

Monitoring the Monitor: Welcome to the Era of Neuroergonomics

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Outline:

1. Vigilance Decrement
2. Competing Theories of Vigilance
 1. Boredom – Mindlessness Theory
 2. Fatigue – Resource Theory
3. Subjective State and Performance
4. Neuroergonomics (Monitoring the Monitor)
 - Transcranial Doppler Sonography
 - Near-Infrared Spectroscopy
 - Tympanic Membrane Temperature
5. The future?

Real-world Examples of Vigilance:

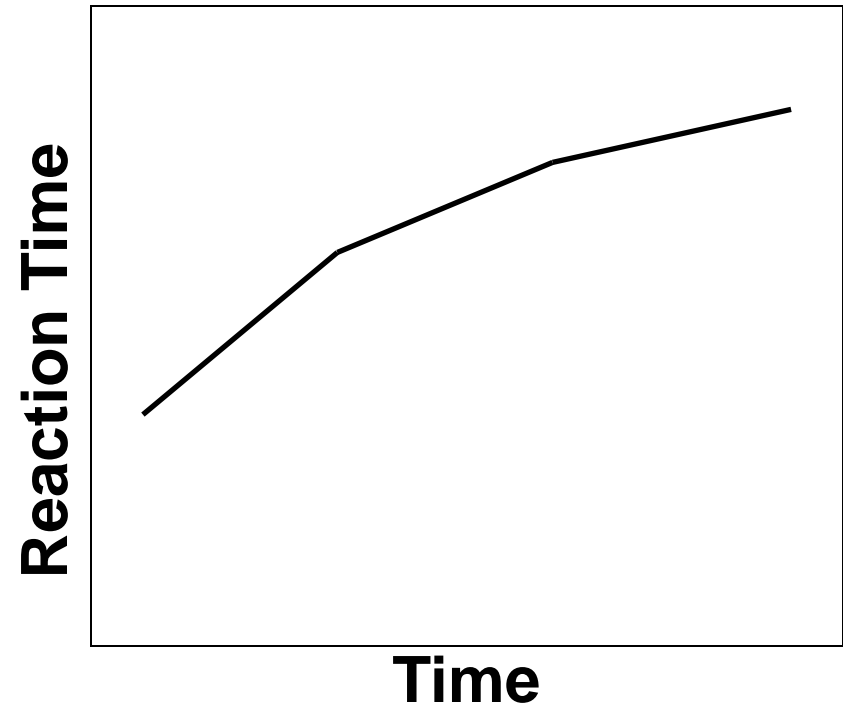
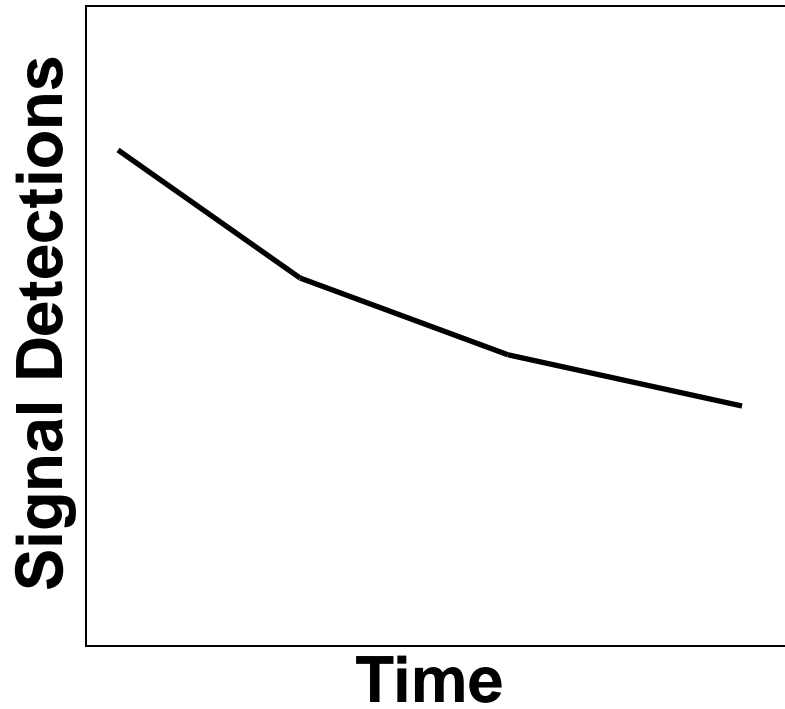


Security Screening



Mine Detection

Vigilance Decrement



Competing Theories of Vigilance:

Boredom - Mindlessness

Fatigue - Resource Theory

Boredom - Mindlessness View of Vigilance:

Detection failures in vigilance tasks result from a “mindless” withdrawal of effort from the monitoring assignment.

Vigilance tasks are often boring, to escape the boredom the person begins to daydream (think about other stuff). The day-dreaming gets in the way of performance.

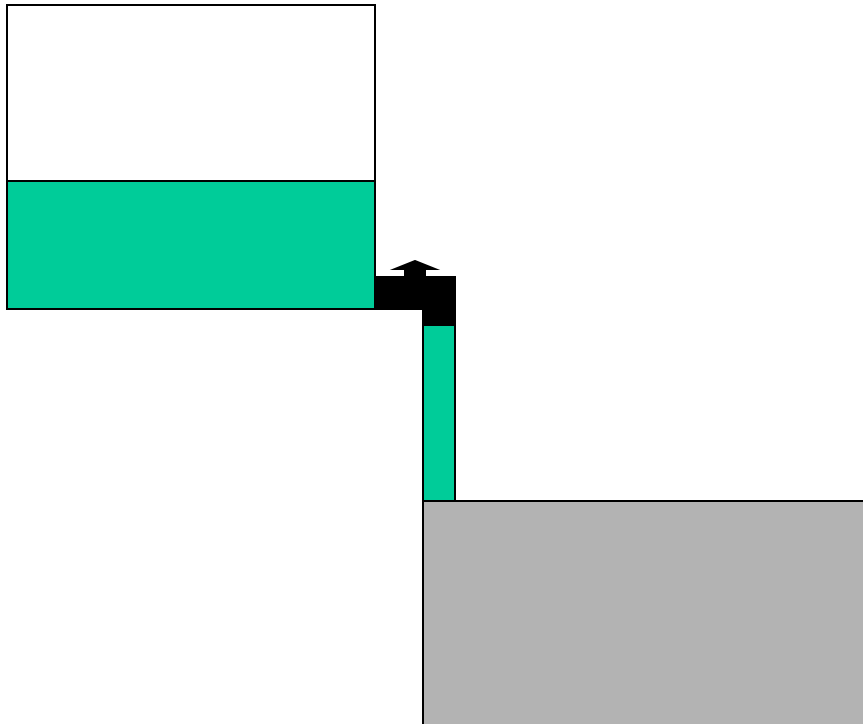
Support for the Boredom Theory:

- Vigilance tasks are often subjectively boring (Scerbo, 1998)
- Reports of daydreaming do occur during vigilance tasks.

The Resource Model of Vigilance

Resources are reservoirs of mental energy dedicated to task performance.

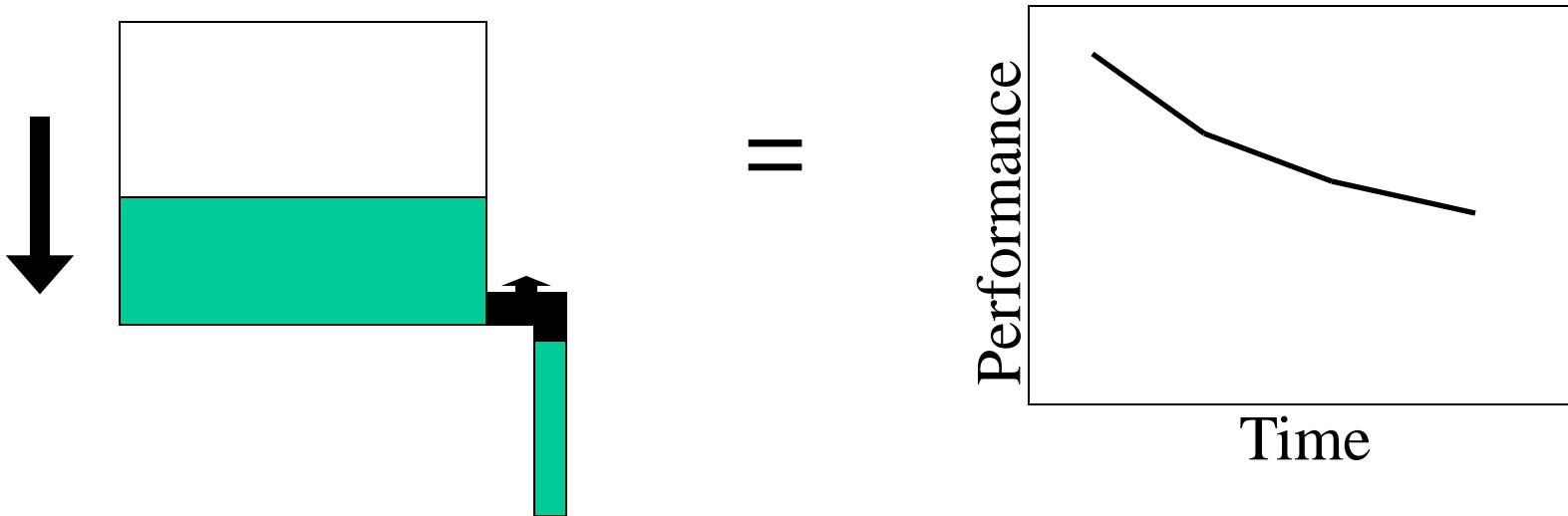
Resource Reservoir



Task Performance /
Activity

Resource Theory of Vigilance

During vigilance tasks, observers need to make continuous signal/noise discriminations without rest, which does not allow for replenishment of resources.



Support for the Resource Theory:

- Vigilance tasks impose a substantial mental burden upon monitors, as reflected in elevated scores on the NASA Task Load Index (NASA-TLX)
- The NASA-TLX scores are rooted in the information-processing demands of the vigilance task itself (psychophysics) and not combating the boredom of the task (Hitchcock et al., 1999).
- Vigilance tasks are highly stressful, as reflected in observer's self-reports of negative mood shifts after participating in a vigil (Hancock & Warm, 1987; Helton et al., 1999; Temple et al, 2000; Warm, 1993) and physiological measures, such as circulating stress hormones.
- Substances that increase energy (anti-fatigue agents) improve vigilance performance, for example, caffeine (Temple et al., 2000).

Subjective States and Theories of Vigilance

Boredom – Mindlessness Model

Links vigilance decrement most strongly to Task-Unrelated Thoughts (TUTs – daydreaming, mind wandering)

Fatigue – Resource Theory

Links vigilance decrement most strongly to feelings of Energetic Arousal (EA – mental fatigue, tiredness)

The Dundee Stress State Questionnaire (DSSQ)

Engagement

- Concentration
- **Energetic Arousal**
- Intrinsic Motivation
- Success Motivation

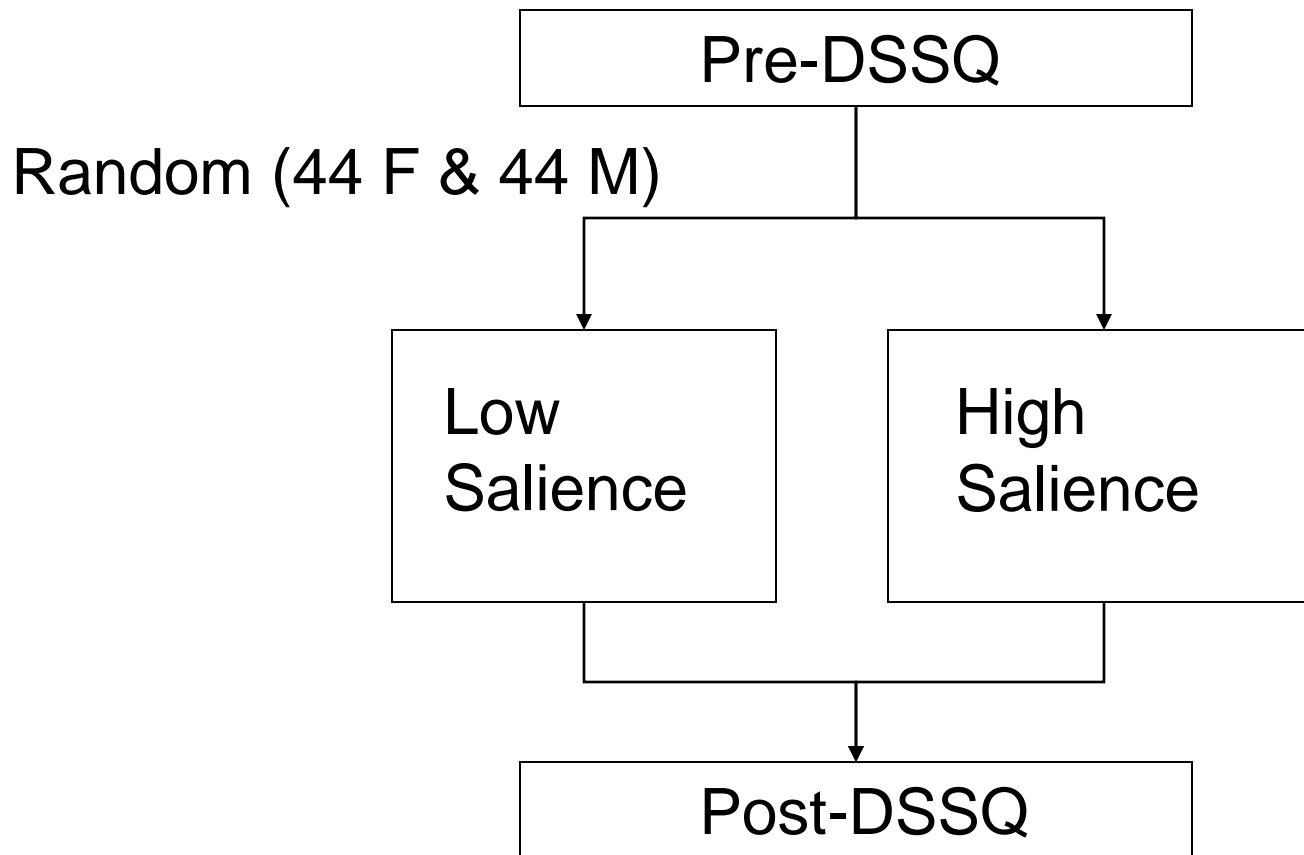
Distress

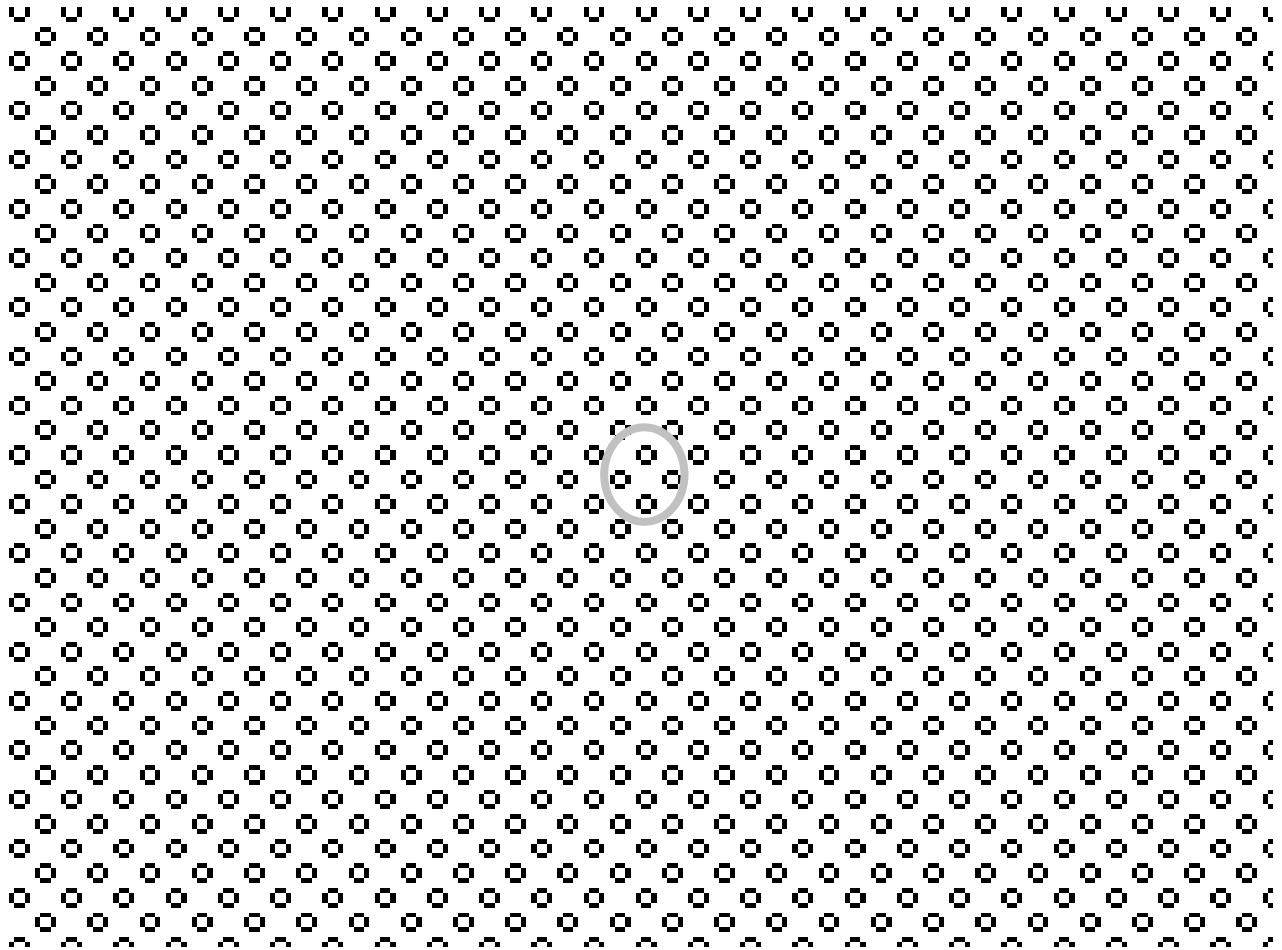
- Confidence and Control
- Hedonic Tone
- **Tense Arousal**

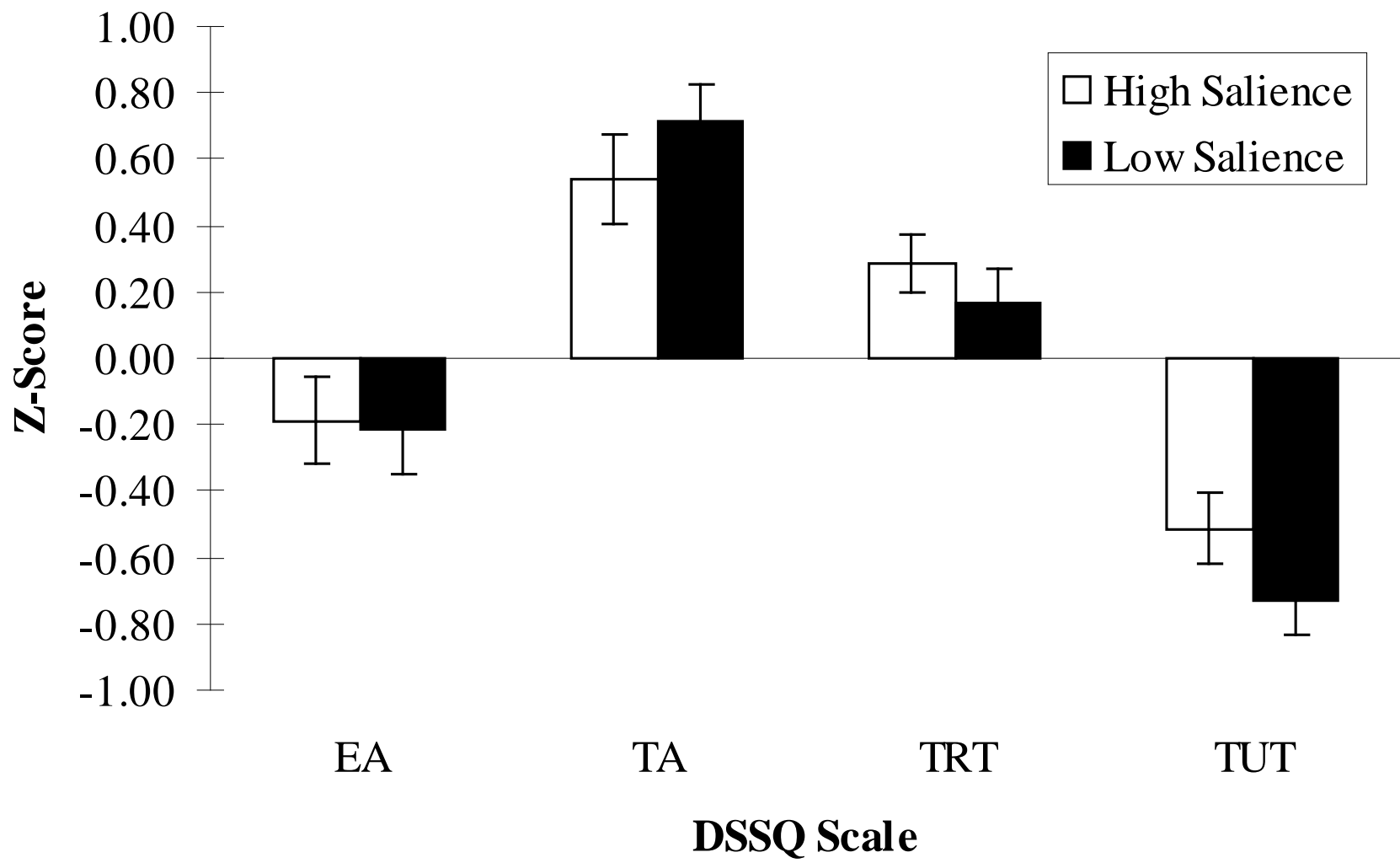
Worry

- Self-Esteem
- Self-Focused Attention
- **Task Related Thoughts**
- **Task Unrelated Thoughts**

Experimental Design:







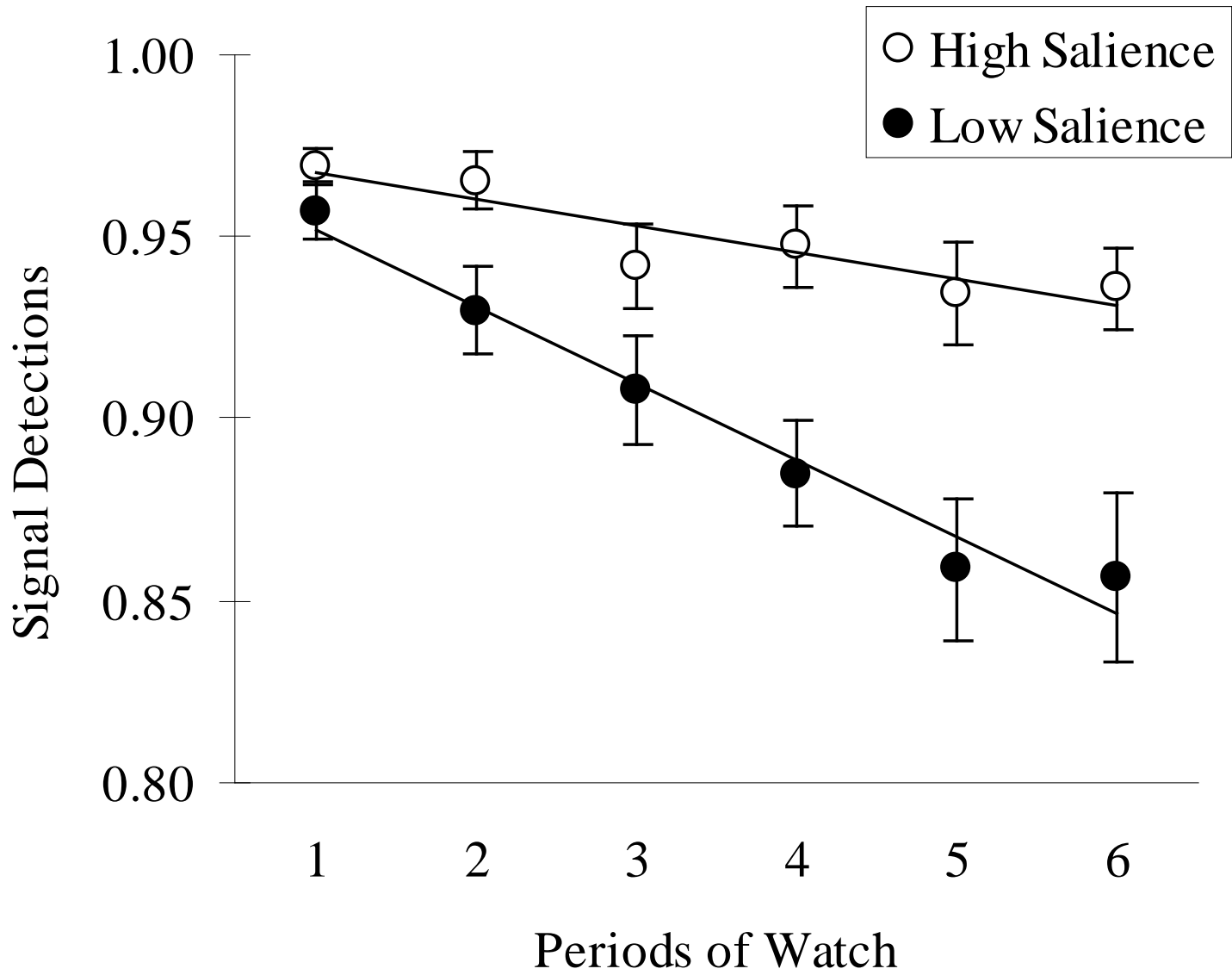


Table 1. Two-step regression models for the signal detection metrics.

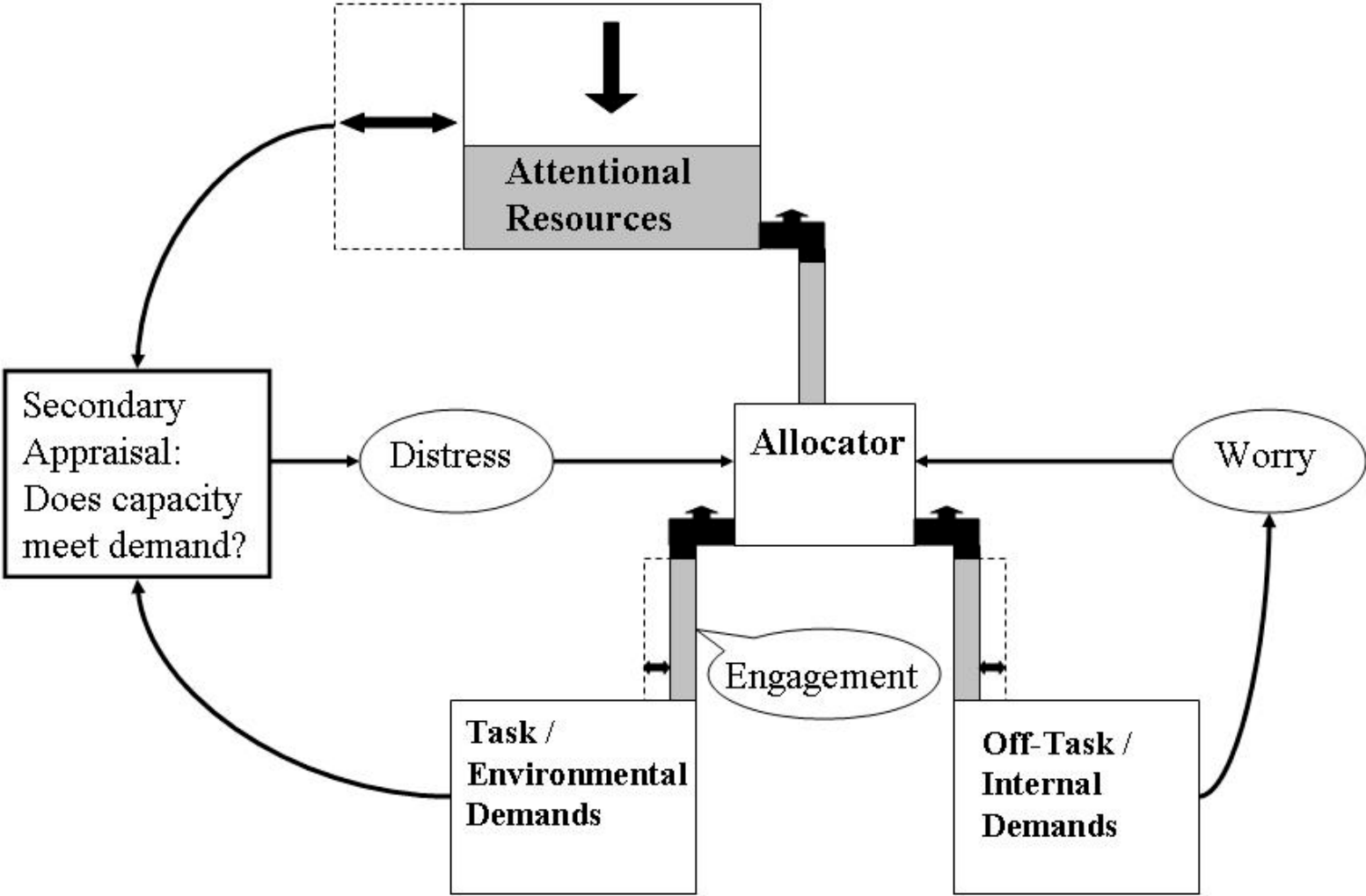
Factor	Intercept		Slope	
	B	<i>p</i>	B	<i>p</i>
<u>Step 1</u>				
Signal Saliency	-0.276	<.01	-0.255	<.01
<u>Step 2</u>				
Signal Saliency	-0.279	<.01	-0.260	<.01
Energetic Arousal	0.232	<.01	0.261	<.01
Tense Arousal	0.075	0.31	0.117	0.12
Task-Related	0.017	0.83	-0.051	0.52
Task-Unrelated	-0.226	<.01	-0.111	0.15

Table 2. Correlations between the signal detection metrics and the post-DSSQ scores (n=88).

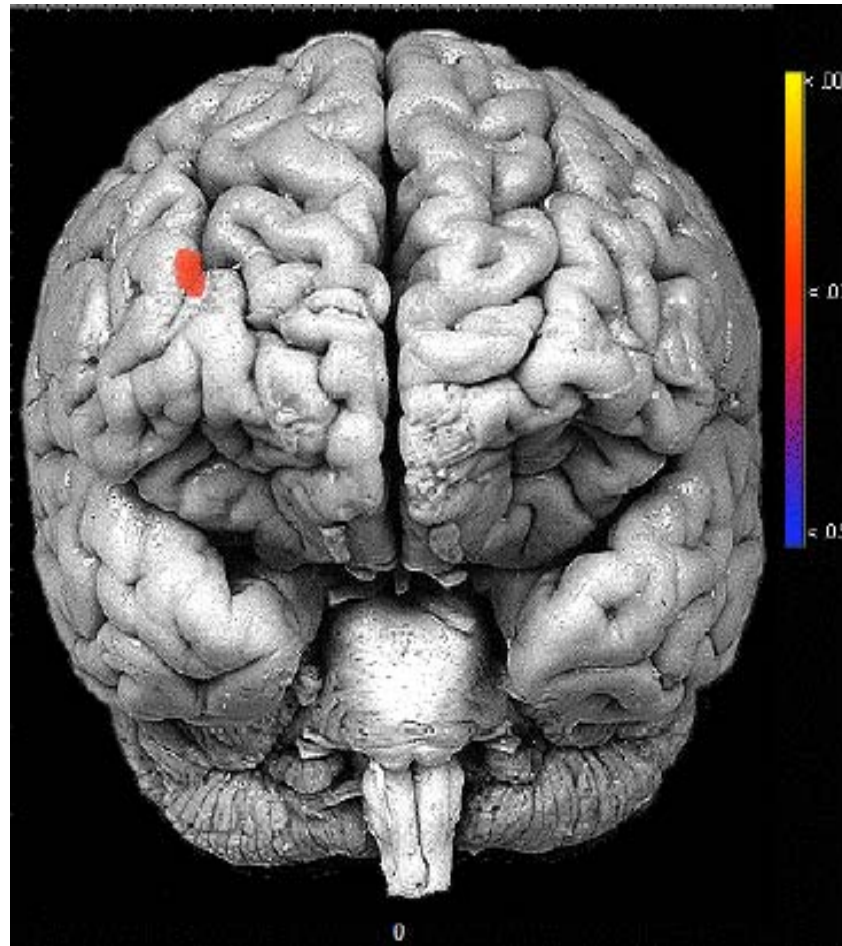
Item	1	2	3	4	5	6
1. Intercept		0.62	0.15	0.07	-0.10	-0.31
2. Slope	0.65		0.25	-0.02	-0.15	-0.13
3. Energetic Arousal	0.41	0.35		-0.12	-0.09	-0.21
4. Tense Arousal	0.04	0.16	0.15		0.34	0.15
5. Task-Related-Thoughts	-0.02	-0.02	-0.02	0.33		0.29
6. Task-Unrelated-Thoughts	-0.24	-0.19	-0.18	0.12	0.38	

Note: $p < .05$ red; above the main diagonal is for high-salience, below is for low salience

Human Performance-Stress Model



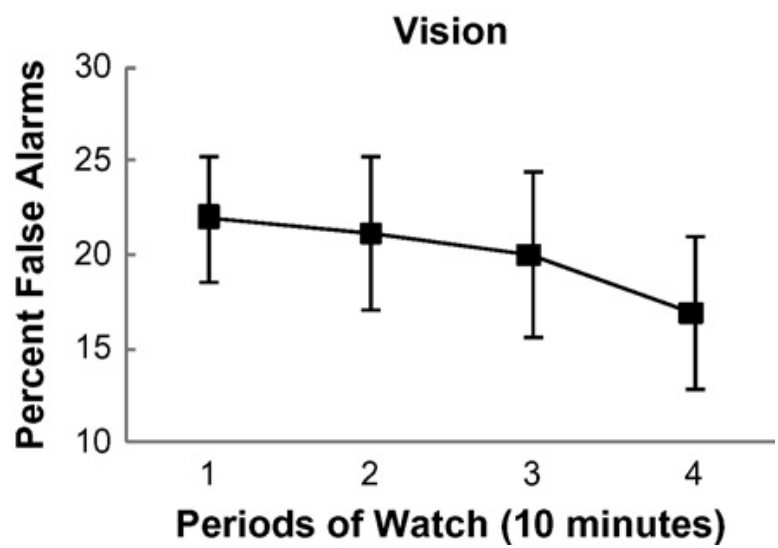
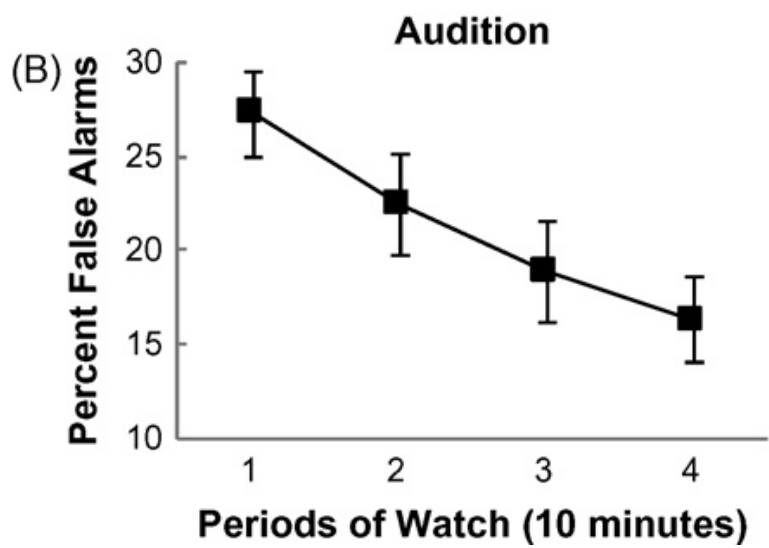
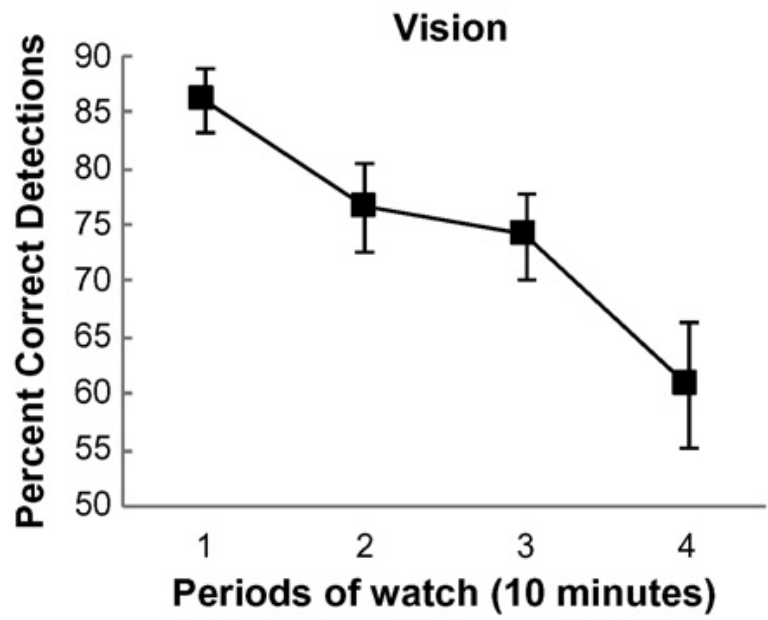
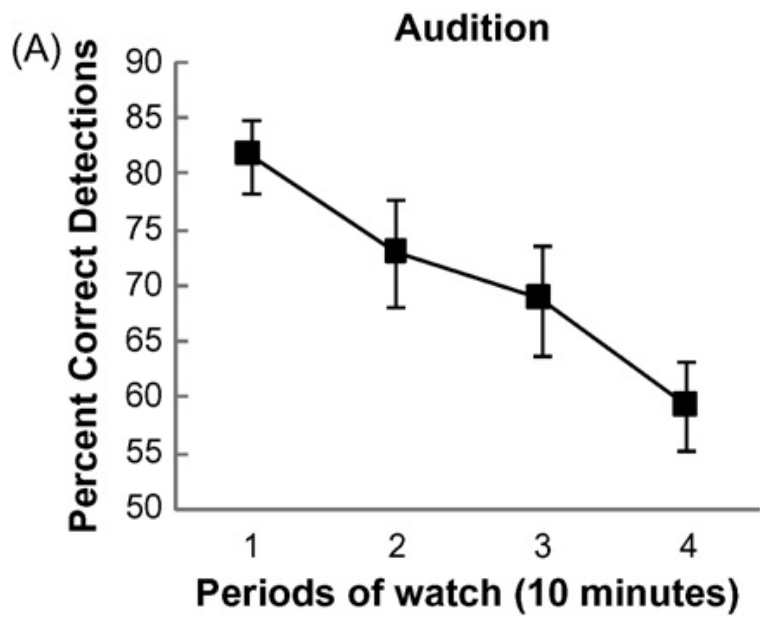
Neuroergonomics of Vigilance

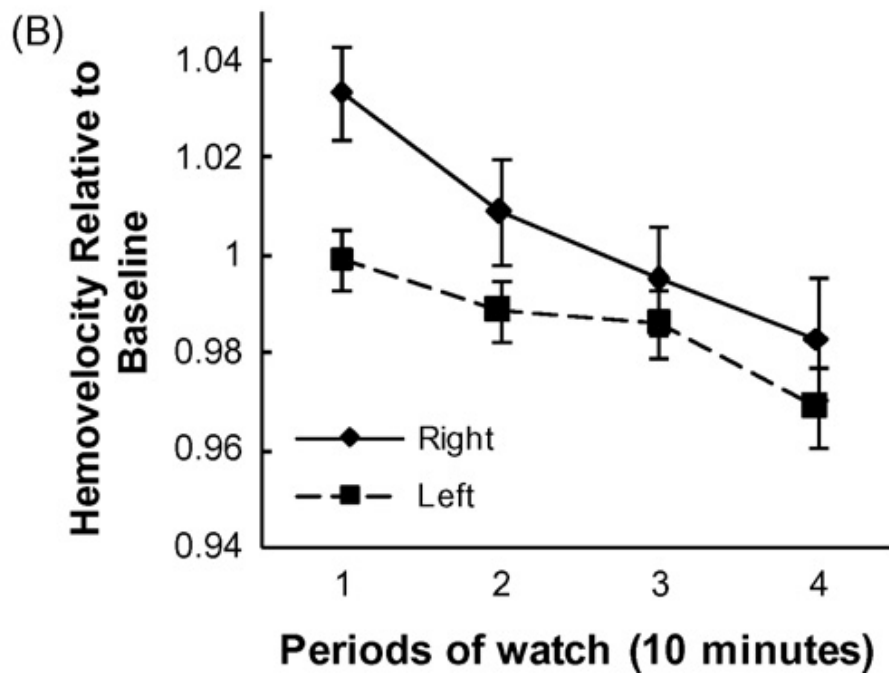
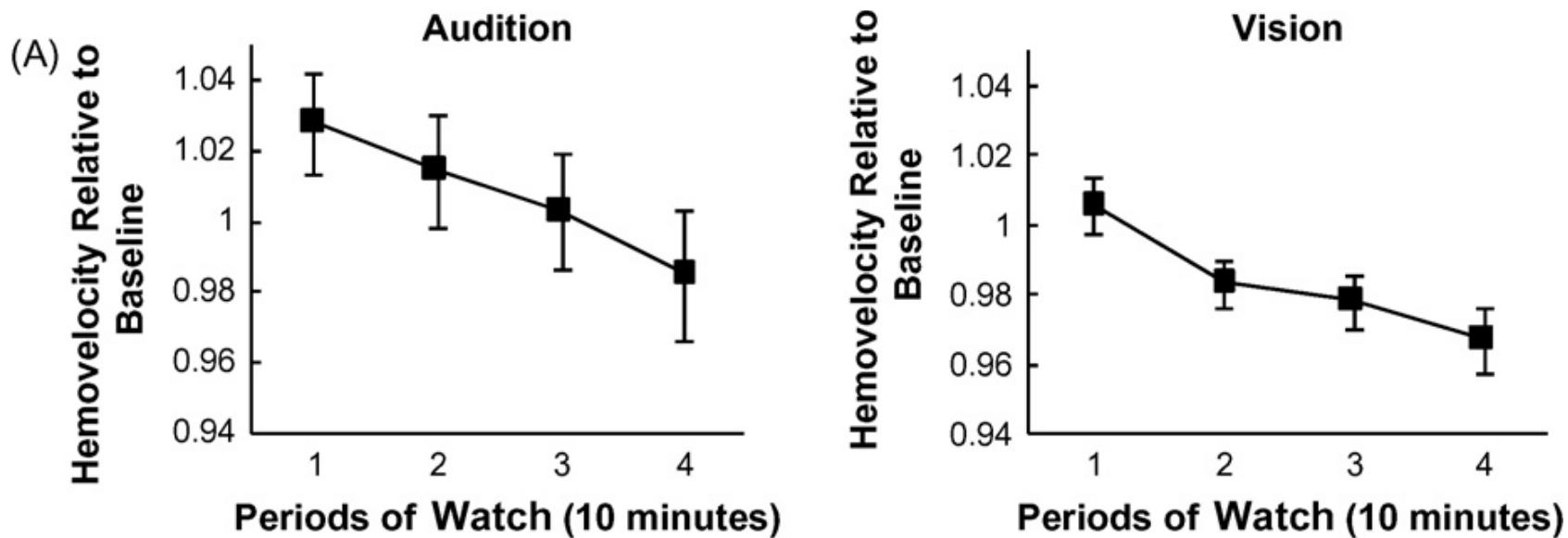


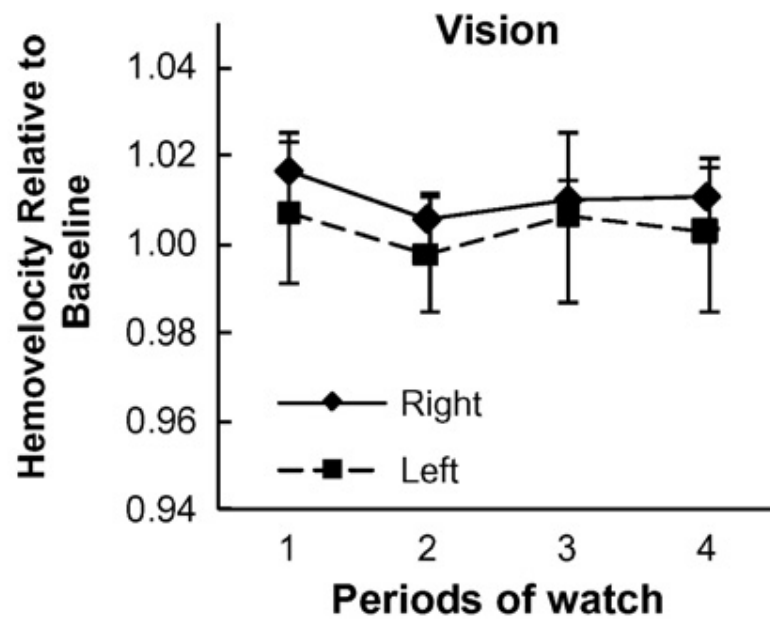
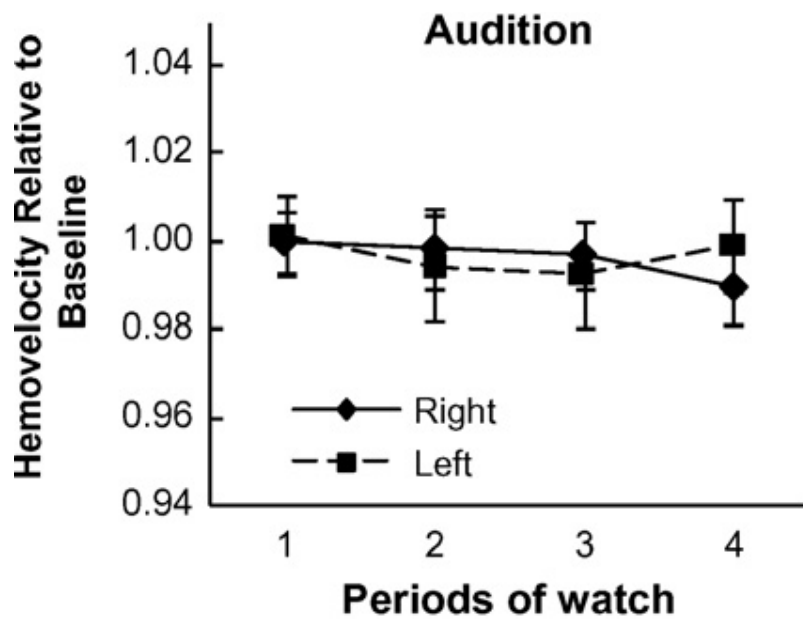
Brain Imaging on a Budget (Shaw et al., 2009):

- Transcranial Doppler Sonography:
Cerebral Bloodflow Velocity



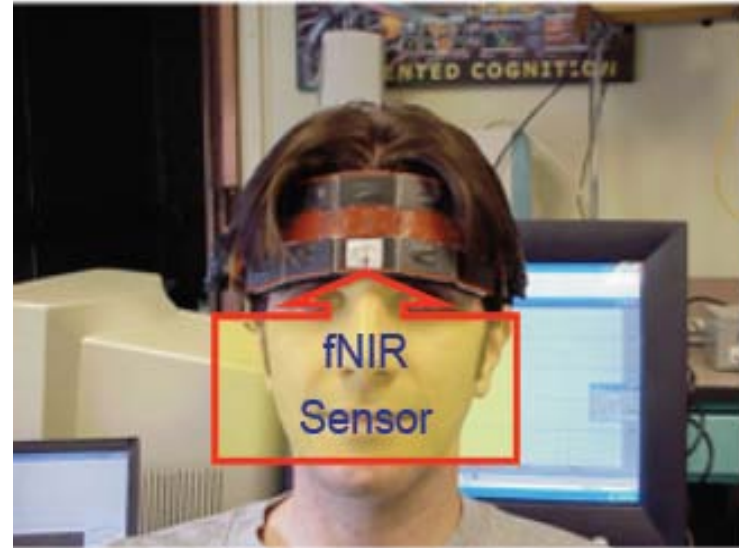




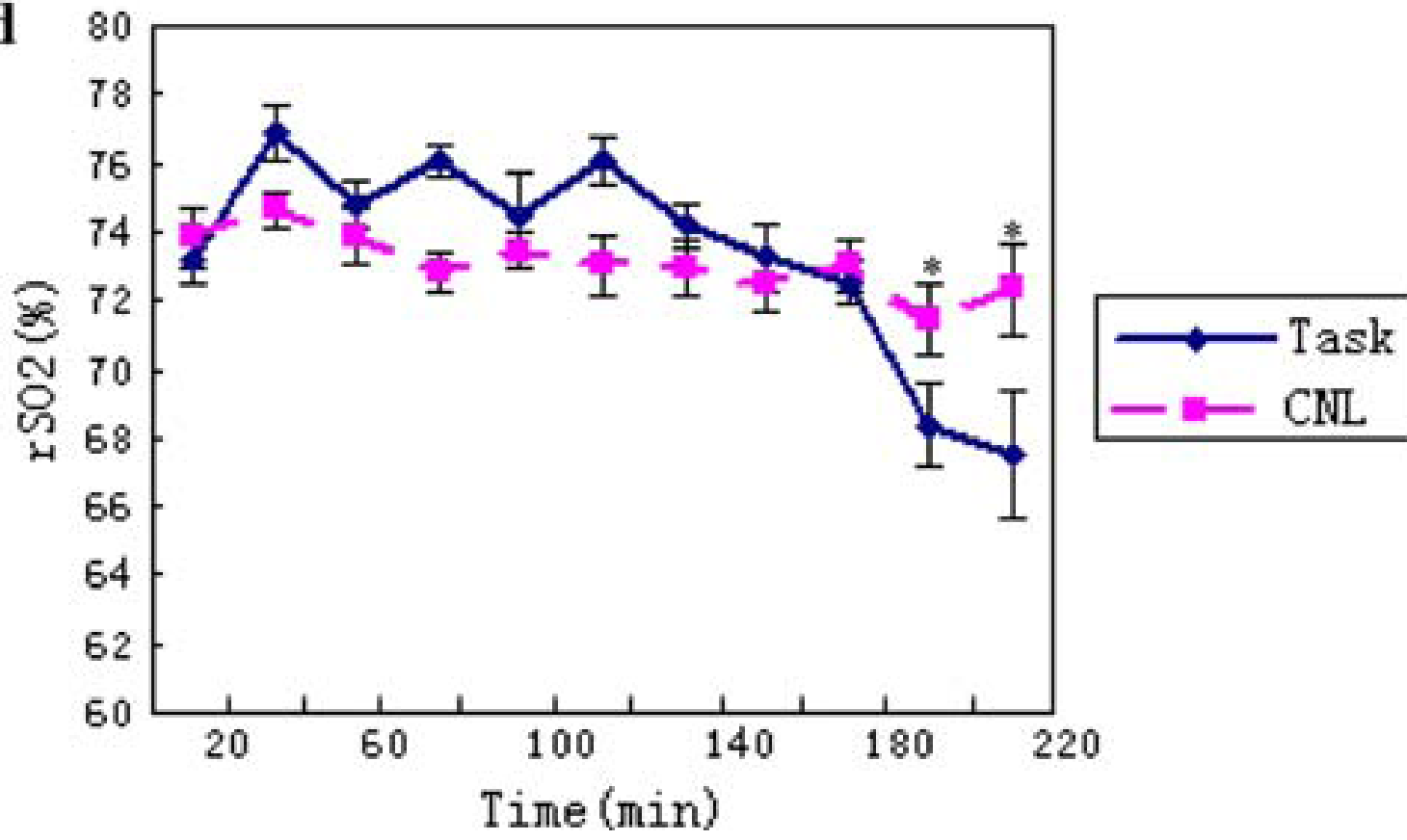


Li et al. (in press): Long duration driving (3hrs)

- Near-Infrared Spectroscopy:
Oxygen Saturation

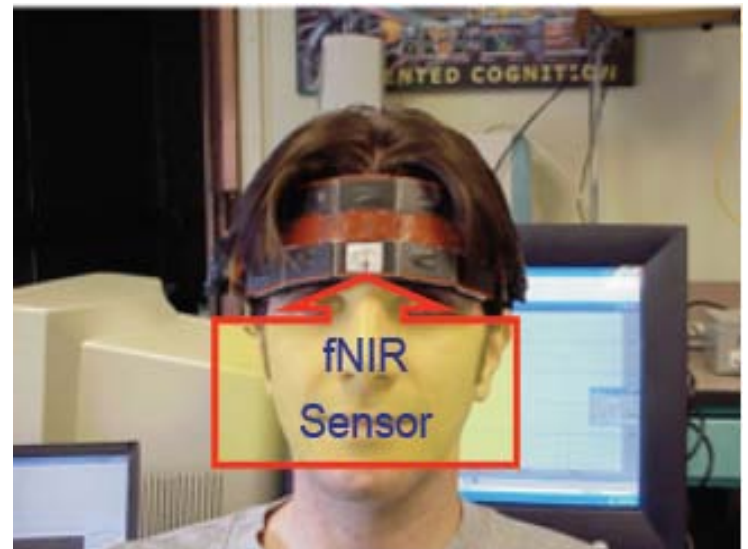


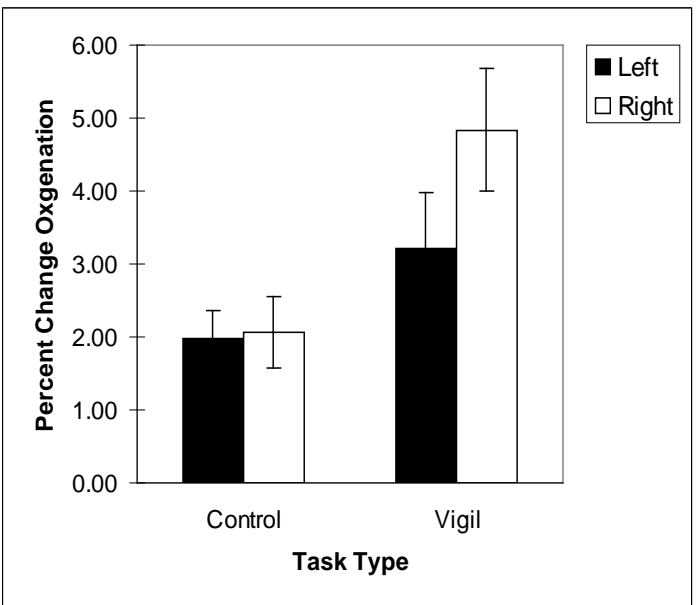
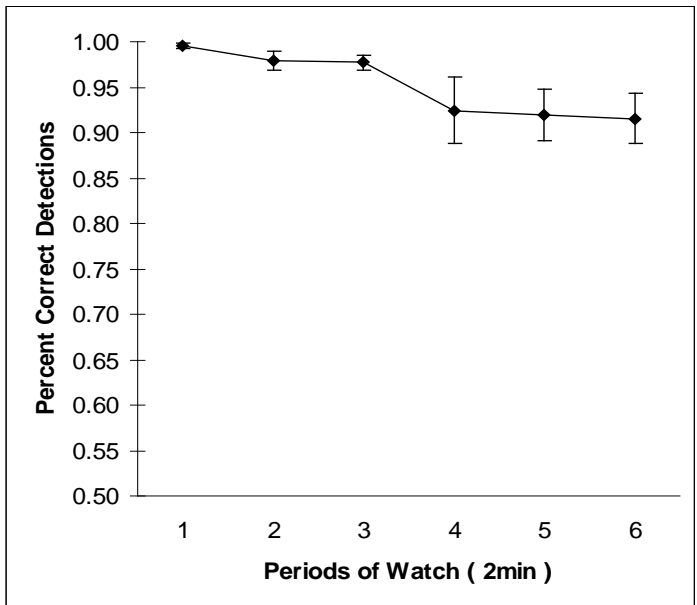
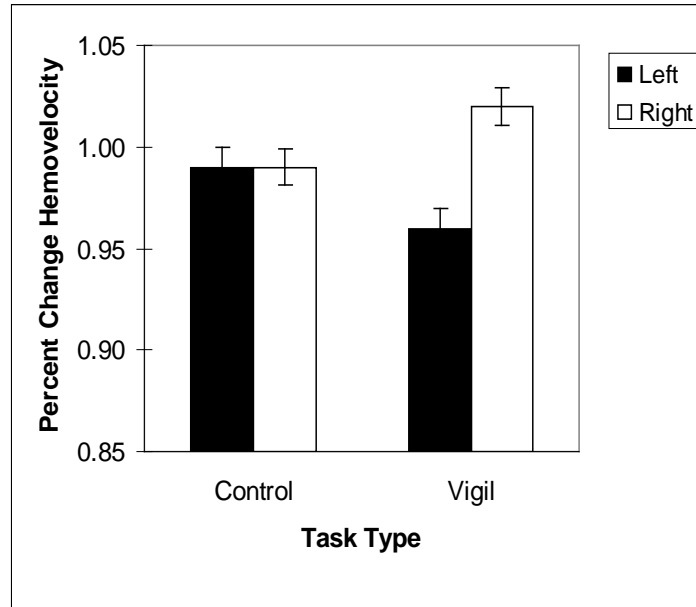
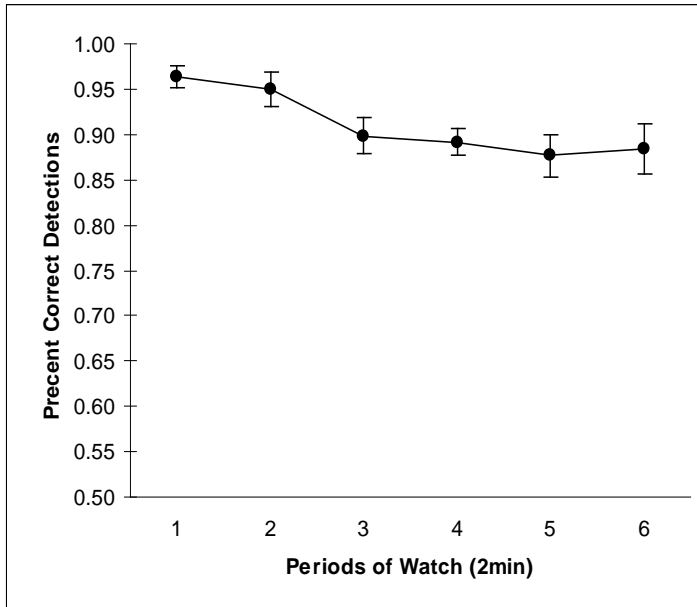
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Helton et al. (2007): Short Duration Task

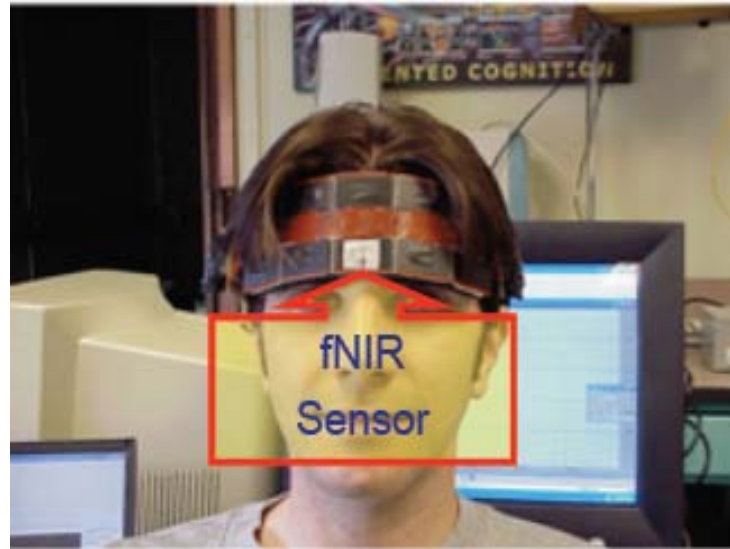
- Transcranial Doppler Sonography: Cerebral Bloodflow Velocity
- Near-Infrared Spectroscopy: Oxygen Saturation

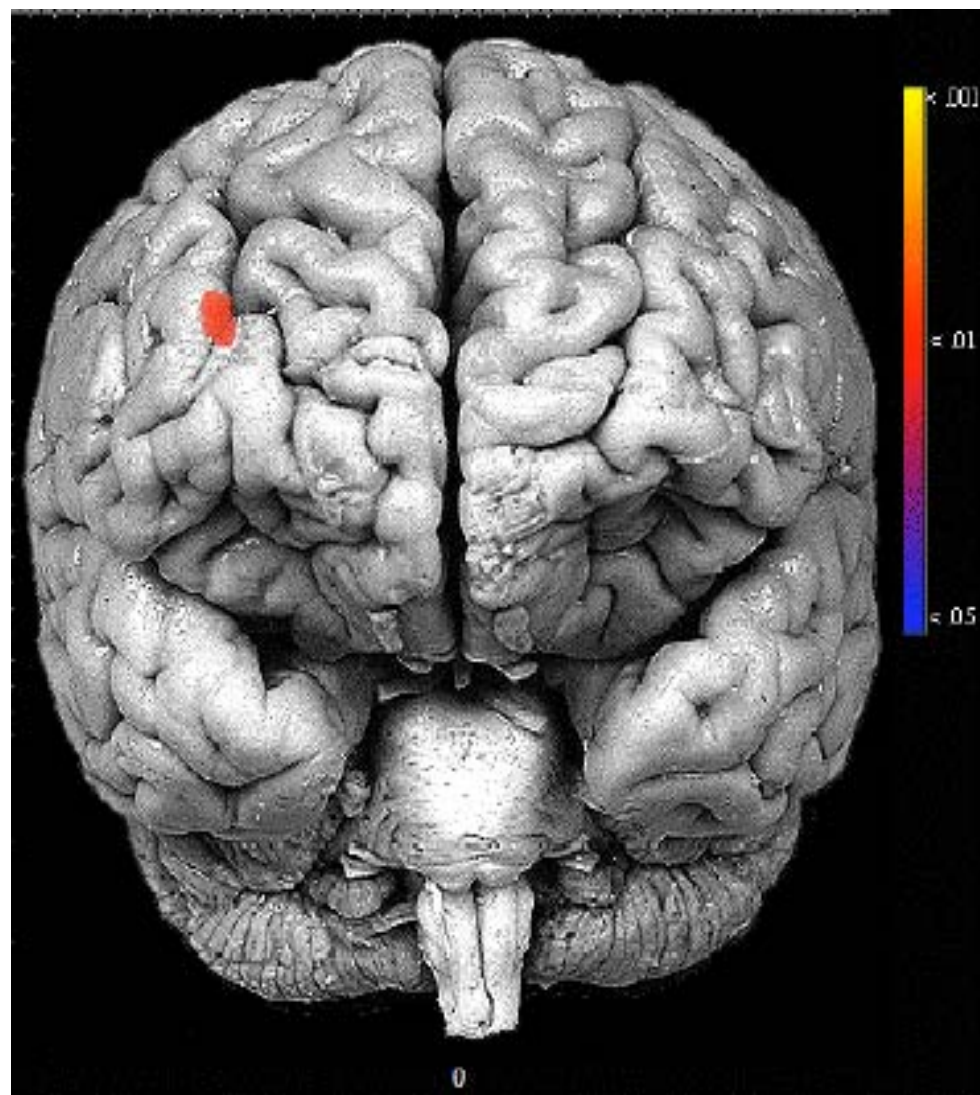


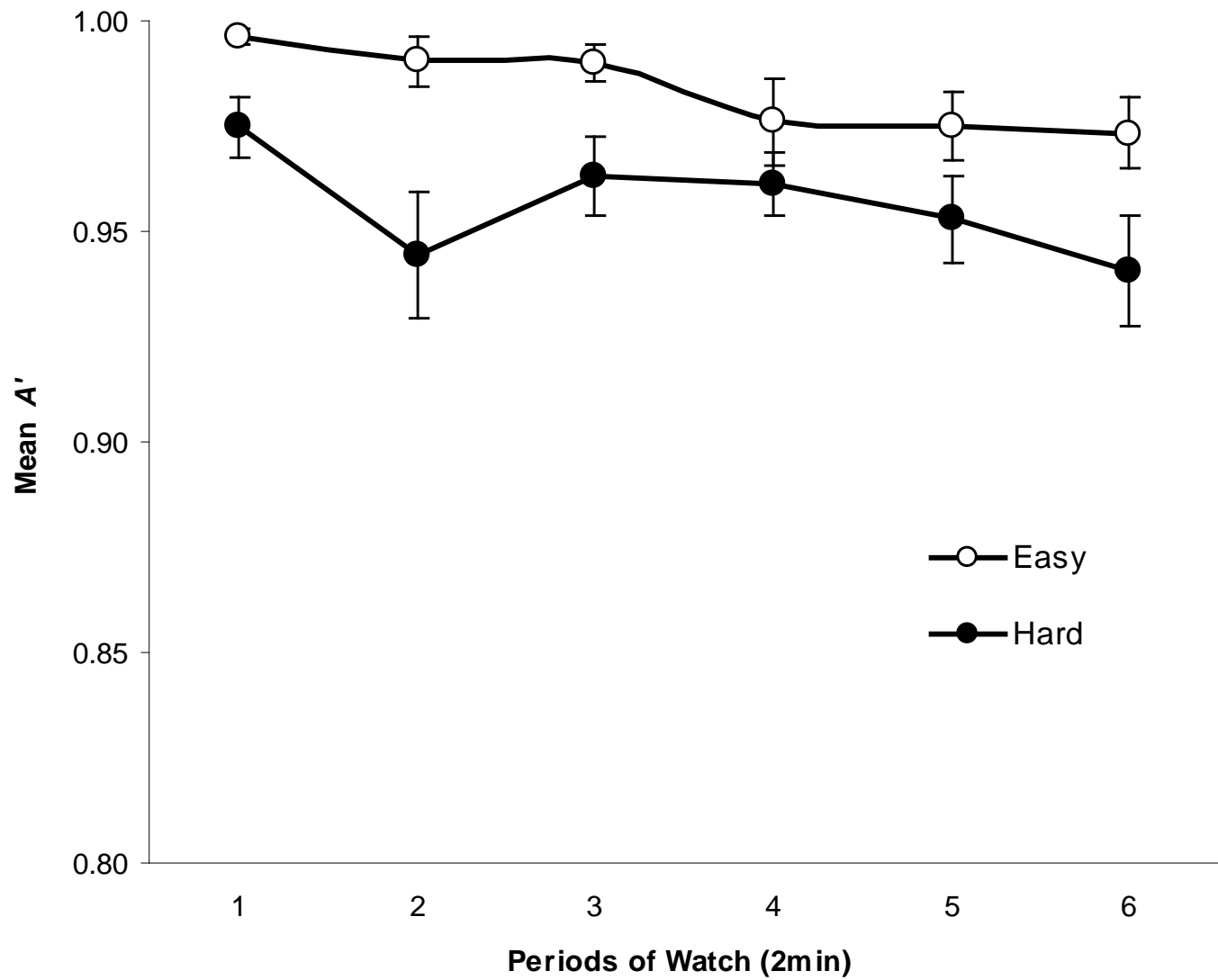


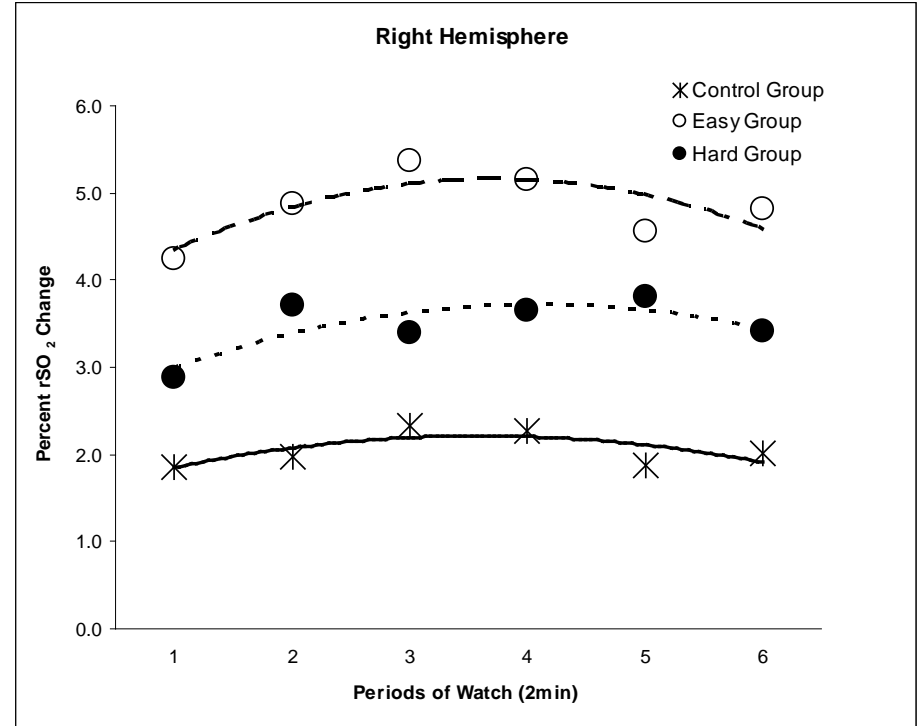
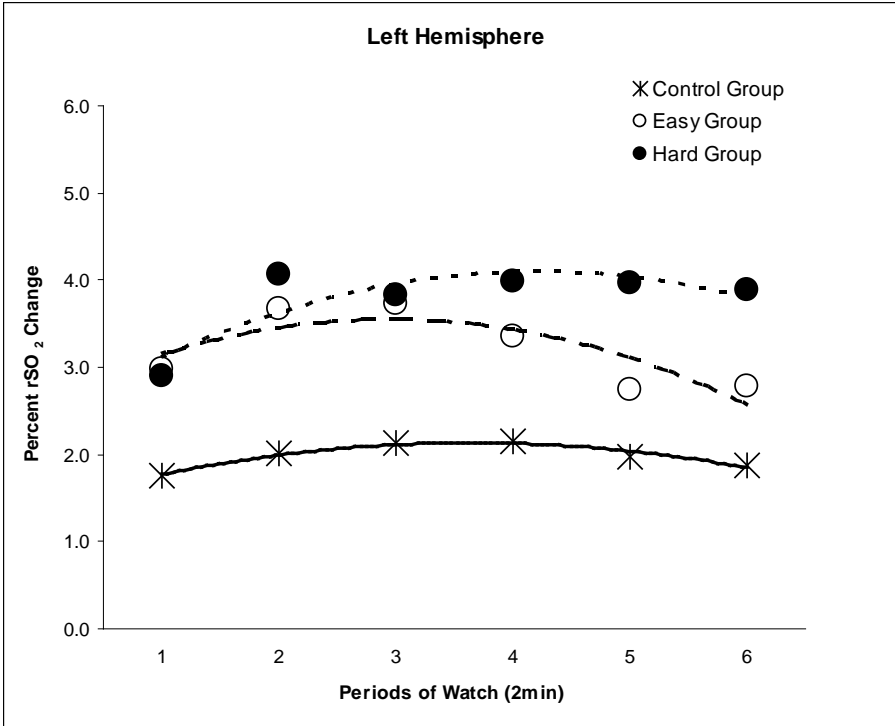
Dependency on Task Difficulty (Helton et al., unpublished):

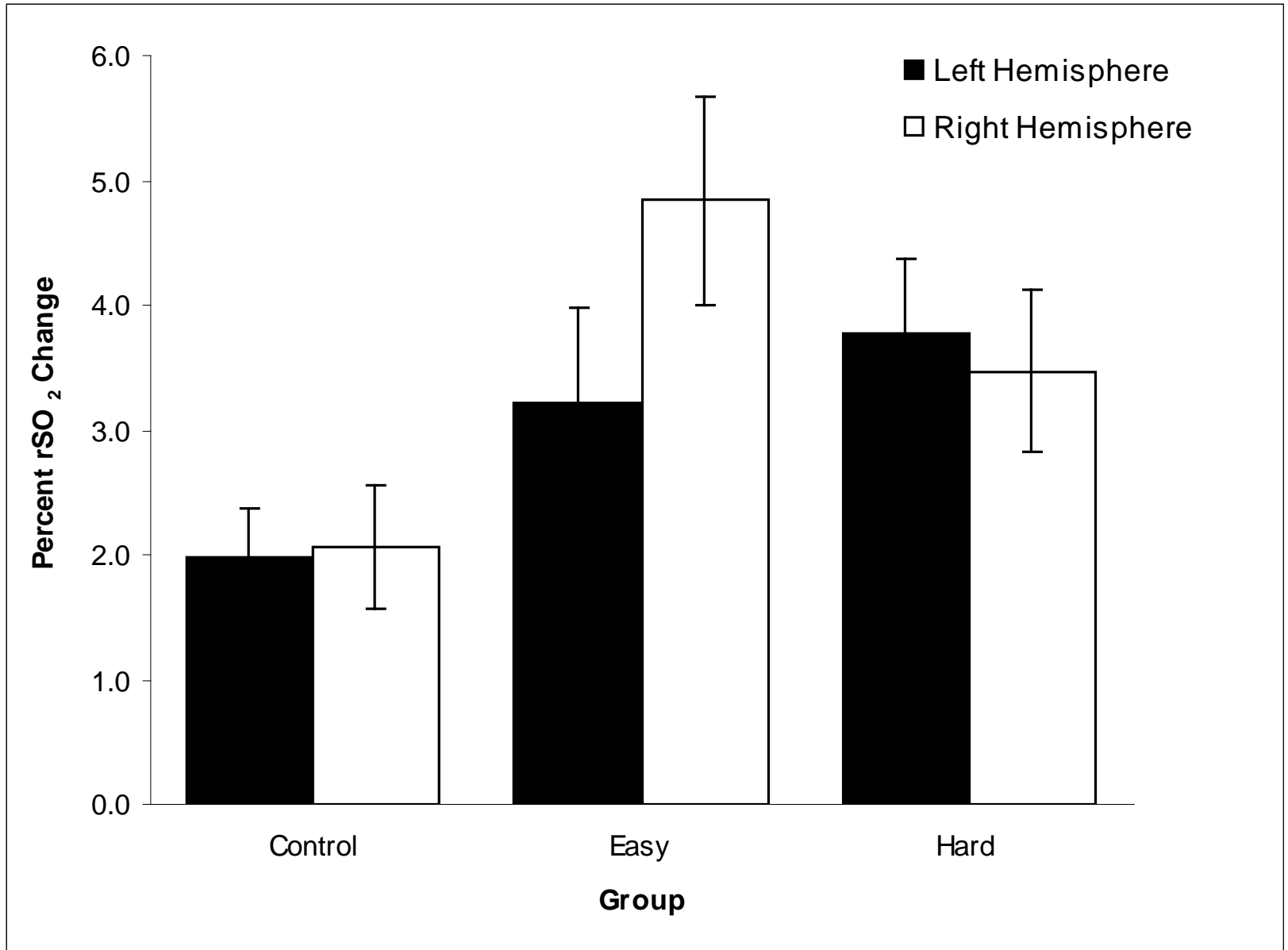
Near-Infrared Spectroscopy:
Oxygen Saturation







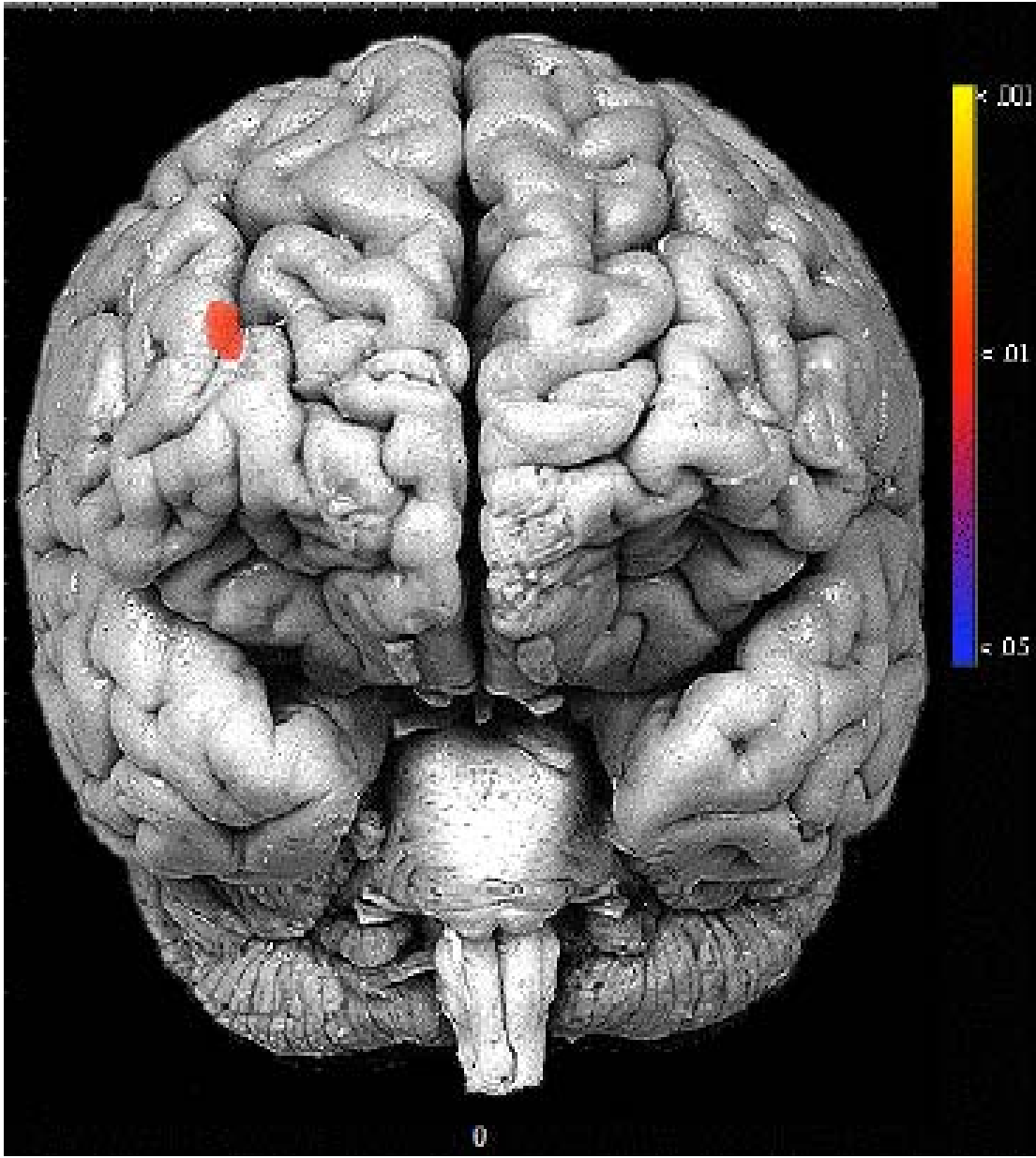




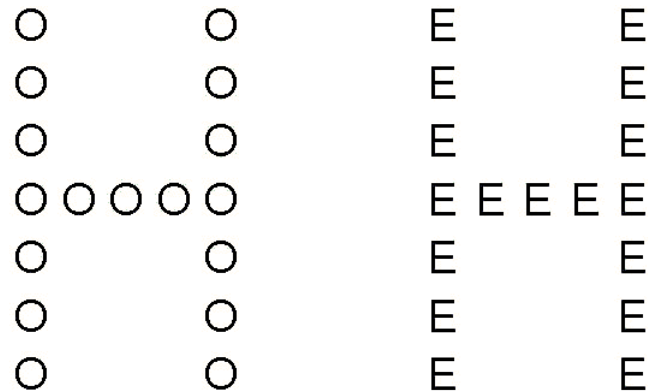
Brain Imaging on a REALLY Tight Budget (Helton et al., 2009):

- Tympanic Membrane Temperature

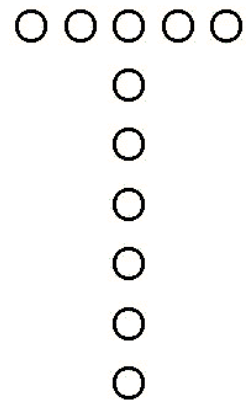




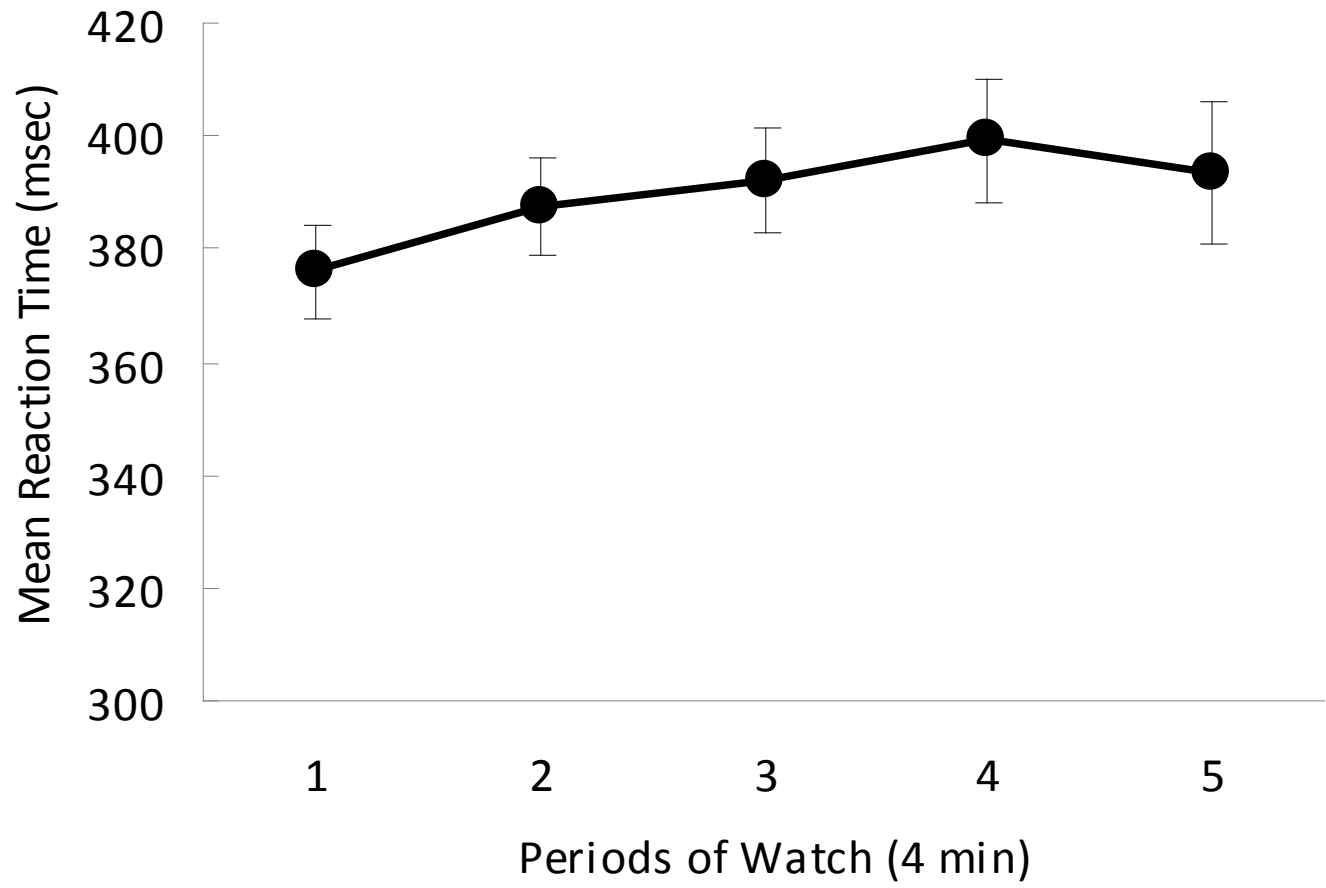
Global – Local Letter Targets:

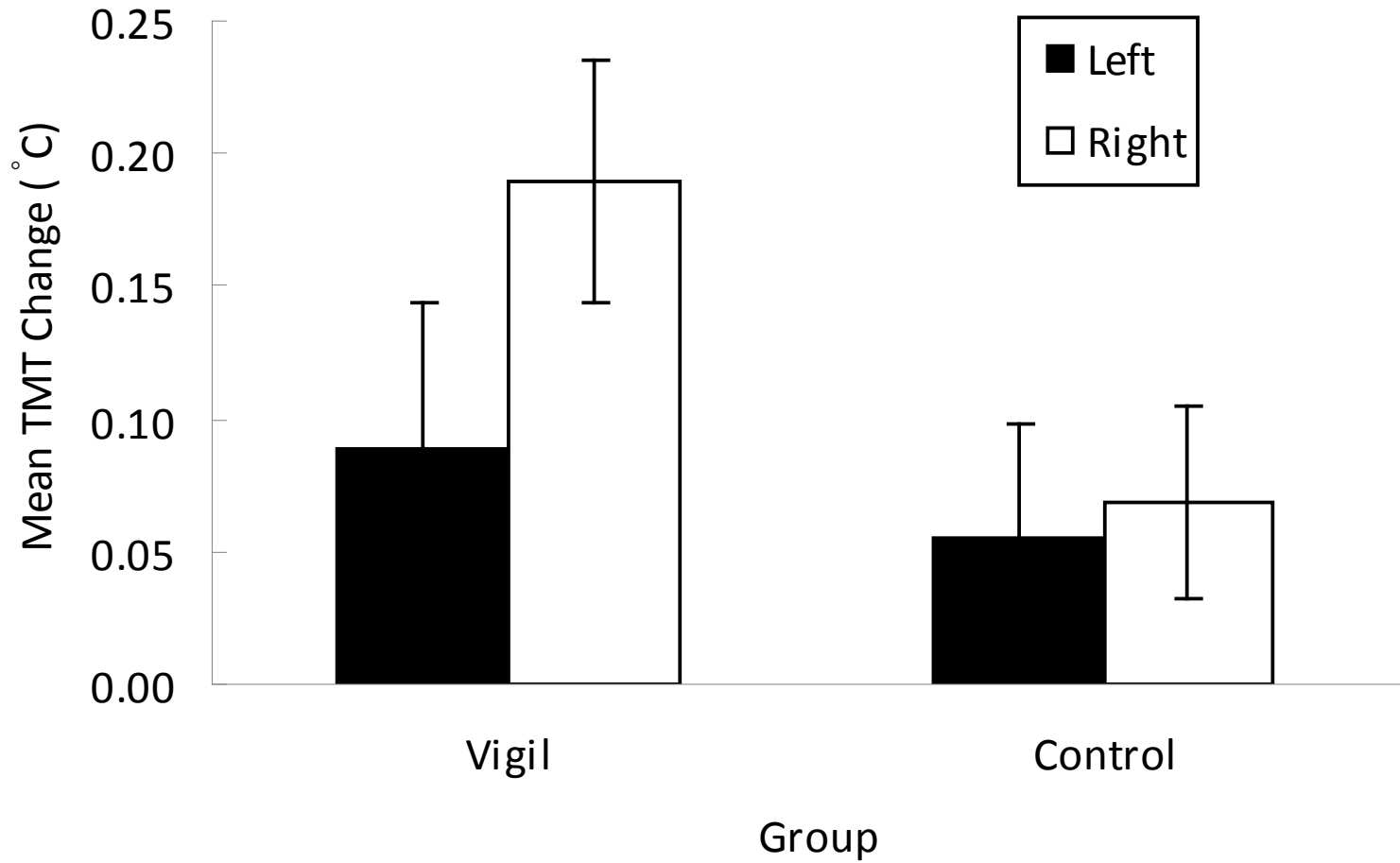


Neutral Stimuli



Target





The Future?

Direct links between brain metabolism with cognitive resources and subjective states.

Employment of multiple-measures, for example, combining eye-tracking (pupil diameter, blink rate, movement) with brain imaging and postural/response measures (key force, slumping, postural sway).

Development of off-the-body measures of physiological response, for example, thermal imagery of the head.

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