

What are the neurophysiological changes in the prefrontal cortex associated with prolonged digital reading device use among young adults aged 18-35?

Young adults aged 21-34 showed no significant differences in prefrontal cortex activation when reading on e-readers compared to paper.

Abstract

Two studies addressed neurophysiological measures in the prefrontal cortex during reading tasks. One experiment used EEG and eye-tracking while participants read short texts (mean = 222 words) on tablets, e-readers, and paper. In that study, older adults showed lower theta band voltage density and shorter fixation durations when using tablets compared to paper or e-readers; in contrast, young adults (aged 21–34) exhibited no significant difference in PFC activation between e-reader and paper reading. A second study measured blood oxygen saturation in the dorsolateral prefrontal cortex during microcone patch stimulation and reported significant increases in activation, although the stimulation was not explicitly linked to reading device use. These findings indicate that digital reading devices produce measurable, device-dependent changes in PFC activity, with the only youth-group data showing comparable responses for e-reader and paper reading.

Paper search

Using your research question "What are the neurophysiological changes in the prefrontal cortex associated with prolonged digital reading device use among young adults aged 18-35?", we searched across over 126 million academic papers from the Semantic Scholar corpus. We retrieved the 50 papers most relevant to the query.

Screening

We screened in papers that met these criteria:

- **Digital Reading Device:** Does the study examine reading on digital devices (e-readers, tablets, smartphones, or computers)?
- **Neurophysiological Measurement:** Does the study use neuroimaging or neurophysiological measurement techniques (fMRI, EEG, fNIRS, etc.) to measure prefrontal cortex activity?
- **Participant Age and Health:** Does the study include participants aged 18-35 years who are free from pre-existing neurological conditions?
- **Reading Duration:** Does the study protocol include reading sessions of at least 30 minutes?
- **Study Type:** Is the study either a primary research study, systematic review, or meta-analysis?
- **Age Group Data:** For studies with multiple age groups, is data for 18-35 year olds reported separately?
- **Learning Conditions:** Does the study focus on participants without specific learning disorders or reading disabilities?

We considered all screening questions together and made a holistic judgement about whether to screen in each paper.

Data extraction

We asked a large language model to extract each data column below from each paper. We gave the model the extraction instructions shown below for each column.

- **Study Design Type:**

Identify the specific type of study design used. Look in the methods section for explicit description of the study design. Possible types include:

- Experimental (e.g., randomized controlled trial)
- Observational (e.g., cross-sectional, cohort)
- Quasi-experimental
- Mixed methods

If the design is not explicitly stated, carefully review the methodology to determine the most appropriate classification. If uncertain, note "Unable to determine" and provide a brief explanation.

- **Neurophysiological Measurement Techniques:**

List all neurophysiological measurement techniques used to assess prefrontal cortex changes. Specifically look for:

- EEG (electroencephalography)
- fNIRS (functional near-infrared spectroscopy)
- Blood oxygen saturation measurements
- Specific brain wave/frequency analyses (e.g., theta band voltage)

Extract the specific equipment, parameters, and protocols used for each technique. Include details such as:

- Specific equipment brand/model
- Electrode/sensor placement
- Sampling frequency
- Duration of measurement

- **Participant Demographics:**

Extract detailed demographic information for participants:

- Total sample size
- Age range (confirm 18-35 years)
- Gender distribution
- Mean and standard deviation of age
- Exclusion/inclusion criteria related to digital reading experience or neurological history

If multiple groups are present (e.g., young vs. elderly adults), extract demographics for each group separately. If any demographic information is missing, note "Not reported" and provide context.

- **Digital Reading Devices and Conditions:**

Catalog all digital reading devices used in the study:

- Specific device types (e.g., tablet, e-reader, specific model)
- Screen characteristics (e.g., backlit, contrast levels)
- Reading conditions (e.g., duration of reading, type of text)

Extract comparative conditions, such as:

- Paper book comparison
- Different digital device comparisons
- Reading task specifications

Ensure all details about device usage are precisely documented.

- **Neurophysiological Outcomes:**

Identify and extract all neurophysiological outcomes related to prefrontal cortex changes:

- Specific brain activation patterns
- Theta band voltage changes
- Blood oxygen saturation levels
- Cognitive effort indicators

For each outcome:

- Report exact measurements
- Note statistical significance
- Include effect sizes if available
- Capture both quantitative measurements and qualitative interpretations

If multiple outcomes are reported, extract each separately with full details.

Results

Characteristics of Included Studies

Study	Study Design	Population	Measurement Methods	Key Variables Examined	Full text retrieved
Kretzschmar et al., 2013	Experimental	57 participants (36 younger adults aged 21-34, 21 older adults aged 60-77)	Electroencephalography (EEG), eye-tracking	Theta band voltage, fixation durations, reading comprehension	Yes
Kawasaki et al., 2024	Observational cohort	40 typically developing adults (age range not specified)	Blood oxygen saturation measurements	Brain activation in dorsolateral prefrontal cortex, blood oxygen saturation	No

- Study characteristics : We found information on study design, population, and measurement methods for 2 studies:
 - Population :

- * 1 study included a mixed age group (younger and older adults)
- * 1 study included adult participants of unspecified age
- Measurement Methods :
 - * We found 3 different measurement methods across the studies: Electroencephalography (EEG), eye-tracking, and blood oxygen saturation measurements
 - * 1 study used both EEG and eye-tracking
 - * 1 study used blood oxygen saturation measurements
- Age reporting : In the two studies we examined, we found different approaches to reporting age ranges: one study specified age groups, while we didn't find age range information in the abstract of the other study

Effects on Prefrontal Cortex Activity

Digital Device-Specific Neural Responses

Temporal Patterns of Activation

Device Type	PFC Activation Measures	Duration of Effect	Key Findings
Tablet Computer (iPad 2)	Theta band voltage density, fixation durations	Duration of reading task (short texts, mean length 222 words)	Lower theta band voltage density and shorter fixation durations for older adults compared to other devices
E-reader (Kindle 3)	Theta band voltage density, fixation durations	Duration of reading task (short texts, mean length 222 words)	No significant difference compared to paper for either age group
Paper	Theta band voltage density, fixation durations	Duration of reading task (short texts, mean length 222 words)	Baseline for comparison
Not specified (focus on microcone patch stimulation)	Blood oxygen saturation	Not specified	Significant changes in brain activation and blood oxygen saturation in dorsolateral prefrontal cortex during stimulation

- Device types and measurements :
 - We found information on different device types used in Prefrontal Cortex (PFC) activation studies:
 - * In one study, tablet, e-reader, and paper were examined
 - * In another study, we found mention of microcone patch stimulation without specifying the device type
 - PFC activation measures :
 - * We found theta band voltage density and fixation durations used in 1 study
 - * We found blood oxygen saturation used in 1 study

- Key findings :
 - * We found lower activation for older adults when using tablets in 1 study
 - * We didn't find a significant difference between e-readers and paper in 1 study
 - * We found paper used as a baseline for comparison in 1 study
 - * We found significant changes in brain activation and blood oxygen saturation in the dorsolateral prefrontal cortex during microcone patch stimulation in 1 study
- The two studies we examined used different measures and had distinct findings, which limits our ability to make direct comparisons between them

Comparative Analysis

Device-Related Differences

Physiological vs. Subjective Measures

Measurement Type	Traditional vs. Digital	Effect Direction	Significance
Theta band voltage density (older adults)	Lower for tablet vs. paper/e-reader	Decreased cognitive effort	Significant
Fixation durations (older adults)	Shorter for tablet vs. paper/e-reader	Decreased cognitive effort	Significant
Subjective preference	Higher for paper vs. digital devices	Preference for traditional medium	Not applicable (subjective measure)
Blood oxygen saturation	Changes observed with microcone patch stimulation	Increased activation	Significant

- Measurement types and comparisons :
 - We found information on four different measurement types across the studies: theta band voltage density, fixation durations, subjective preference, and blood oxygen saturation
 - Traditional vs. digital media comparisons :
 - * We found lower theta band voltage density for tablet compared to paper/e-reader in 1 study
 - * We found shorter fixation durations for tablet compared to paper/e-reader in 1 study
 - * We found higher subjective preference for paper compared to digital devices in 1 study
 - * We didn't find a traditional vs. digital comparison for blood oxygen saturation in 1 study
 - Effect directions :
 - * We found decreased cognitive effort in 2 measures (theta band voltage density and fixation durations)
 - * We found preference for traditional medium in 1 measure (subjective preference)
 - * We found increased activation in 1 measure (blood oxygen saturation with microcone patch stimulation)
 - Statistical significance :
 - * We found significant results in 3 measures
 - * We found 1 measure where significance was not applicable (subjective measure)

In one study, findings suggest that tablet use may require less cognitive effort for older adults compared to paper or e-reader use, while also noting a subjective preference for paper among participants. The blood

oxygen saturation study showed significant increased activation with microcone patch stimulation, but this was not directly compared to traditional media.

References

- Akihiro Kawasaki, Yutaka Matsuzaki, and Taku Kawada. “Neuroregulatory Effects of Microcone Patch Stimulation on the Auricular Branch of the Vagus Nerve and the Prefrontal Cortex: A Feasibility Study.” *Journal of Clinical Medicine*, 2024.
- F. Kretzschmar, Dominique Pleimling, J. Hosemann, Stephan Füssel, Ina Bornkessel-Schlesewsky, and Matthias Schlewsky. “Subjective Impressions Do Not Mirror Online Reading Effort: Concurrent EEG-Eyetracking Evidence from the Reading of Books and Digital Media.” *PLoS ONE*, 2013.