Critical for Learning Writing by Hand Enhances Brain Function

Researchers investigated how handwriting versus typewriting affects brain connectivity and learning, using high-density Electroencephalography (HD EEG) to explore the implications for education.

Study

Forty university students, mostly in their early twenties, participated in a study at the Developmental Neuroscience Laboratory, Norwegian University of Science and Technology (NTNU). Of these, data from 36 right-handed participants were included after quality checks on HD EEG recordings.

Right-handedness was determined using the Edinburgh Handedness Inventory to eliminate the potential confounding effects of using both hands.

Participants were recruited on campus and compensated with a $15 cinema ticket. Informed consent was obtained, with the option to withdraw at any stage. The study was approved by the Regional Committee for Medical and Health Ethics (Central Norway).

Fifteen Pictionary words were presented using E-Prime 2.0 software on a Microsoft Surface Studio. Participants either wrote in cursive with a digital pen or typed using a keyboard. Each word appeared in two conditions across 30 trials.

Brain activity was recorded during the first 5 seconds of each task using a 256-channel Geodesic Sensor Net (GSN). Measures were taken to reduce motion artifacts, such as excluding typed text from the display. EEG data were preprocessed with Brain Electrical Source Analysis (BESA) software, incorporating artifact corrections and coherence-based connectivity analyses.

Findings

HD EEG recordings captured neural activity during handwriting and typing tasks. After artifact removal, the brain's regions of interest were analyzed using a four-shell ellipsoidal head model.

The time-series data of reconstructed sources were transformed into the frequency domain using complex demodulation, and functional connectivity was calculated using the coherence method.

A high-resolution connectivity matrix was generated, visualizing the functional brain networks. Extracted network measures highlighted significant differences in connectivity patterns between handwriting and typing.

In the handwriting condition, time-frequency analyses showed pronounced neural activity in theta (3.5-7.5 Hz) and alpha (8-12.5 Hz) bands, especially in parietal and central brain regions. Coherence results revealed that handwriting elicited significantly stronger connectivity in these frequency ranges compared to typing.

Positive connectivity patterns, visualized as red contours, were notably more prominent during handwriting, persisting throughout the trial duration, particularly from 1,000 to 4,500 ms. In contrast, typewriting showed weaker and less widespread connectivity patterns.

Connectivity matrices revealed widespread theta/alpha coherence in handwriting, particularly between parietal-left, parietal-midline, and parietal-right regions, as well as central-left and central-right regions.

These patterns were illustrated through significant clusters-16 distinct connections corresponding to 32 paired clusters unique to handwriting. This connectivity strength was absent in typewriting, indicating that handwriting engages neural networks more extensively.

Statistical analyses demonstrated significant differences in connectivity between handwriting and typewriting, with 32 positive clusters identified. These differences were primarily localized to parietal and central regions, with significant effects observed in the theta and alpha frequency bands.

T-tests confirmed that handwriting engaged distinct neural processes compared to typewriting, reflecting differences in cognitive and motor demands.

Further network analyses visualized the adjacency matrix for handwriting, depicting hubs, nodes, and edges of a simplified theoretical brain network. Hubs, identified by higher functional connectivity, were more active during handwriting, particularly in the parietal and central regions.

These widespread theta/alpha coherence patterns were absent in typewriting, emphasizing the distinct cognitive and motor engagement required for handwriting.

Conclusion

To summarize, this study explored brain connectivity during handwriting and typewriting using HD EEG in young adults. Participants wrote visually presented words on a touchscreen using a digital pen and typed the same words on a keyboard.

Connectivity analyses focused on parietal and central brain regions, which are linked to cognitive processes like attention, memory, and sensorimotor integration.

The findings revealed increased connectivity in theta (3.5-7.5 Hz) and alpha (8-12.5 Hz) frequency bands for handwriting compared to typing, emphasizing handwriting's role in enhancing brain connectivity associated with learning and memory formation.

Source:

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