Attentional State, Not Trait, Predicts Learning from Educational Videos

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Introduction

- EEG-based measure of attention predicts retention from short educational videos
- Trait inattention does not predict retention from short educational videos
- Working memory capacity and GPA predict quiz performance
- Working memory capacity, not trait inattention, affects acute attention

Methods: Experimental design

- 152 participants viewed 3-6 min educational videos while EEG was recorded.
- Immediate multiple-choice quizzes measured short-term retention.
- Experiments 1–2 included an additional distraction condition (mental arithmetic).

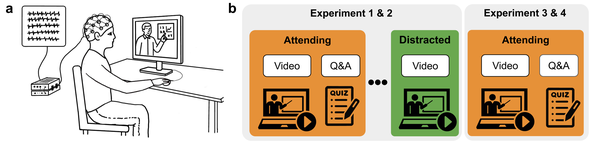


Figure 1. Experimental design. a) Overview of the EEG recording setup during video-based learning tasks. **b)** In Experiments 1 (N=31) and 2 (N=29), participants watched videos under two conditions: attending, where they viewed the videos as they normally would, followed by a quiz; and distracted, where they rewatched the videos while performing a mental arithmetic task. Additional details, including video overlap and experimental differences, are provided in the Methods section and the *BBBD* dataset paper.

Methods: Participant characteristics

Trait measures included:

- Inattention and hyperactivity (ASRS)
- Working memory capacity (reverse digit span)
- Self-reported GPA
- Trait scores varied continuously across participants - dimensional, not categorical

Take Home
We separated momentary attentional engagement (**state**) from stable individual differences (**traits**) in the same participants.

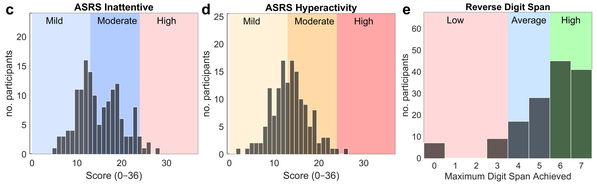


Figure 1. Participant characteristics d) Distributions of inattention and hyperactivity scores on the Adult ADHD Self-Report Scale (ASRS; N=149). Shaded regions in panels (c) and (d) indicate score ranges suggestive of clinically significant symptom levels, as per established guidelines 47. **e)** Distribution of maximum reverse digit span scores (N=147), grouped into low (0-3), average (4-5), and high (6-7) working memory capacity 48.

Results: Neural Attention Is Suppressed by Distraction

- EEG intersubject correlation (ISC) indexes shared neural responses to video.
- First component showed a fronto-central topography.
- Distraction (mental arithmetic) significantly reduced ISC across all components.
- The first component showed the strongest attentional modulation.
- Confirms ISC is sensitive to attentional engagement.

Take Home
Neural synchrony drops when attention is withdrawn validating ISC as a real-time marker of attention

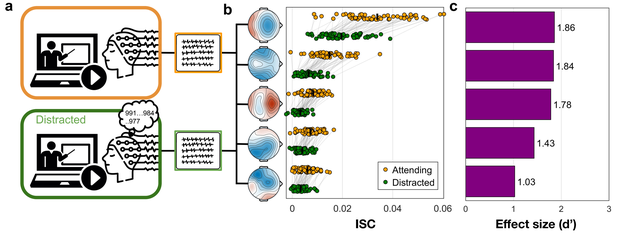


Figure 2. Effect of a distracting secondary task on video-evoked responses (mental arithmetic). a) Participants in Experiment 1 & 2 (N=60) rewatched the videos while performing a distracting mental arithmetic task (counting backwards silently in their heads from a random prime number between 800-1000 in steps of 7). **b)** EEG data were analyzed using correlated component analysis (CorrCA), resulting in 5 spatial filters (C1-5). Each dot is a participant and lines connect each participant's ISC values. **c)** Bar plots indicate the effect size (Cohen's *d'*) on ISC. Positive d' indicates a drop in ISC in the distracted conditions. All differences were statistically significant (paired t-test, $p < 10^{-8}$, N=60, d-prime here is the $t \cdot \sqrt{N}$ [52]).

Results: Neural Attention Predicts Quiz Performance

- Acute neural attention (ISC) strongly predicted quiz performance.
- Working memory capacity (WMC) predicted performance.
- GPA predicted performance.
- Inattention and hyperactivity did not predict quiz scores.
- Attention effect was strongest predictor in the model.

Take Home
Moment-to-moment attention during viewing of videos matters more than ADHD traits.

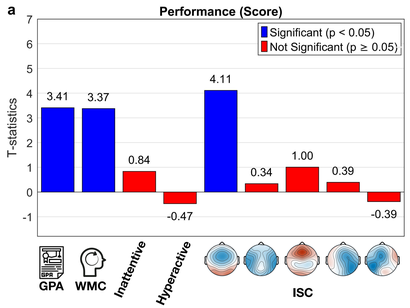


Figure 3. Factors that affect learning performance. a) t-statistics for the generalized linear model, modeling the behavioral performance of students answering questions about each short-form educational video (10-12 questions per video, N=152 participants).

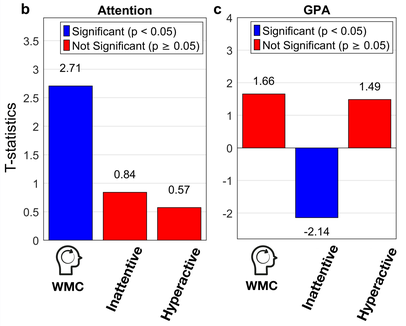
Results: Trait Predictors of Neural Attention and GPA

Neural Attention (ISC)

- Working memory capacity positively predicted ISC.
- Inattention did not predict ISC.
- Hyperactivity did not predict ISC.
- Suggests WMC supports moment-to-moment attentional engagement.

GPA

- Inattention negatively predicted GPA.
- WMC did not significantly predict GPA in this model.
- Hyperactivity did not predict GPA.
- Replicates known link between inattentive traits and cumulative academic outcomes.



Take Home
Trait inattention impacts GPA, but does not reduce neural engagement.

Working memory capacity positively predicts neural attention.

Figure 3. Factors that affect learning performance. b) t-statistics for the GLM modeling the first ISC-EEG component. **c)** t-statistics for the GLM modeling GPA.

Summary / Discussion

- Working memory capacity positively predicts neural attention (ISC).
- Neural attention predicts quiz performance.
- Inattention negatively predicts GPA.
- Inattention does not predict neural attention or quiz performance.
- Acute attentional state and trait inattention influence different academic outcomes.

Take Home
Neural attentional state mediates learning, supported by working memory, while trait inattention impacts cumulative academic performance.

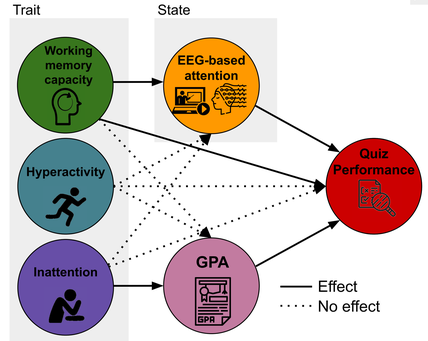


Figure 4 Summary of results: In this mediation analysis, all possible effects from left to right were tested. Solid arrows indicate statistically significant effects, dashed arrows means there was no significant effect.

Dataset: Brain, Body, Behavior dataset (BBBD)

Open Resource for Naturalistic Brain–Body Dynamics Research
Large-scale multimodal recordings during naturalistic educational video viewing.
Includes EEG, physiology, eye tracking, and behavioral measures.
Designed for studying attention, learning, and brain–body dynamics.

Dataset at a Glance
Number of Experiments: 5
Total Subjects: 178

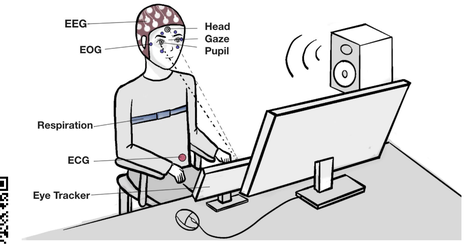
Total Raw Modalities (7)
EEG | ECG | EOG | Respiration | Eye Tracking (Pupil Size, Gaze and Head position)

Total Hours of Raw Data (hours):

EEG	ECG	EOG	Head	Gaze	Pupil	Respiration
91.2	93.5	94.4	92.5	110.6	110.6	44.2

Total Derived Modalities (12)
Continuous - Heart Rate | Breath Rate | Saccade Rate | Blink Rate | Gaze-Fixation Rate
Discrete - Heart Beats | Breath Peaks | Saccades | Blinks | Gaze-Fixations
Preprocessed - Filtered ECG | Filtered EEG

Phenotypes Available (4)
Demographics and behavioral metadata (Age, Sex, GPA, caffeine intake, study habits)
Phenotypes: ASRS (Adult ADHD Self Report) | Digit Span (WMC) | Stimuli Questionnaire Responses



"Brain, Body, Behavior Dataset (BBBD)"

Paper

Website

Acknowledgements

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"Attentional state, not trait, predicts test performance in video-based learning", Jens Madsen and Lucas C. Parra, *iScience*

National Science Foundation grant number **DRL-2201835**