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Your Brain on ChatGPT: Accumulation of Cognitive Debt when Using an AI Assistant for Essay Writing Task

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Journal Club

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Content

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- Study Objectives
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- Methodology
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Why Chose This Paper?

- Immediate popularity and attention of the paper
- Active debates in academia and social media (Method, Peer-Reviewing)
- Strong relevance to Education and AI (Our Area)
- Our own use of AI in writing

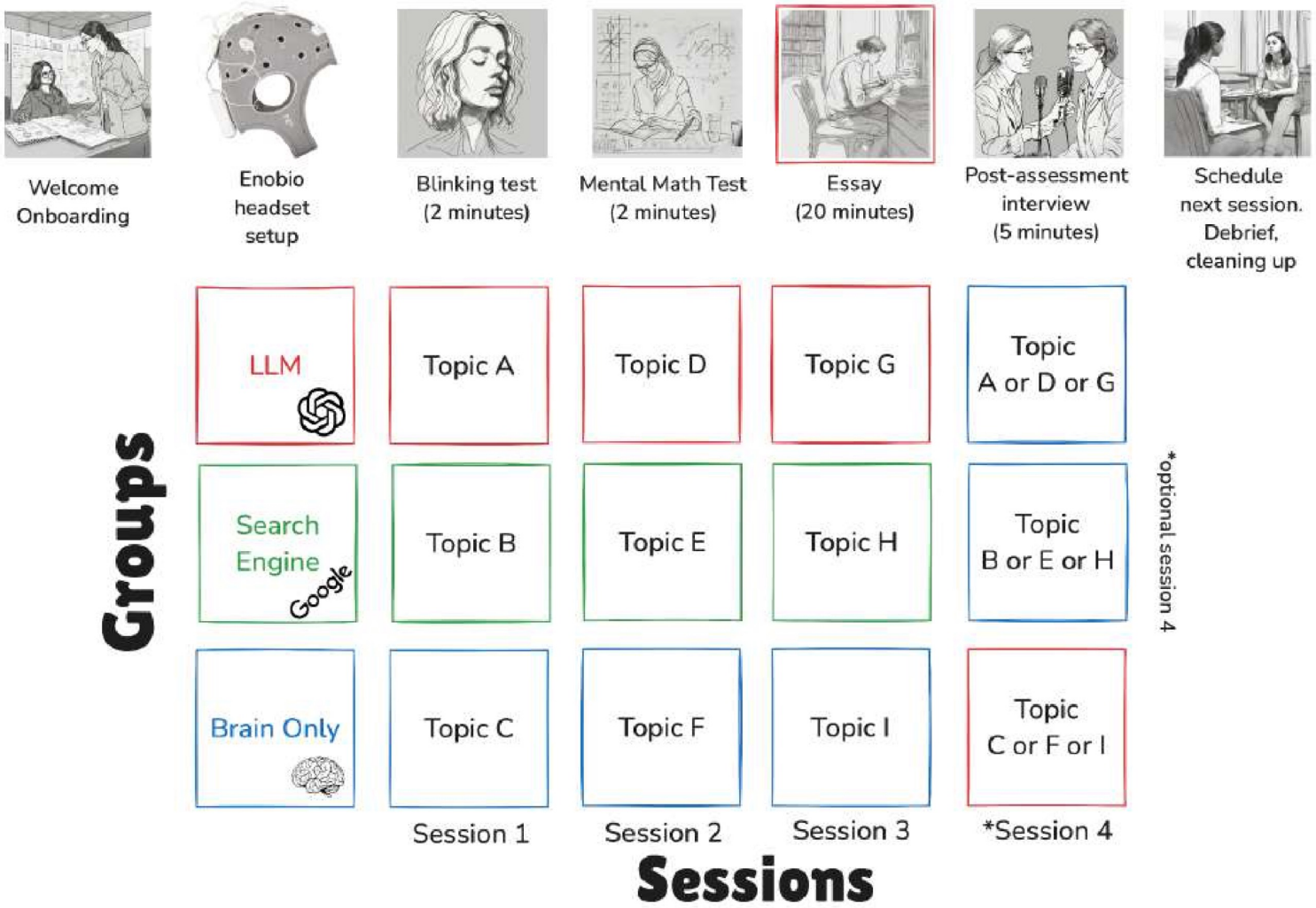
Study Objectives

1. Do people write **differently** when using ChatGPT, Google search, or just their own brain?
2. How does the **brain behave** in each of these scenarios?
3. Does AI use affect **memory** and the ability to **recall** or quote what we wrote?
4. How much **ownership** do people feel over their work when AI is involved?

Experimental Design

- Participants: 54 university students (MIT, Wellesley, Harvard, Tufts, Northeastern).
- Groups:
  - Group 1 (LLM): Only ChatGPT allowed. → 18 Participants
  - Group 2 (Search): Internet search (no AI). → 18 Participants
  - Group 3 (Brain-only): No external tools. → 18 Participants
- Sessions:
  - Sessions 1–3: Each group sticks to same method.
  - Session 4: Switch conditions as LLM-to-Brain and Brain-to-LLM. → 9 participants

Study protocol



(Kosmyna et al., 2025)

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The session 1 prompt : LOYALTY

Many people believe that loyalty whether to an individual, an organization, or a nation means unconditional and unquestioning support no matter what. To these people, the withdrawal of support is by definition a betrayal of loyalty. But doesn't true loyalty sometimes require us to be critical of those we are loyal to? If we see that they are doing something that we believe is wrong, doesn't true loyalty require us to speak up, even if we must be critical?

Assignment: Does true loyalty require unconditional support?

Methodology

- **EEG brain activity**

A method to record brain activity using electrodes on the scalp. Measures electrical signals across frequency bands. (dynamic directed transfer function, dDTF)

- **NLP analysis of essays**

Computational methods to study the written essays.

  - ***Named Entity Recognition (NER):*** *detecting names, places, dates.*
  - ***N-grams:*** *sequences of words (e.g., "climate change").*
  - ***Ontology analysis:*** *mapping concepts and relationships between topics.*

- **Human & AI scoring of essays**

Performed scoring with the help from the human teachers and an AI judge (a specially built AI agent).

- **Interviews with participants**

Collected the participants' statement on ownership, satisfaction, memory recall.

Results

EEG brain activity →

NLP analysis of essays →

Human & AI scoring of essays →

Interviews with participants →

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EEG Brain Activity

- LLM Group: Weakest overall connectivity (reduced cognitive effort).
- Search Group: Intermediate engagement.
- Brain-only Group: Strongest, widest neural connectivity.
- Session 4 (switch):
  - LLM-to-Brain: under-engaged, weak recall → “cognitive debt.”
  - Brain-to-LLM: stronger recall + wider neural networks, benefited from AI.

EEG Frequency Bands (linked to mental states)

1. **Alpha (8–12 Hz):** relaxation, attention control.
2. **Beta (13–30 Hz):** active thinking, focus, problem-solving.
3. **Theta (4–7 Hz):** memory, learning, drowsiness.
4. **Delta (0.5–3 Hz):** deep rest, baseline brain activity.

NLP analysis of essays

- LLM Group:
  - Highly repetitive, copy-paste style, weak originality.
  - Strong grammar, structure → scored higher by AI judge.
- Search Group:
  - Middle ground, factual and structured.
- Brain-only Group:
  - Essays most unique
- Session 4 (switch):
  - LLM-to-Brain: Essays became shorter and less structured once participants lost access to ChatGPT.
  - Brain-to-LLM: Essays grew longer and more detailed, with improved grammar and flow.

Human & AI scoring of essays

- Both scored essays.
- AI Judge: Often rated LLM essays higher (good structure, grammar).
- Human Teachers: Preferred Brain-only essays for originality, depth, and ownership.

Interviews with participants

- Essay Ownership
  - LLM Group: Felt low ownership - “not really my essay.”
  - Search Group: Moderate sense of authorship.
  - Brain-only Group: High attachment and pride.
- Memory & Recall
  - LLM Group: Weak recall, struggled to quote from essays.
  - Search Group: Moderate memory and recalling ability
  - Brain-only Group: Stronger recall, better memory encoding.
  - Session 4: LLM-to-brain group was struggled to recall, and Brain-to-LLM Group thrived.
- Topic Choice & Satisfaction
  - Most preferred familiar topics for continuity.
  - LLM users: Liked polish but missed personal “voice.”
  - Search: Factual but formulaic.
  - Brain-only: Less polished, but felt authentic.

Conclusion / Summary

- LLMs enhance access and reduce friction in learning,but at a **cognitive cost**.
  - Weaker critical thinking and intellectual independence.
  - Reinforcement of echo chambers shaped by algorithms and shareholder priorities.
  - Reduced ownership, satisfaction, and memory recall among LLM users.
- **Human Strength**: Brain-only participants showed stronger engagement, deeper satisfaction, and more authentic ownership of their work.
- **Educational Insight**: Teachers easily detected LLM essays due to their uniformity and lack of depth.
- **Future Direction**: Careful, longitudinal research is essential to evaluate long-term effects before declaring LLMs a net positive for human cognition.

Limitations of the Study (as noted by the author)

- Limited number of participants and less coverage
- Use of only one LLM
- Use of only text inputs
- No division of the sub-tasks of essay writing (idea generation, writing)
- Not considering the longitudinal impact

Sample Coverage

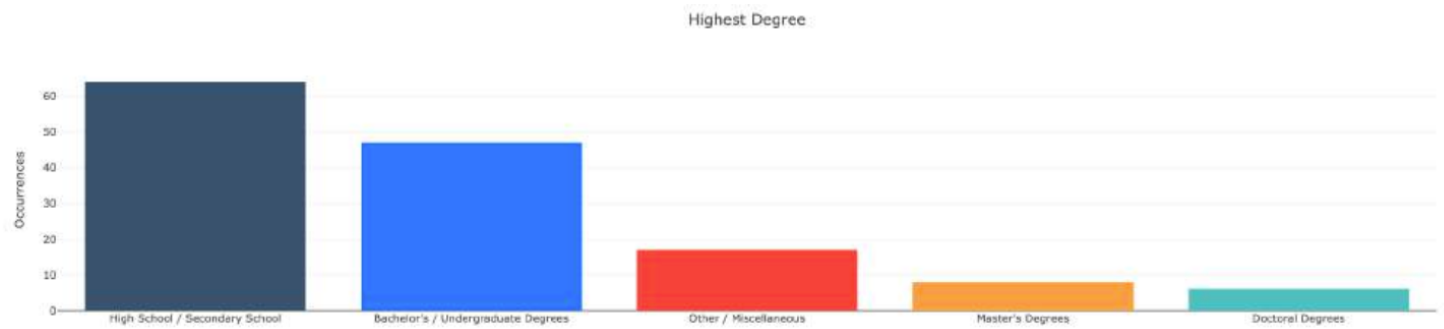

Figure 2. Distribution of participants' degrees.

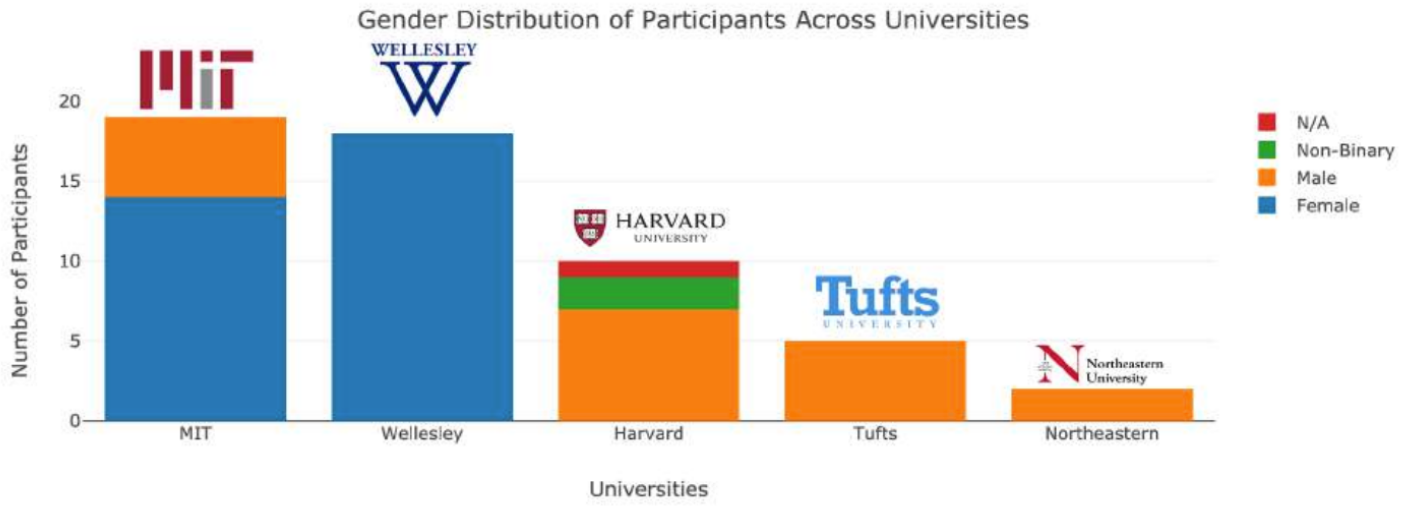

Figure 3. Distribution of participants' educational background.

Discussion Points

- **What are the thoughts on the study and its results?**
  - Study design?
  - Can long-term effects be measured?
  - Is there cognitive debt?
- **What is the best experimental design for LLM and cognitive ability testing?**
  - How can we incorporate the various uses of AI (e.g., brainstorming, structuring, writing)?
  - How should participants be selected and filtered?
- **How can these results be applied in the context of learning and student outcomes?**
  - How can AI be effectively used for teaching and learning?
  - How can we balance human cognitive ability with the efficacy of AI use?

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Thank You!