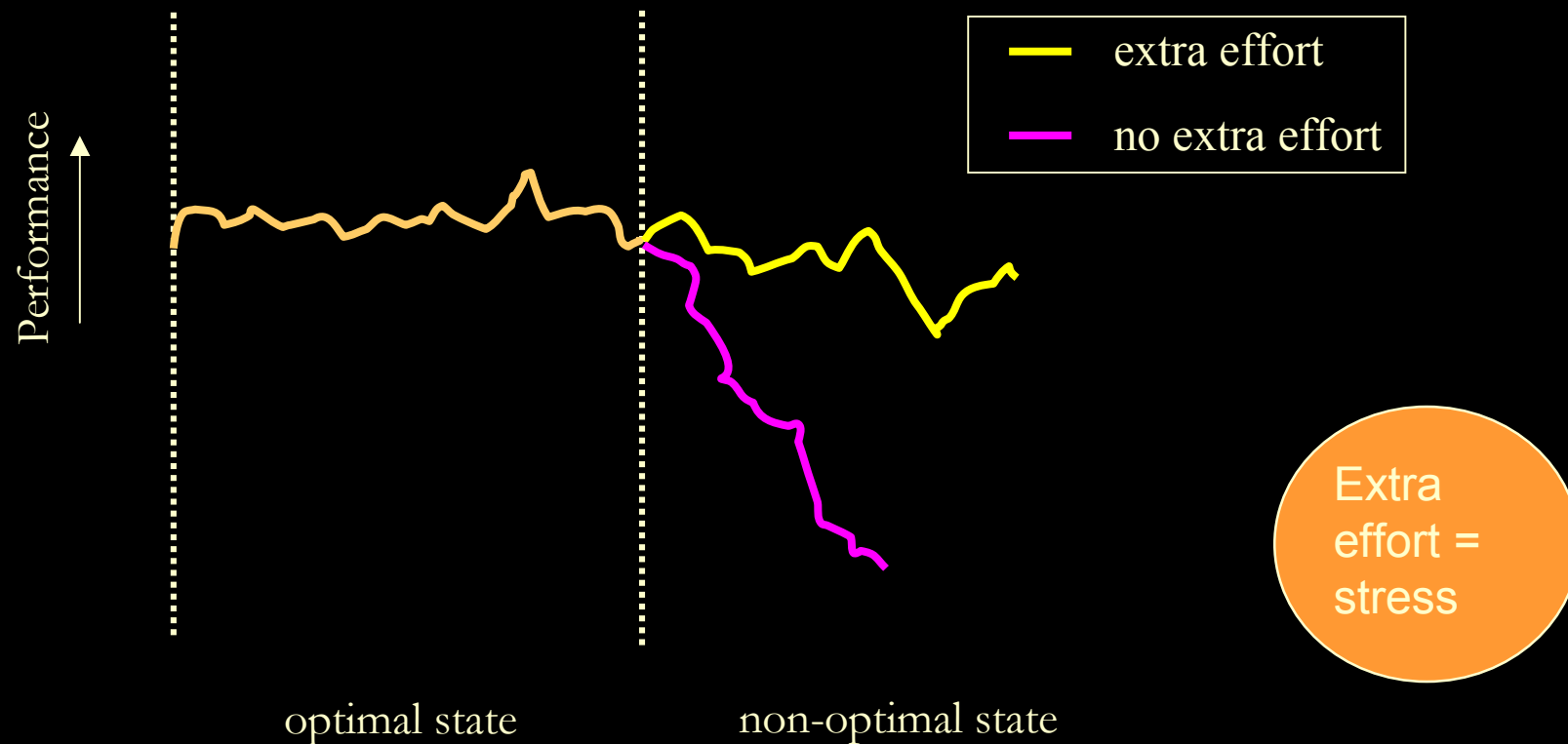


Fig. 1. The supply chain for adenosine triphosphate (ATP) production, that powers the neuron. Release of glutamate (yellow circles) stimulates glucose uptake (blue arrow) and glycolysis in the astrocyte to produce lactate. The lactate diffuses into the extracellular space, to be absorbed by the neuron for ATP production, for restoration of ionic gradients, and re-sequestration and encapsulation of neurotransmitters. Astrocytes also convert glutamate to glutamine, which is shuttled to the neurons to restore their pools of neurotransmitters (yellow arrows). Glutamate, acting on AMPA receptors, stimulates norepinephrine release (red circles) from nearby noradrenergic varicosities. These act on β-adrenoceptors, to further stimulate glucose uptake and glycolysis, causing astrocytes to produce more lactate to support sustained neural firing.

Theory of state regulation, Sanders 1983

- Actual state vs. required (target) state – effort allocation



Lower hypothalamic pituitary axis activity in ADHD

- impaired response to stress
- Hong H.J. et al (2003). Yonsei Medical Journal 4, 608-614
- Stress belongs to the task positive network?
- Control group is more stressed?

Reaction time paradigm to tap state regulation

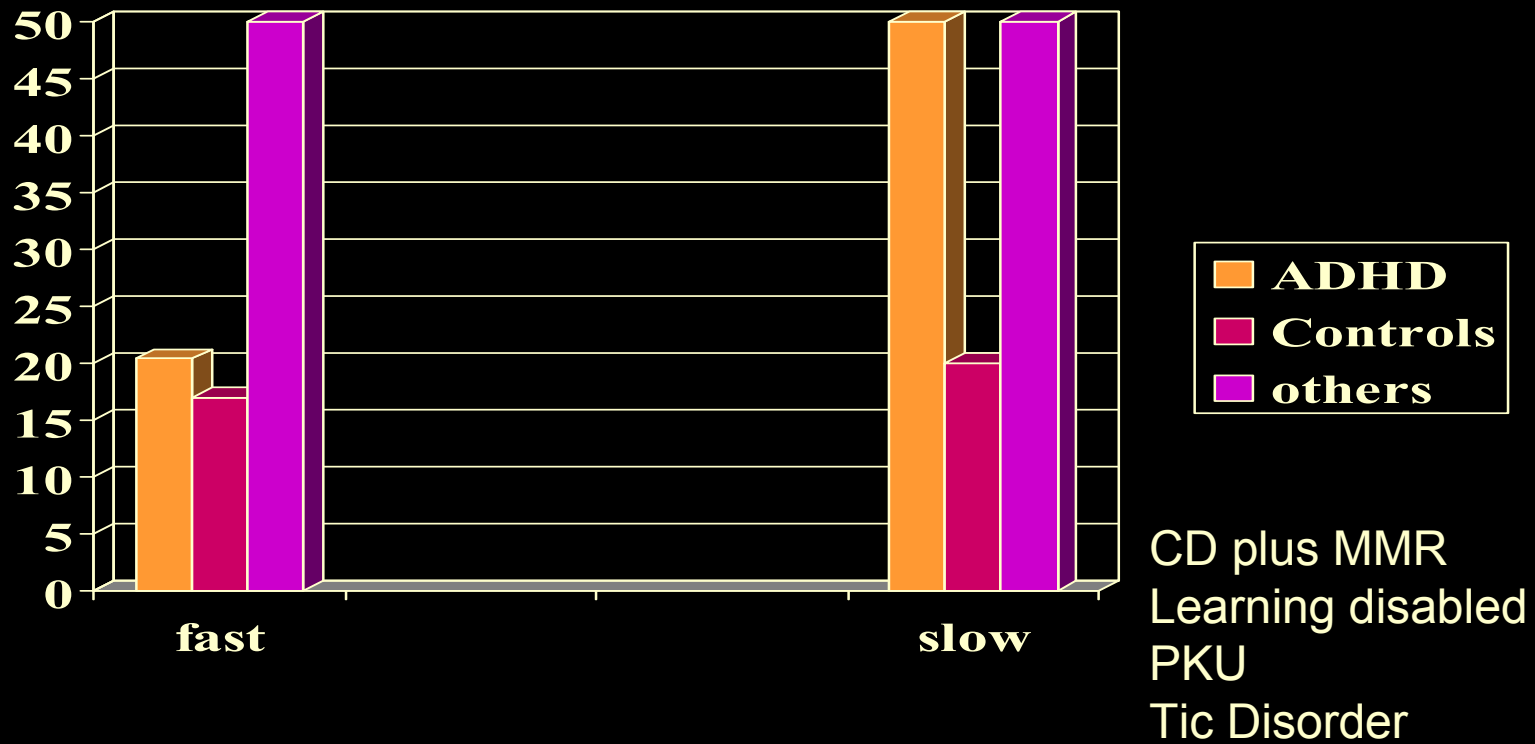
- **Event rate manipulation**

Signal rate

optimal -activated

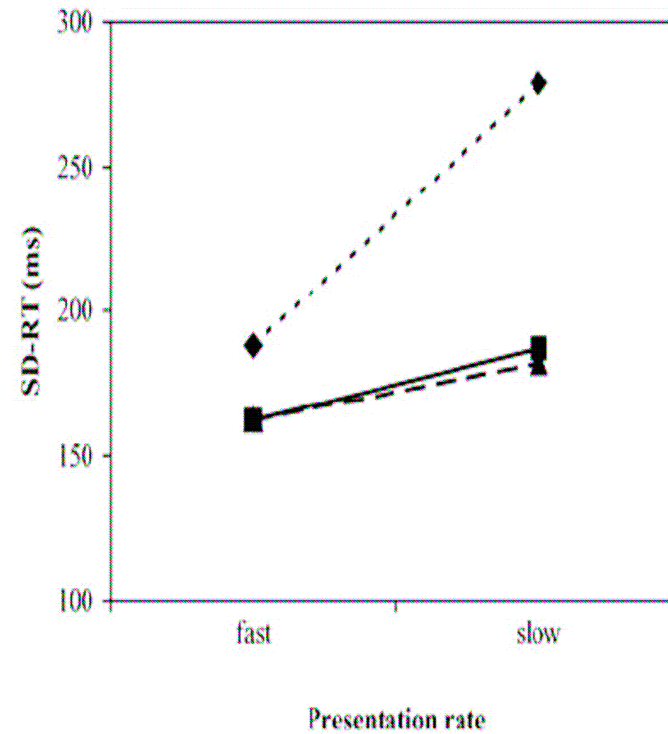
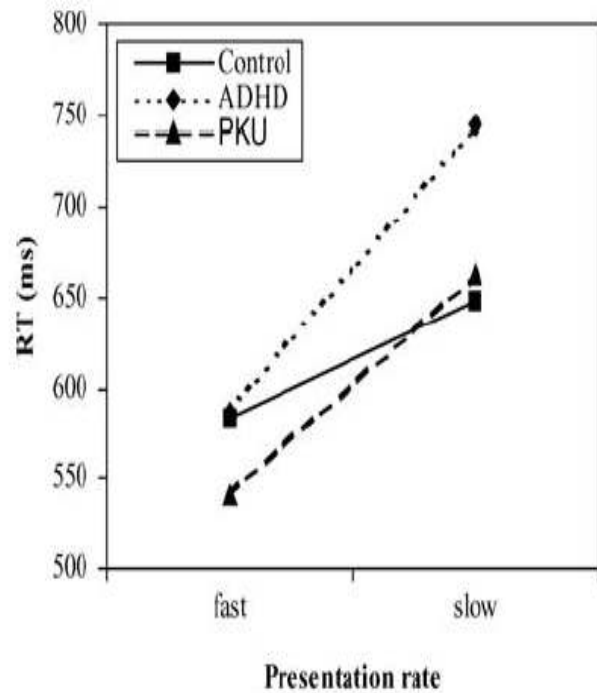
Under-activated

errors



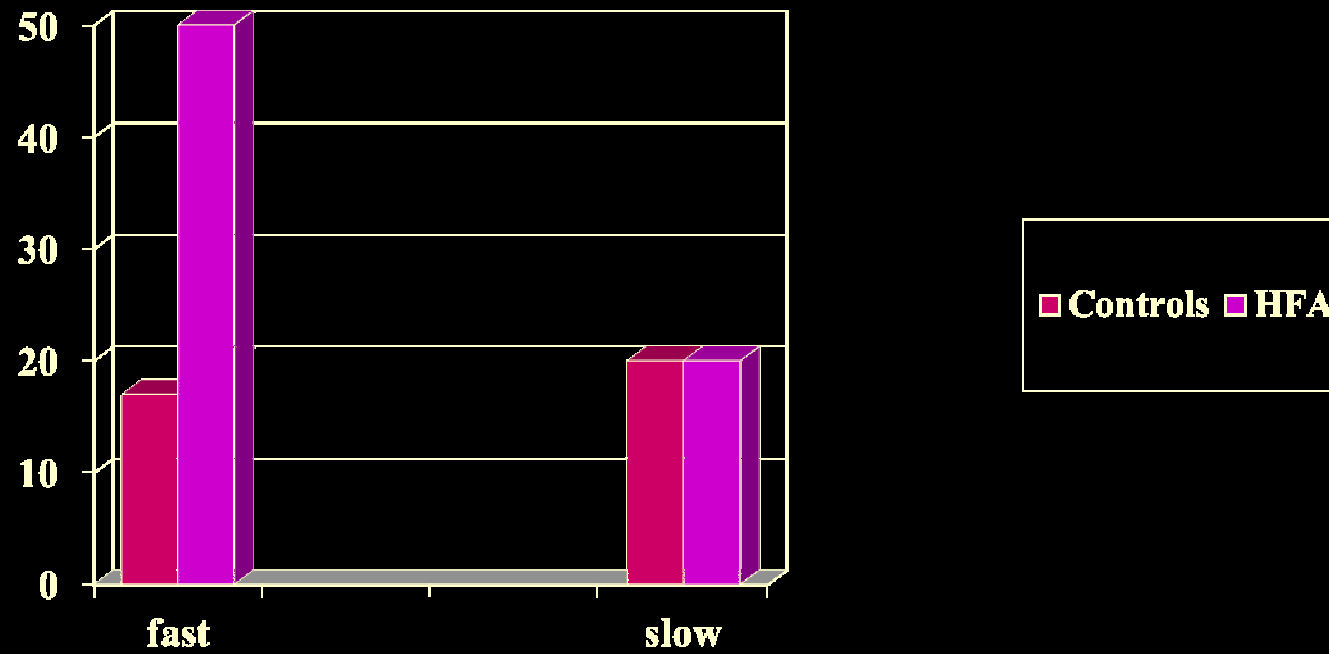
Comparing ADHD versus PKU

17



HFA against controls

errors



A Meta-Analytic Study of Event Rate Effects on Go/No-Go Performance in Attention-Deficit/Hyperactivity Disorder

Baris Metin, Herbert Roeyers, Jan R. Wiersema, Jaap van der Meere, and Edmund Sonuga-Barke

994 BIOL PSYCHIATRY 2012;72:990–996

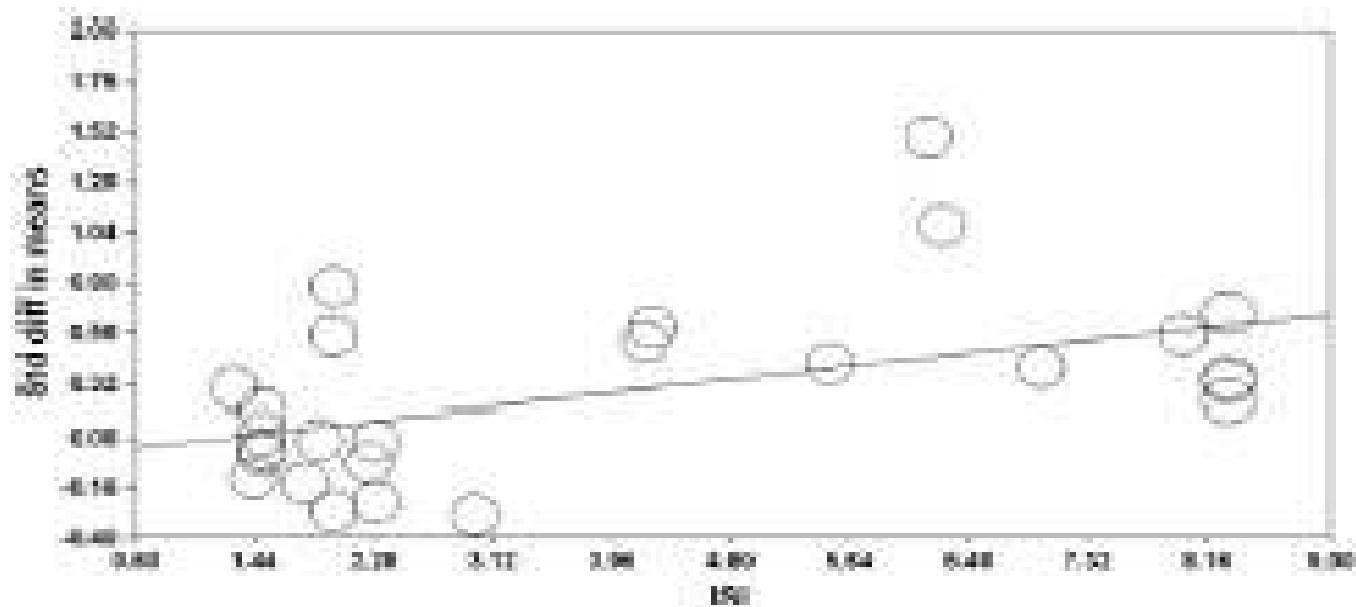
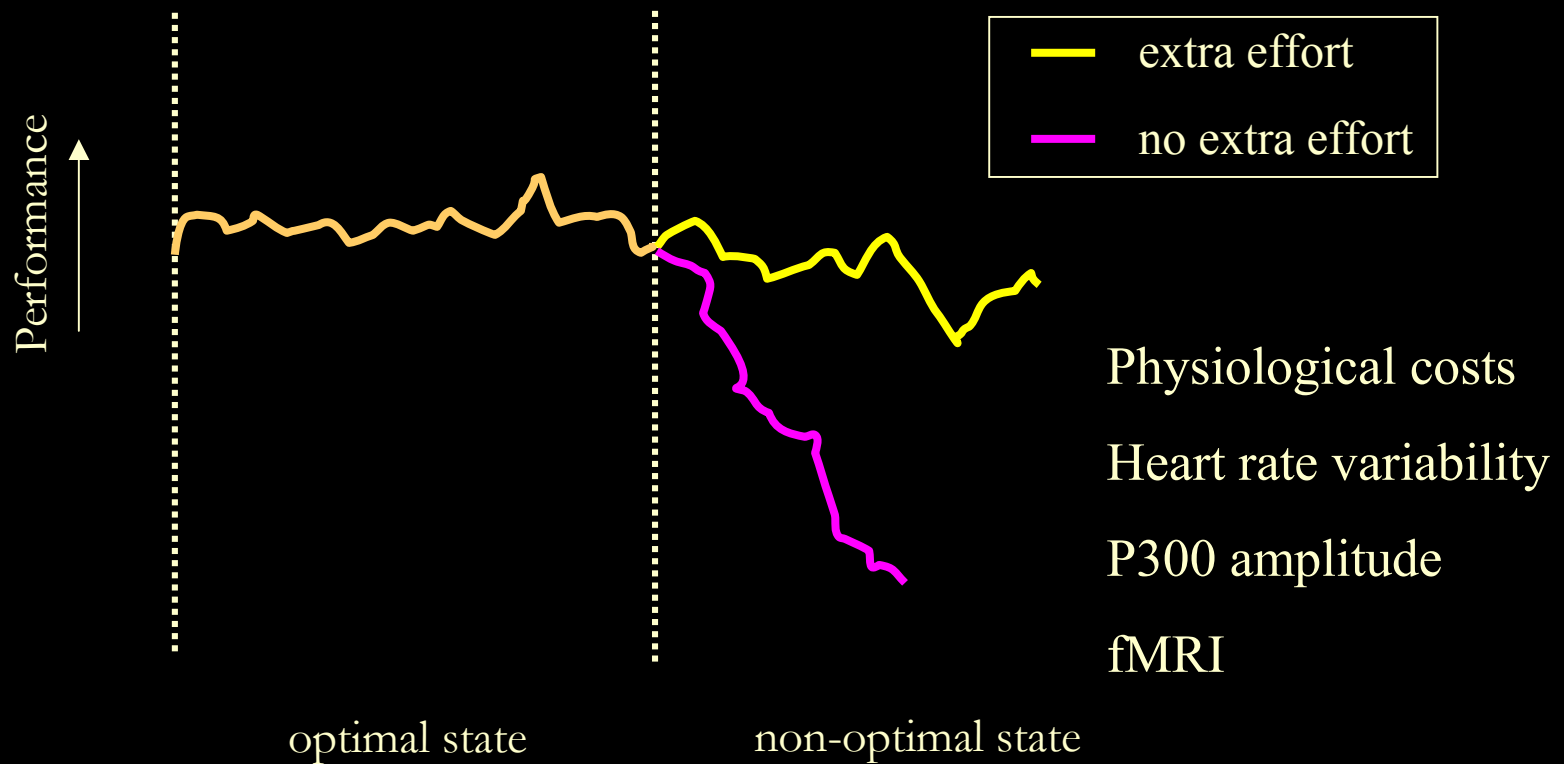


Figure 5. Scatter plot for regression of interstimulus interval (ISI) on effect size for mean reaction time. Std diff, standard difference.

Event rate effect

- is specific for ADHD children and adults
- 60 tot 80 % of the effect is inherited
(London group: Jonna Kuntsi)
- prematuritas and antenatal maternal anxiety
load on the ER effect

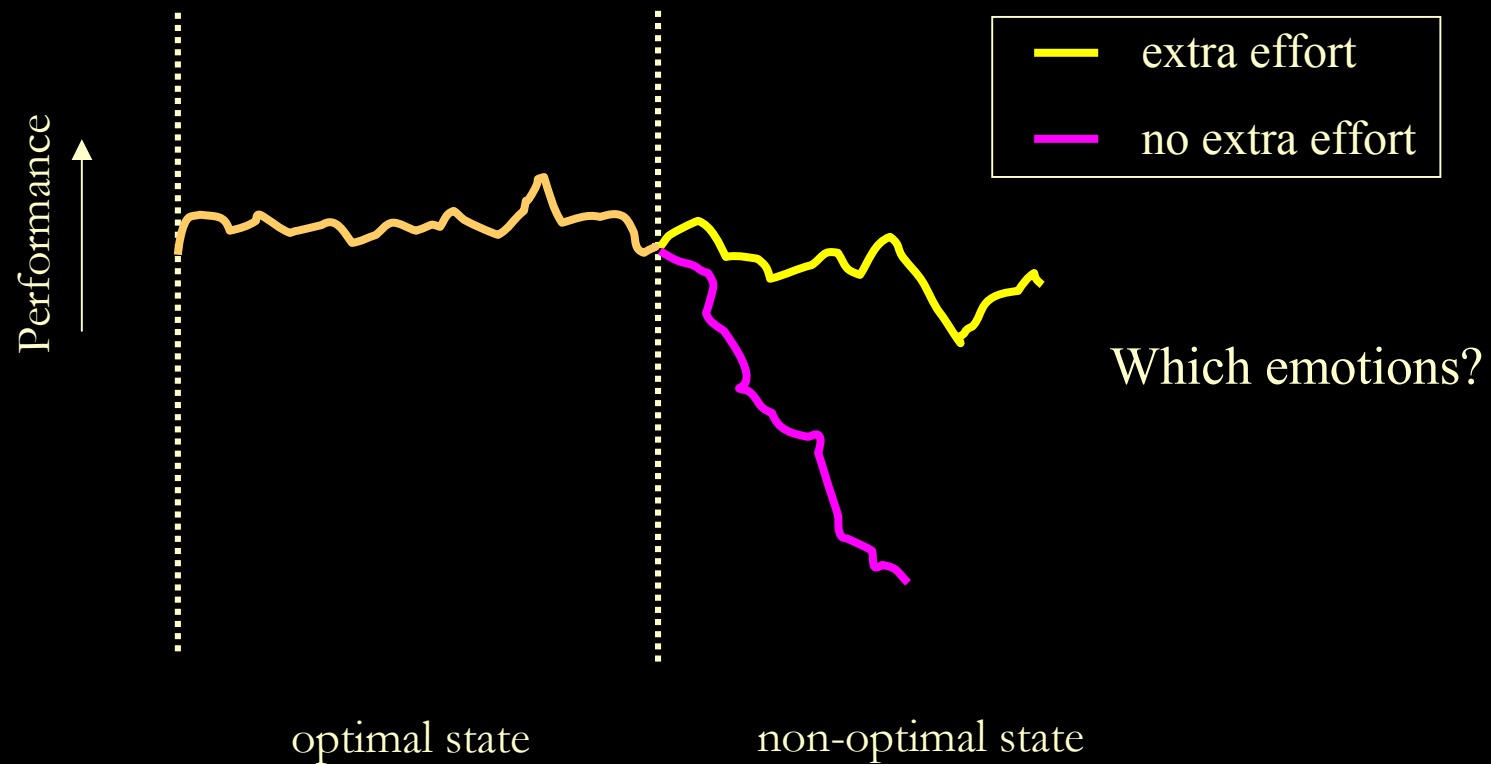
- Actual state vs. required (target) state – effort allocation



In conclusion

- Psychophysiological indices point in the direction of diminished effort allocation in ADHD children. Their task positive attention network becomes *less* active; as a consequence, their default network mode becomes *more* active?

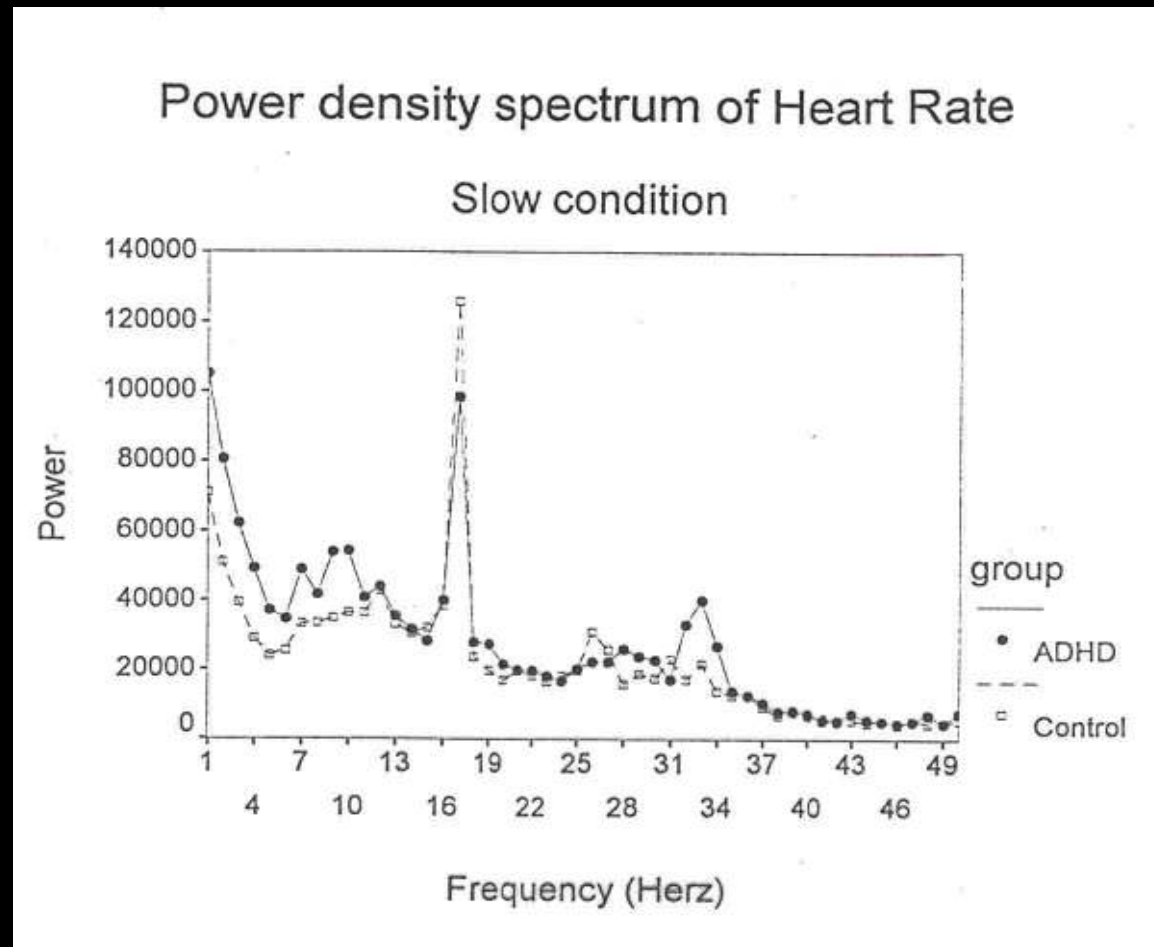
- Actual state vs. required (target) state – effort allocation



Present study

- Reaction times
- Heart rate variability (effort/motivation index)
- Observations of facial movements

CPT, Heart Rate Variability



Go No-Go test

Heart rate variability (0.10 Hz)



Emotions to be expected given the context

- Stress
- Frustration
- Anger
- Boredom

- Methods: self-reports – physiological measurements – facial expressions

Observational system for facial expressions

- Ekman and Friezen (1978). FACS; Facial Action Coding System
- Muscle movements in the face
- Units of movements are defined in terms of expressions

Facial movements and emotions

- Stress is indexed by the sum of the facial movements
- Fear, anger, disgust and boredom are negative emotions associated with particular facial movements

Facial movements

- Brow raiser
- Brow lowerer
- Blink
- Eyes down
- Lip corner puller
- Tongue show
- Lip presser
- Lips part / Mouth stretch
- Lips suck
- Jaw sideways
- Puff

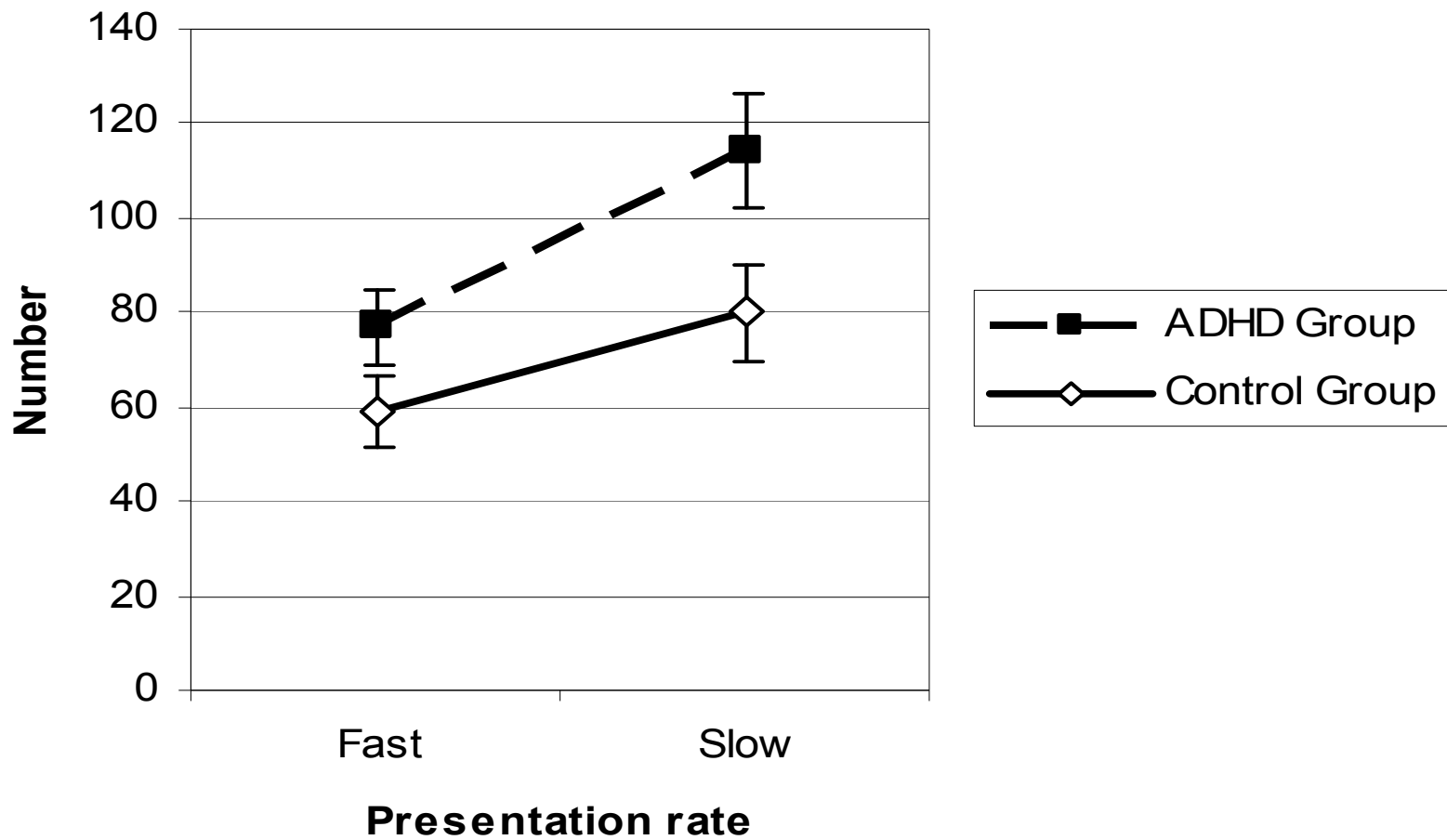
Fear and anger

boredom

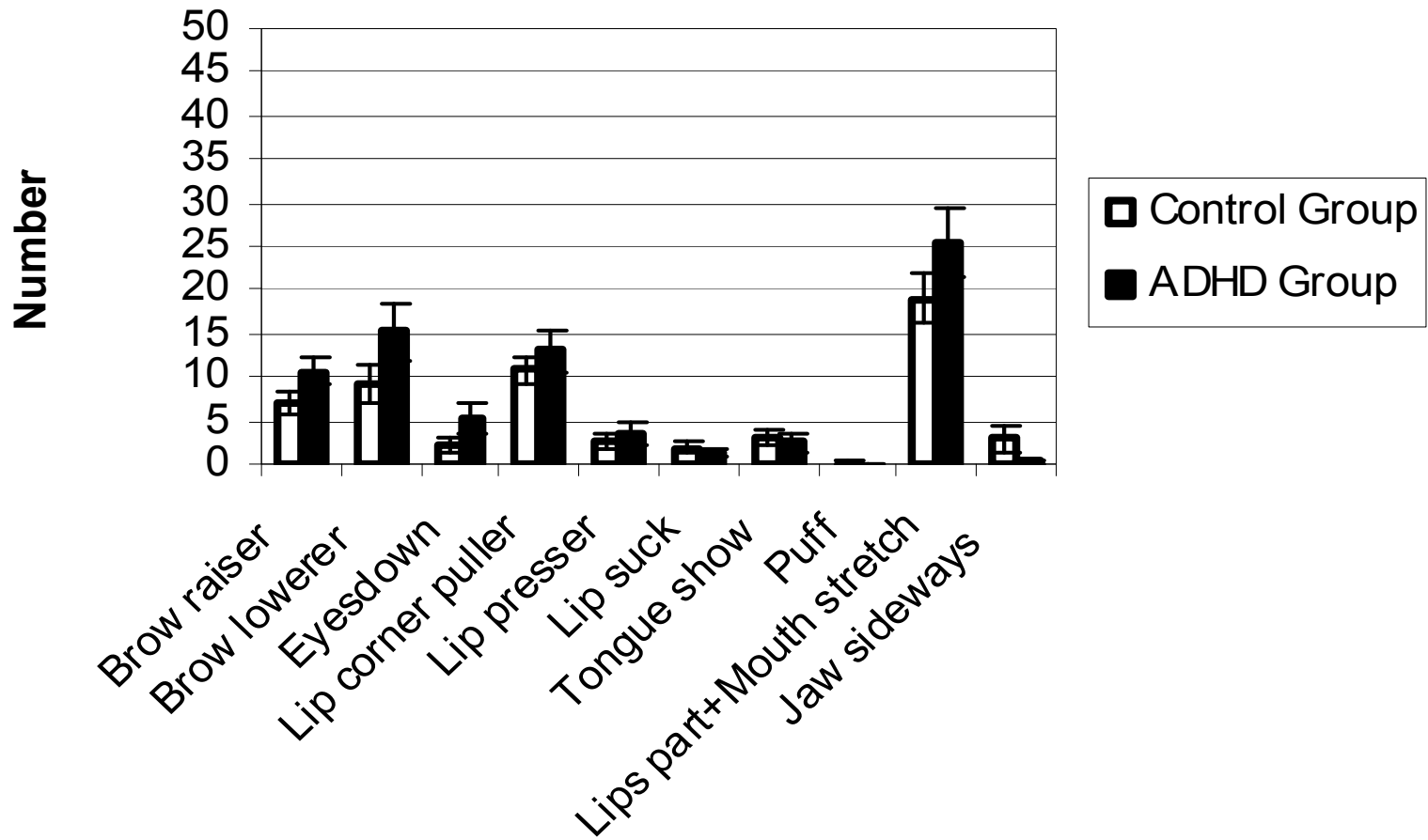
disgust

disgust

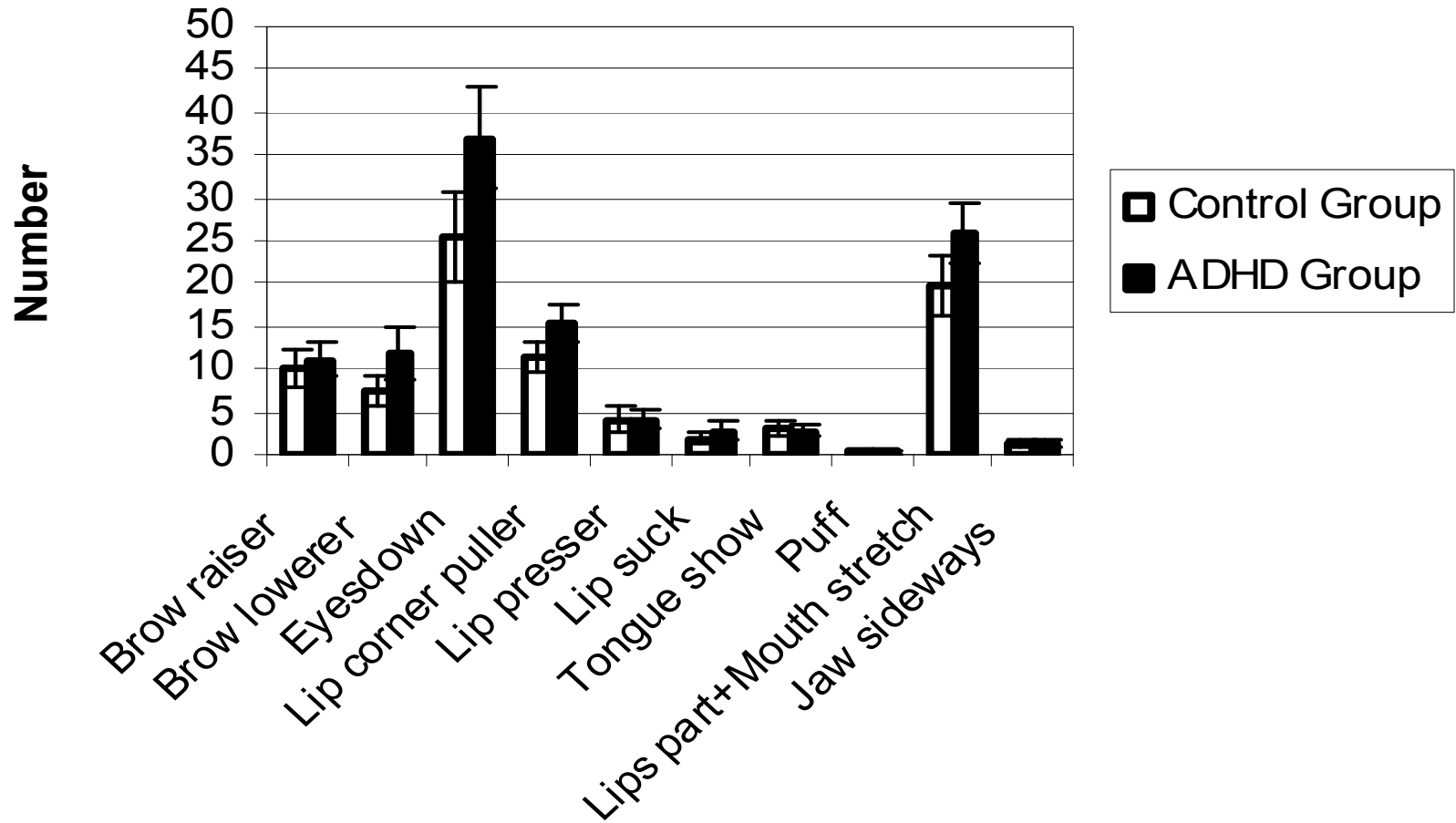
Facial movements during the go no-go test



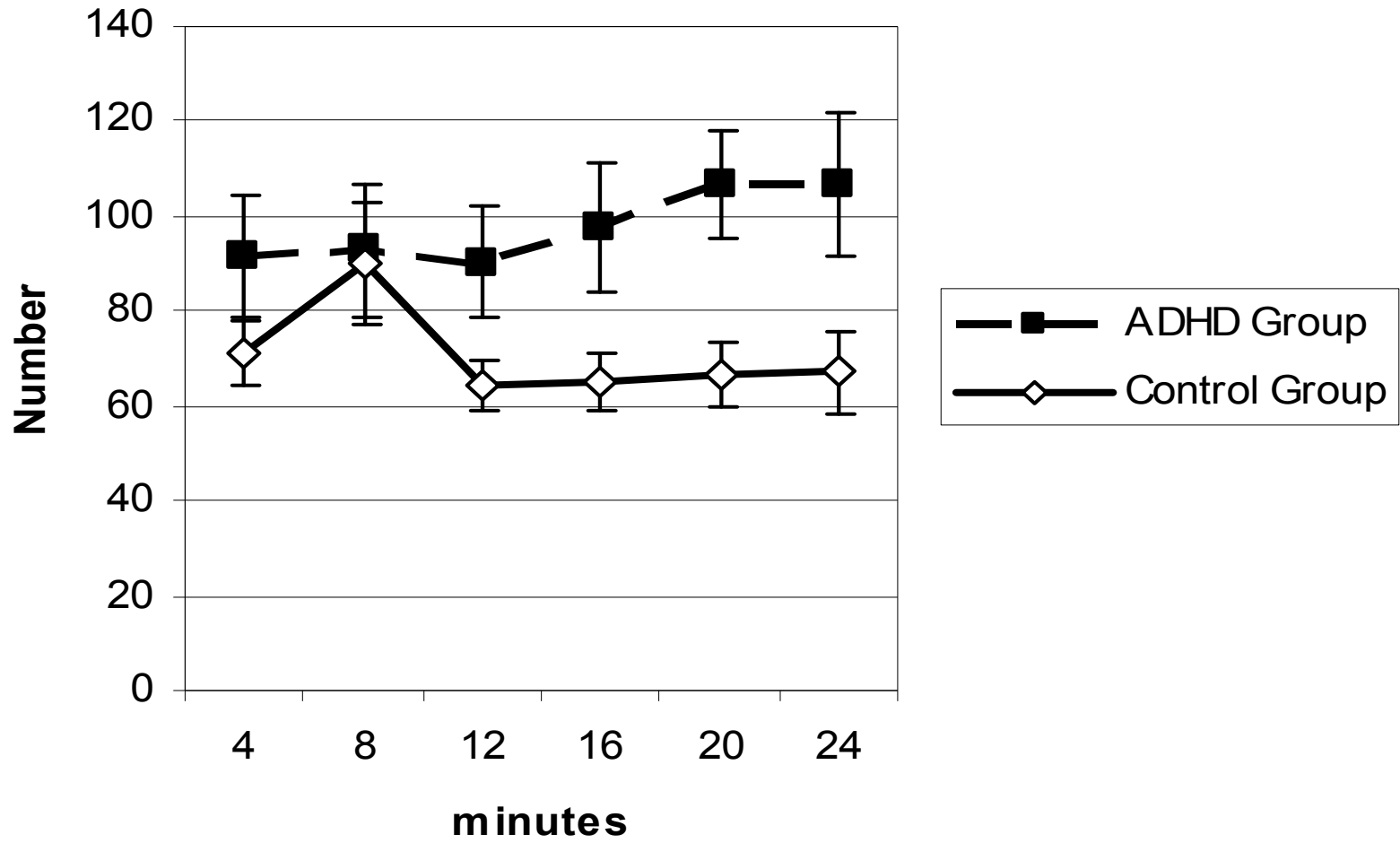
Facial movements go no-go test Fast condition



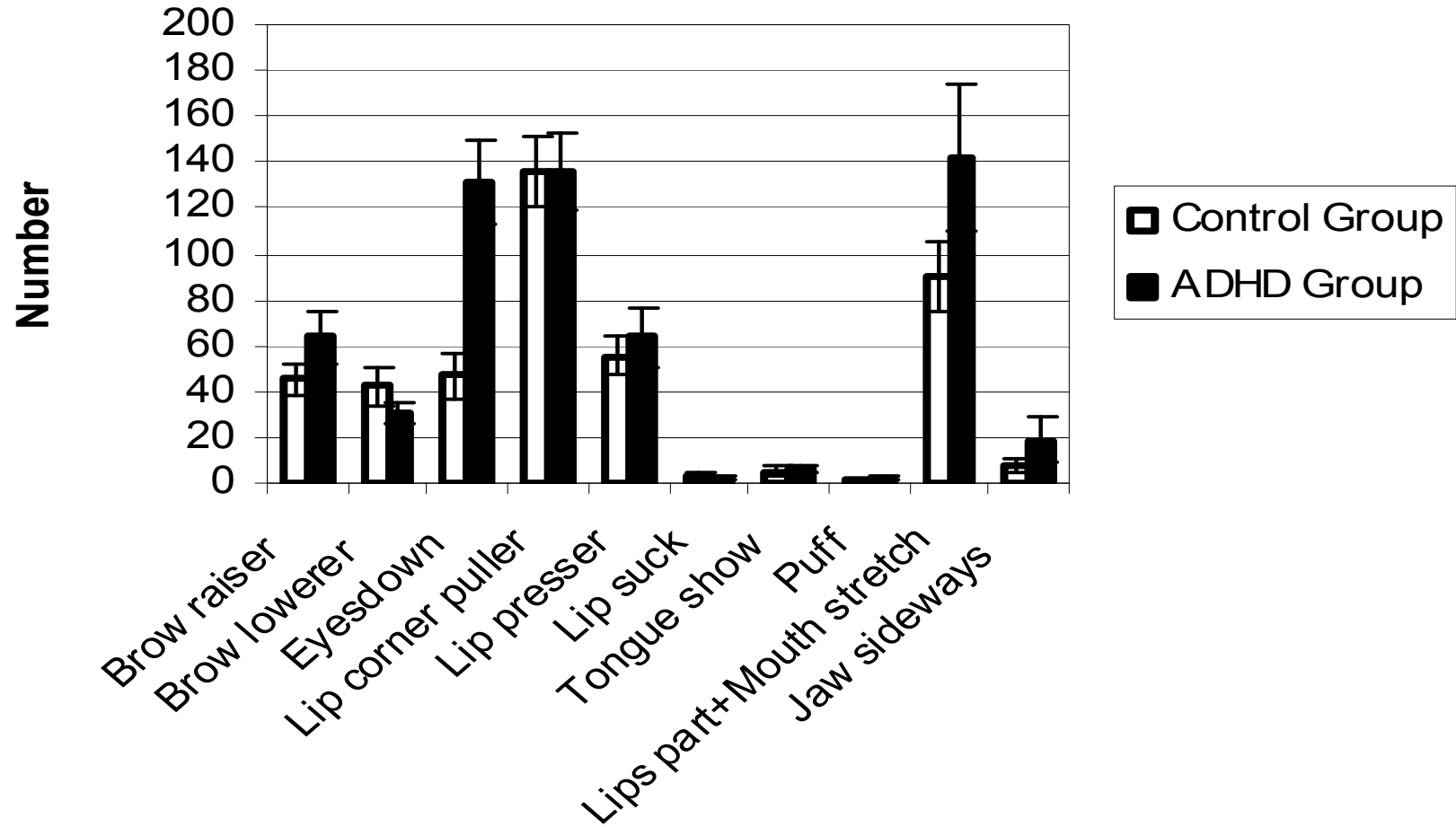
Facial movements go no-go test Slow condition



Facial movements during the CPT test



Facial movements CPT test



According to the total amount of facial movements

- ADHD children are easily stressed (facial movements, self-touching, scratching etc). According to ethologists, such behaviors are called displacement activities which are strongly connected with the stress response (Troisi, 2002).

According to the Ekman and Friezen observation system

- The main emotion connected with stress in ADHD is a state of boredom
- *Boredom is a flavor of stress (see for instance Richard Thackray 1981, The stress of boredom and monetary. Psychosomatic Medicine, 43, 165-)*

Limitations of the Ekman and Friezen observation method

- Overlap between action units and emotions
- An alternative approach is the Circumplex model (Russell, Posner)
- Unpleasant emotion plus low arousal is boredom

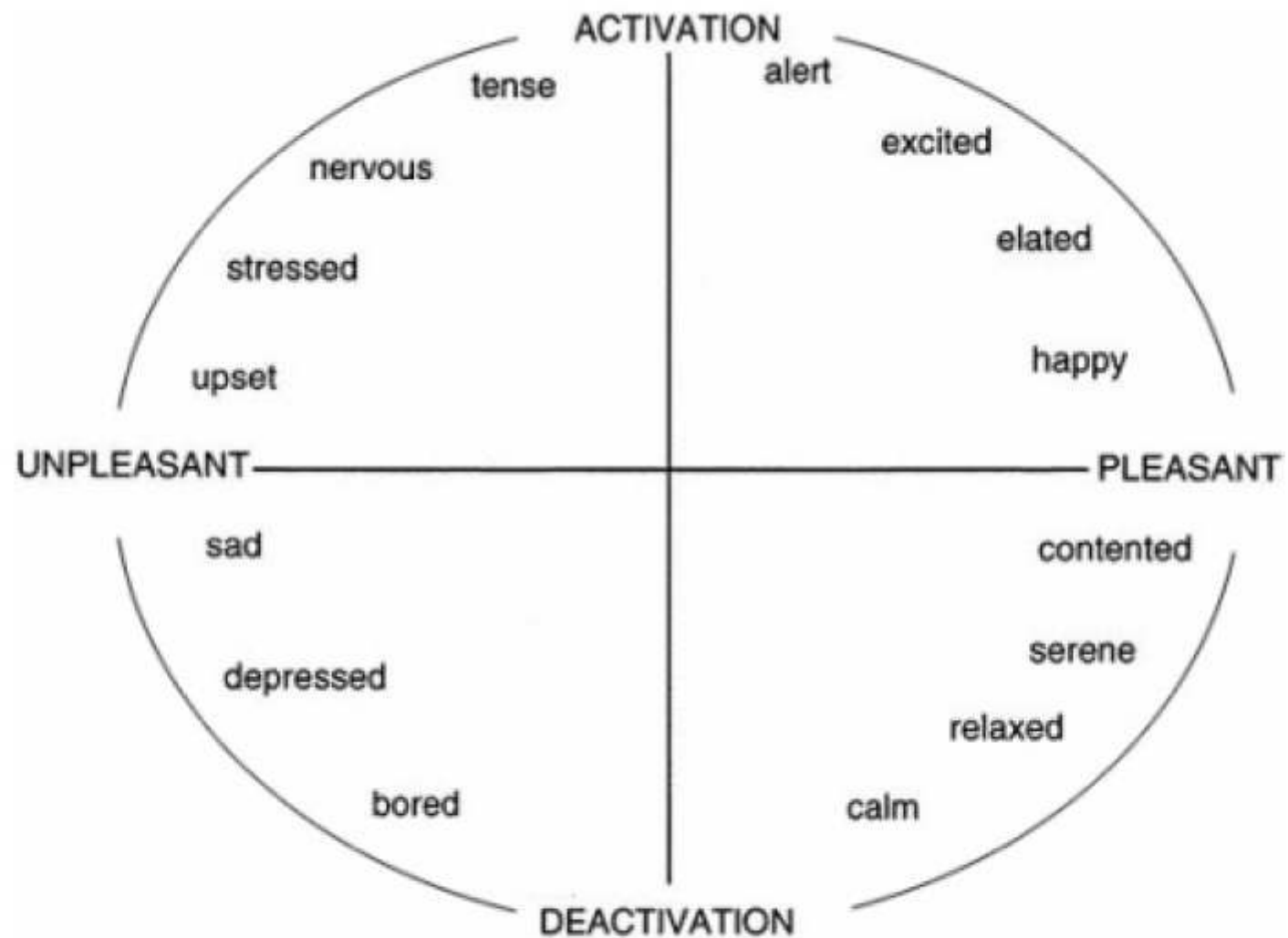


Figure 1. A graphical representation of the circumplex model of affect with the horizontal axis representing the valence dimension and the vertical axis representing the arousal or activation dimension.

ADHD

facial activity

r range .29 to .52



Reaction time performance

r range .23 to .31



Heart rate variability (.10 Hz component)
less physiological costs/deactivation

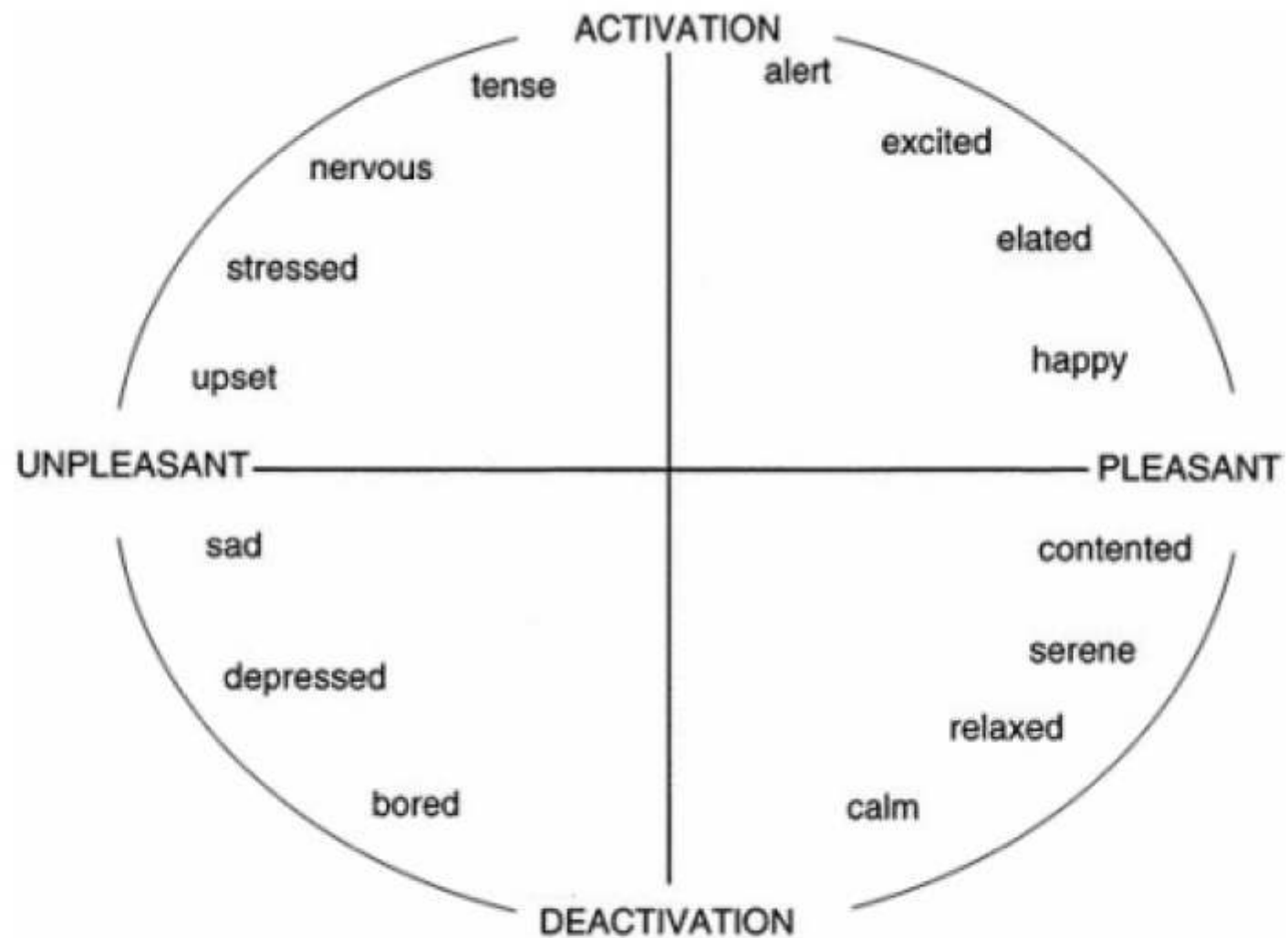


Figure 1. A graphical representation of the circumplex model of affect with the horizontal axis representing the valence dimension and the vertical axis representing the arousal or activation dimension.

According to the circumplex model

- ADHD: boredom
- Boredom is a motivational barrier
- Academic emotion directly related to learning outcome (Pekrun, 2011)

Future research 1

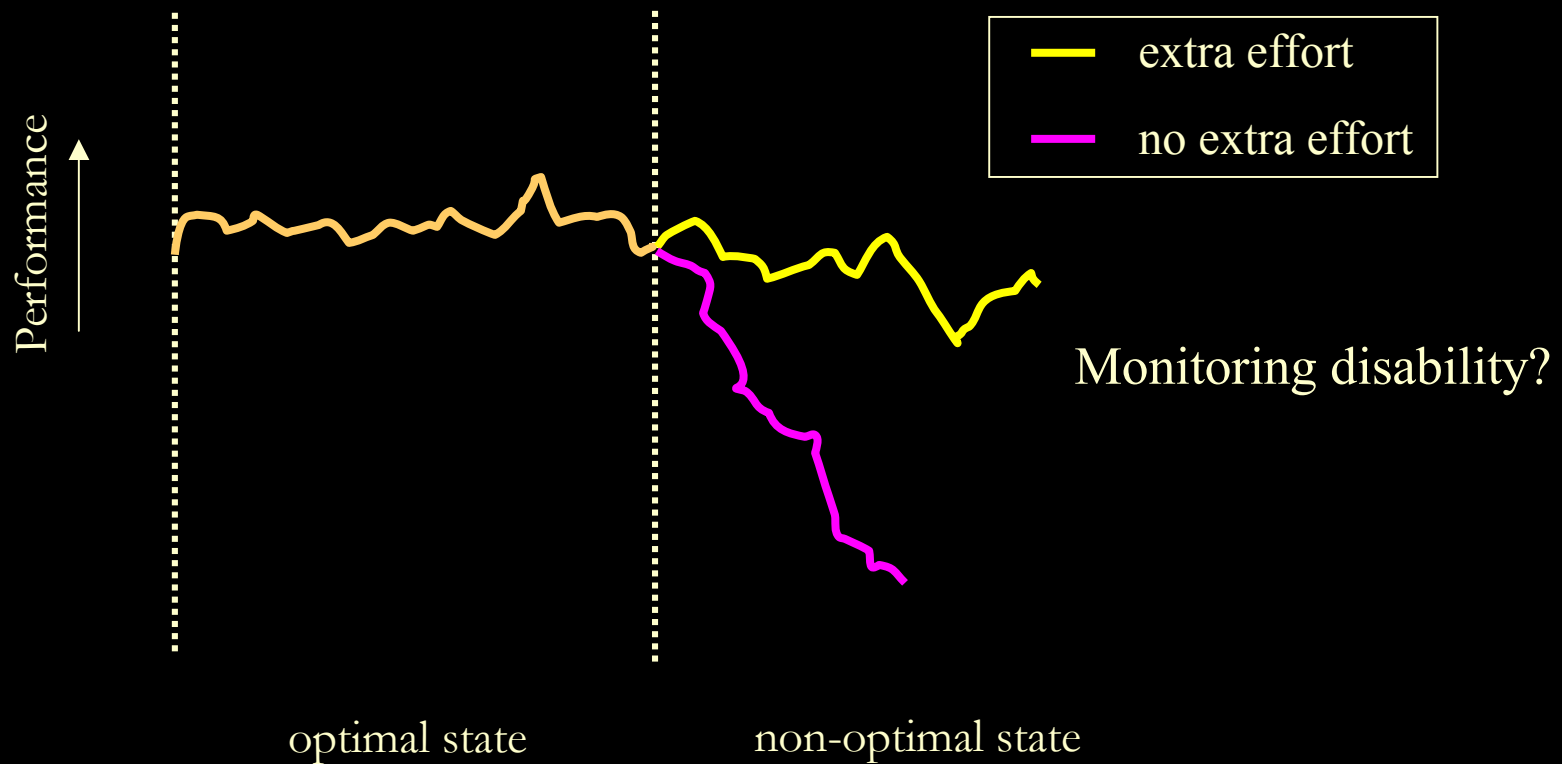
- Relation stress (boredom) and the default mode network

Future research 2

- Relation (boredom) and the awareness of their own failure to mobilize sufficient energy

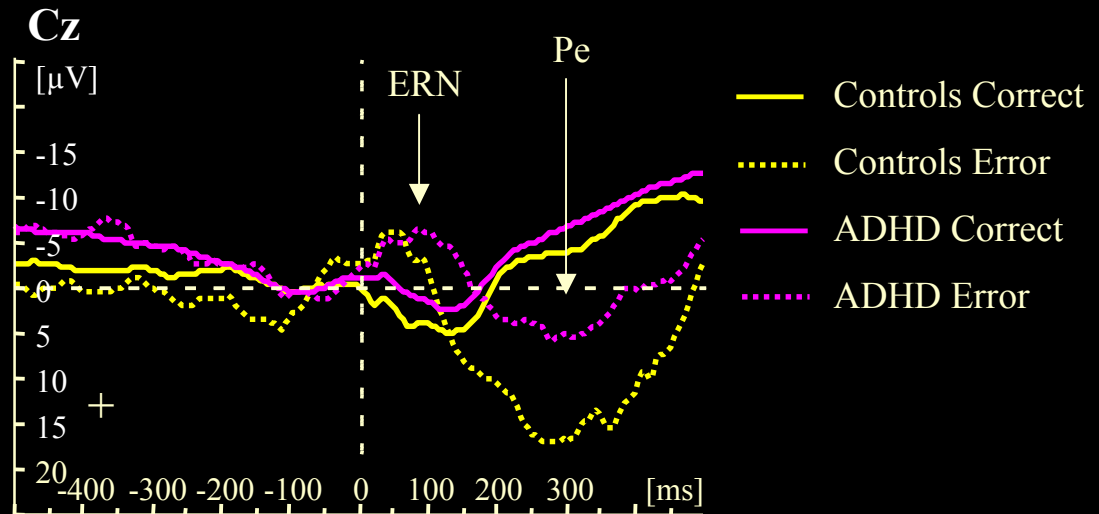
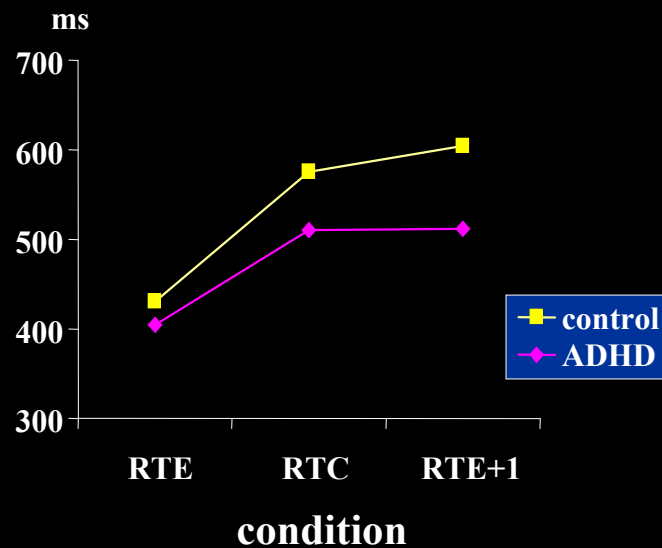
Theory of state regulation

- Actual state vs. required (target) state – effort allocation



Error Processing - Wiersema, van der Meere, & Roeyers (2005)
– Journal of Neural Transmission

- Children with ADHD showed less pronounced post-error slowing on Go/No-Go and S1-S2 task
- No difference in ERN but diminished Pe in ADHD



- ➔ *Intact error detection but abnormal response strategy adjustments and deviant conscious (emotional) evaluation of the error*
- ➔ *Possible ACC disturbance*

*Brain activation state before error
making*

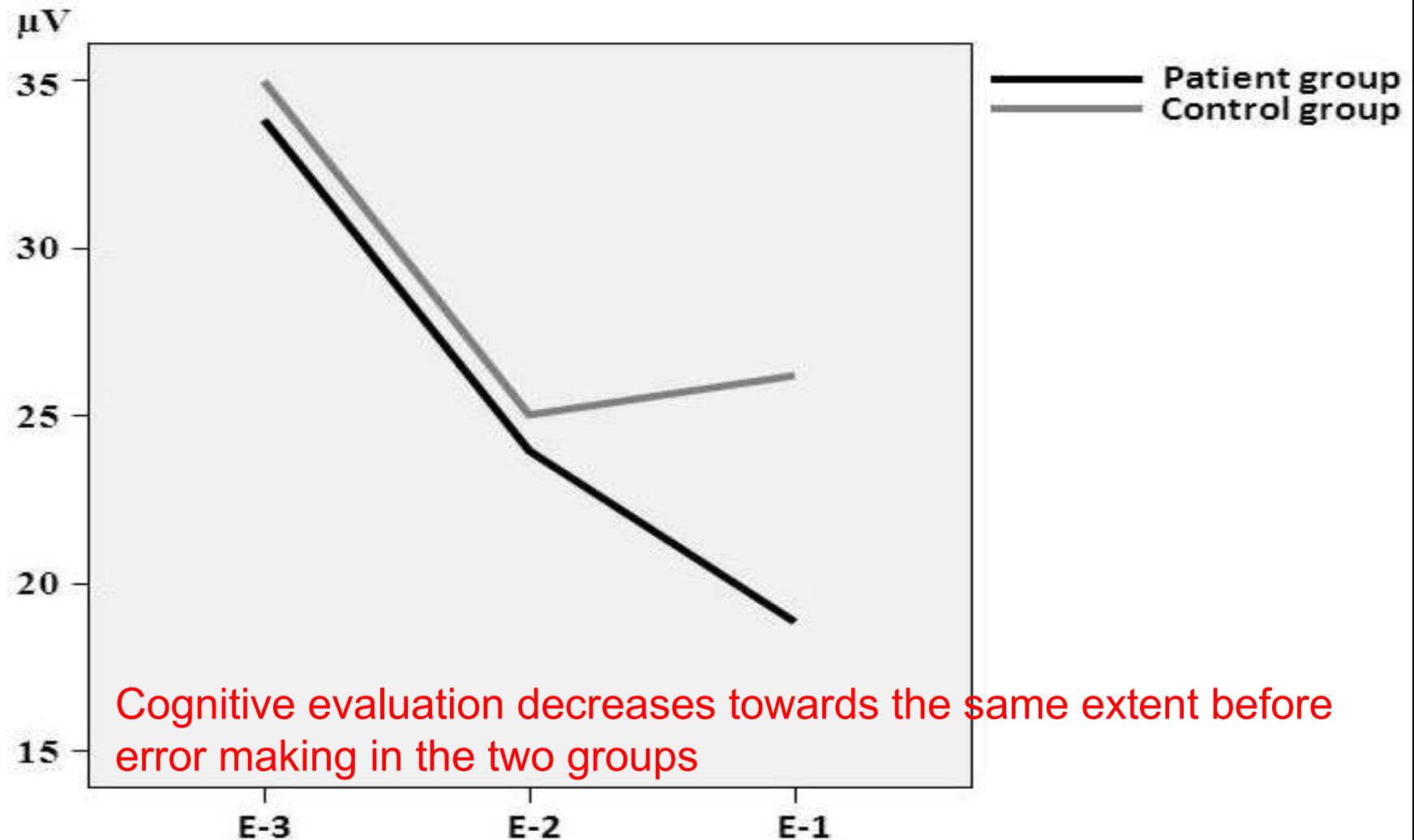
C - C - C - C - E

The amplitude of the parietal P300 potential
reflects the quality of stimulus evaluation

therefore

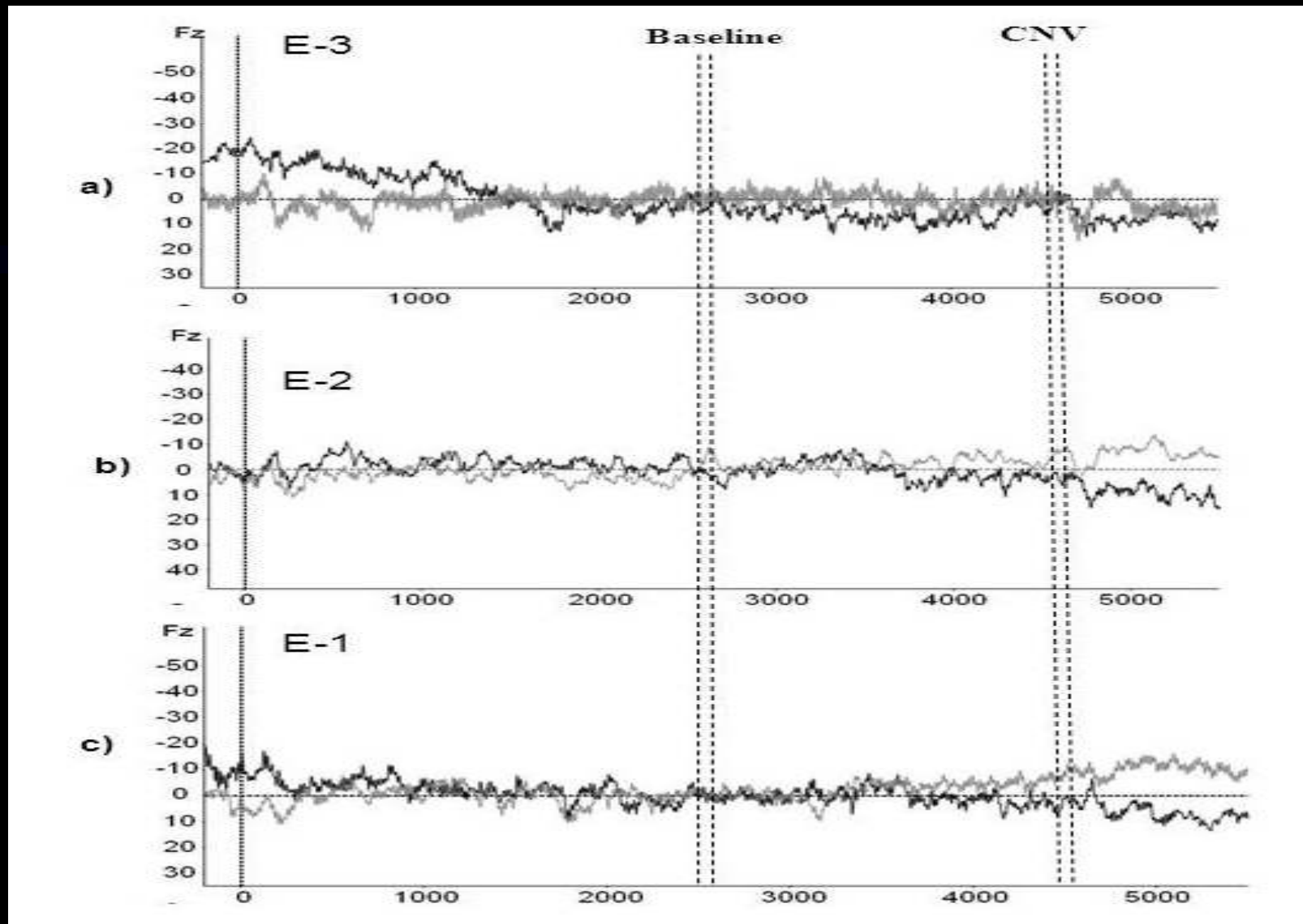
Error preceding trials are characterized by a
smaller amplitude of the P300 potential

P300 amplitude on trials before error making



Contingent Negative Variation

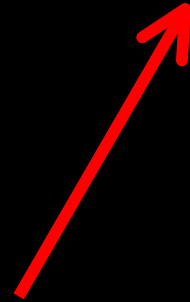
- The late part of this negative slow wave reflects
 - Motor preparation
 - Readiness to respond (Bereitschaftspotential)
 - Stimulus anticipation
- Errors are preceded by a decrease of the late CNV



The late CNV amplitude becomes less negative one trial before error making in the patient group, indicating poor motor preparation

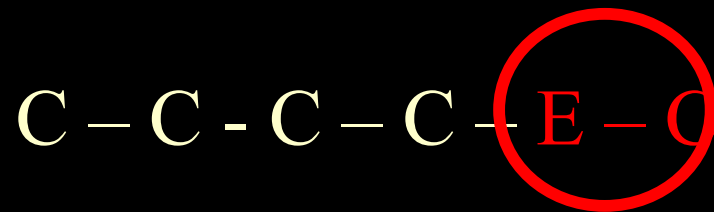
*IN SUM: Brain activation state
before error making*

C - C - C - C - E



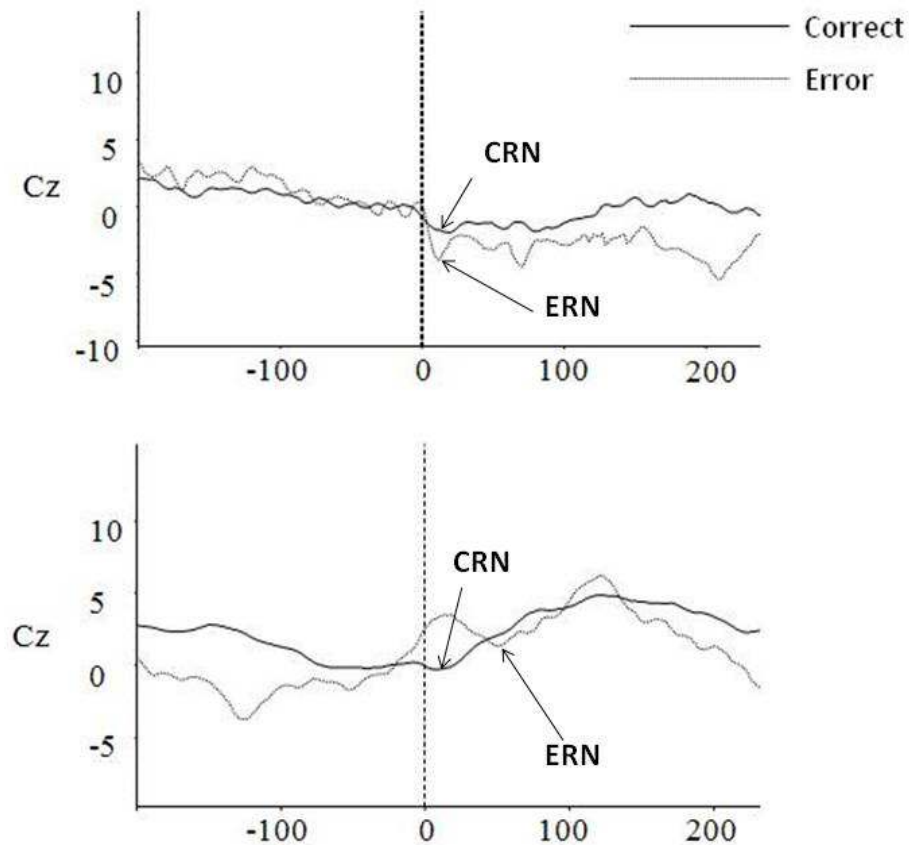
poor motor preparation

Brain activation state during and after error making

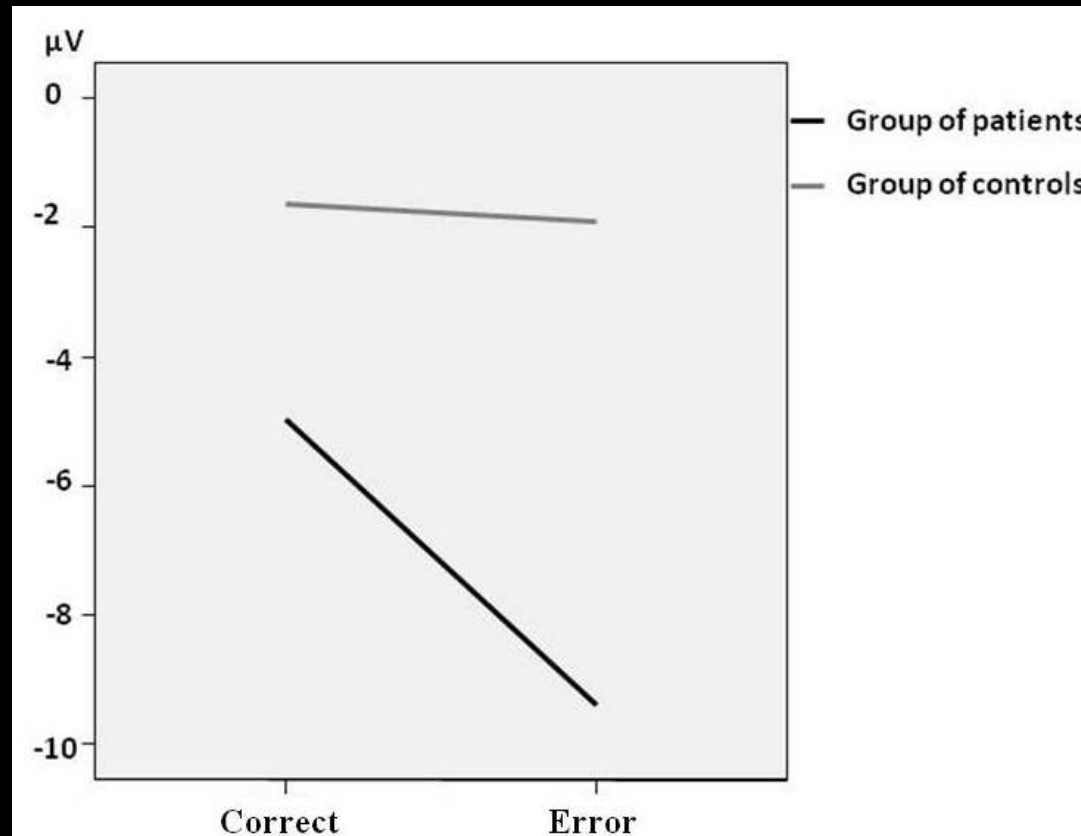


- Error awareness leads to performance improvement on the subsequent trial

Response-related negativity reflecting error AWARENESS



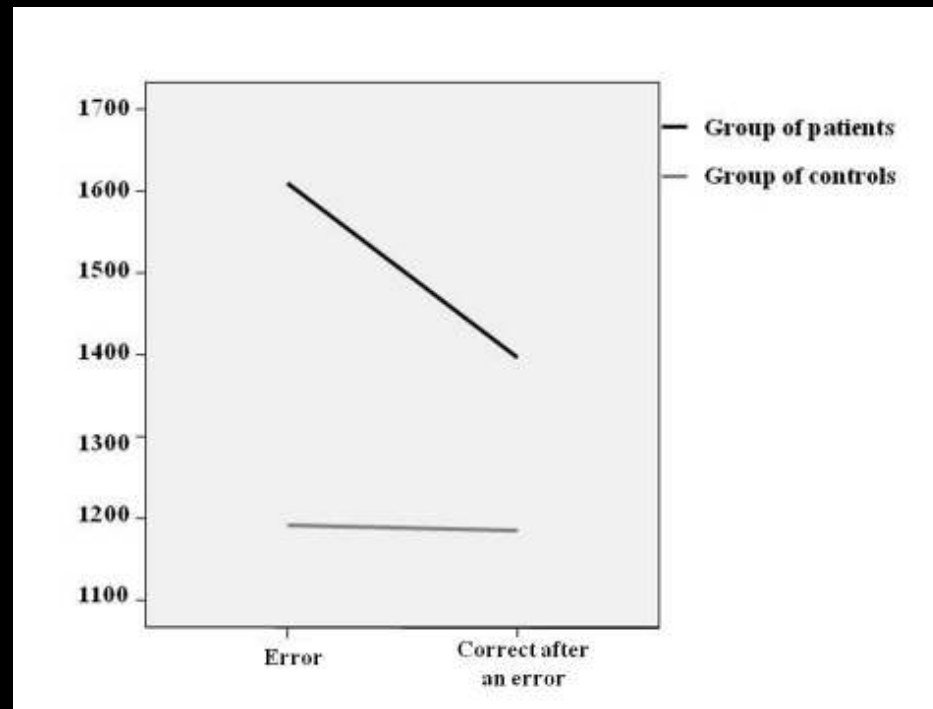
Response-RELATED negativity



RRN most pronounced in patient group indicating full awareness of error making

AS A RESULT, Performance improvement after error awareness is most pronounced in the patient group

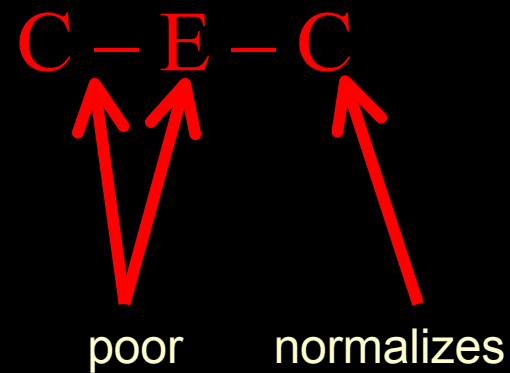
Mean reaction time



Also normalization of the motor preparation occurred after error making in the patient group

In sum

- Performance monitoring



Motor preparation

Overall conclusion

- Poor attention performance is highly associated with poor motivation and boredom
- Direct observations and quantitative recordings of behaviour are time consuming and more complicated than psychometric assessment.
- However, what is lost in time is gained in validity.

Definitions of boredom

- The state of being weary and restless through lack of interest
- State of low arousal and dissatisfaction attributed to an inadequate stimulating environment
- W. Mikulas and S. Vodanovich

*Boredom has received very little
attention by researchers*

- Why? It is a silent emotion as compared with anger or anxiety

Six basic emotions

- happiness – sadness – surprise – disgust – anger – fear
- Different set of emotions that influencing learning and cognition : boredom and frustration
- Craig et al (2008). Cognition and Emotion
- Malkovski et al (2002) Experimental Brain Research