ChatBCI: A Fast P300 Speller Brain-Computer Interface Incorporating Generative AI-Based Word Prediction

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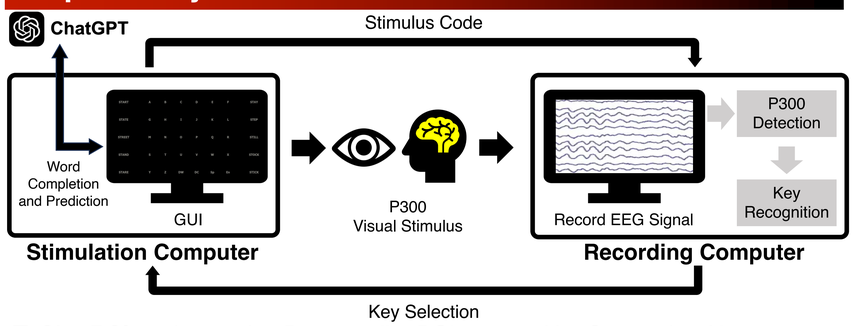
***Equal Contributions**

Background

- Brain-computer interface (BCI) spellers enable users to compose sentences by selecting target keys from a graphical user interface (GUI) keyboard via detection of P300 event-related potentials (ERPs) in the electroencephalogram (EEG) signals following the presentation of a visual stimulus
- Existing BCI-based spellers spell each word, letter by letter, or predict a word after its initial letters are spelled, thereby, requiring high number of keystrokes, prolonged spelling time, and high cognitive load

➪I WANT TO BUY A NEW PHONE ➪I WANT TO BUY A NEW PHONE

Proposed System



- **ChatBCI**, an innovative P300 speller BCI powered by Generative AI

➪I WANT TO BUY A NEW PHONE

  - Word Completion: Complete a partially spelled word
  - Word Prediction: Directly predict the next word

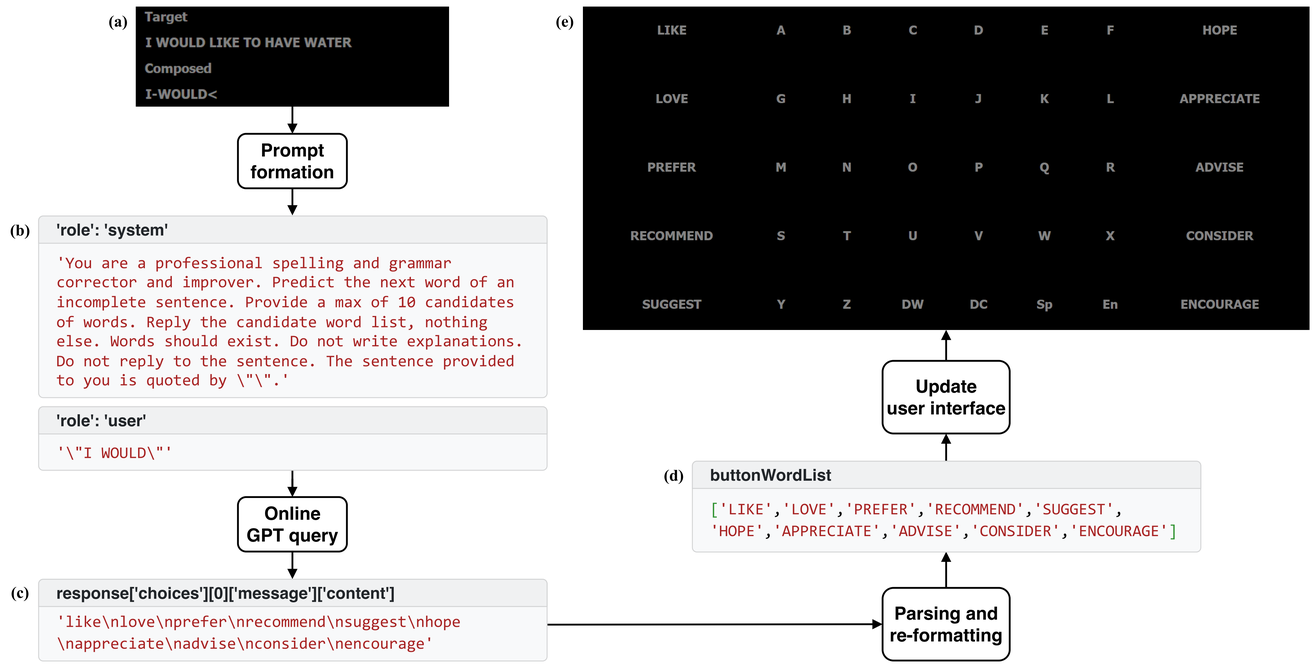
Methods

- **EEG (from Brain Products):**
  - 32-channel cap @250Hz
  - Used 16 channels (Fz, Cz, Pz, Oz, P3, P4, P7, P8, FC1, FC2, CP1, CP2, C3, C4, O1, O2)
  - Bandpass filter (0.5-30 Hz)
  - 240-dimensional feature vector after utilizing the moving average
  - [0-700 ms] post stimulus interval
- **P300 Detection:**
  - Stepwise linear discriminant analysis (SWLDA)
- **Target Key Recognition:**
  - Select row and column with highest cumulative SWLDA score
  - Intersection of selected row and column locates the target key

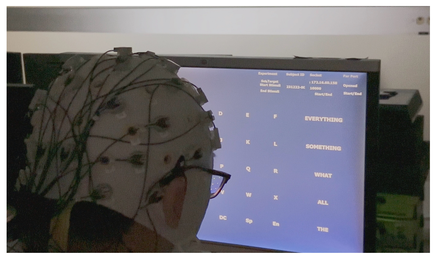
Experiments

- **Sessions:**
  1. **Calibration:** 20 keys were used for training the SWLDA model
  2. **Validation:** 3 consecutive correct key selections within 10 attempts using the trained model
  3. **Online Spelling:**
     - Copy-spell user-created target sentence
       - with ChatBCI
       - letter-by-letter spelling (LL)

Large Language Model (LLM) Integration



Results



An example of experimental setup

Images shown to subjects for creating target sentence for the copy-spell task

- **Complete Time: 58% faster than letter-by-letter spelling**
- **Character Rate: 151% higher than letter-by-letter spelling**
- **ITR: 220% higher than letter-by-letter spelling**
- **Keystroke Saving:**
  - **Over 61% keystrokes saved in copy-spell tasks**
  - **Over 84% keystrokes saved in improvision tasks**

Subject	Task	Image	Composed Sentence	# Char.	ChatBCI Results			LL Results		
					Complete Time (min)	Character Rate (characters/min)	ITR (bits/min)	Complete Time (min)	Character Rate (characters/min)	ITR (bits/min)
S01	Copy-spell	Phone	I-WANT-TO-BUY-A-NEW-PHONE	25	**13.62**	**2.78**	**16.99**	28.53	1.33	6.38
S02	Copy-spell	Apple	AN-APPLE-A-DAY-KEEPS-DOCTORS-AWAY	33	**8.70**	**5.76**	**35.31**	24.18	2.07	9.94
Average	Copy-spell			29	**11.16**	**4.27**	**26.15**	26.36	1.70	8.16

Acknowledgment

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