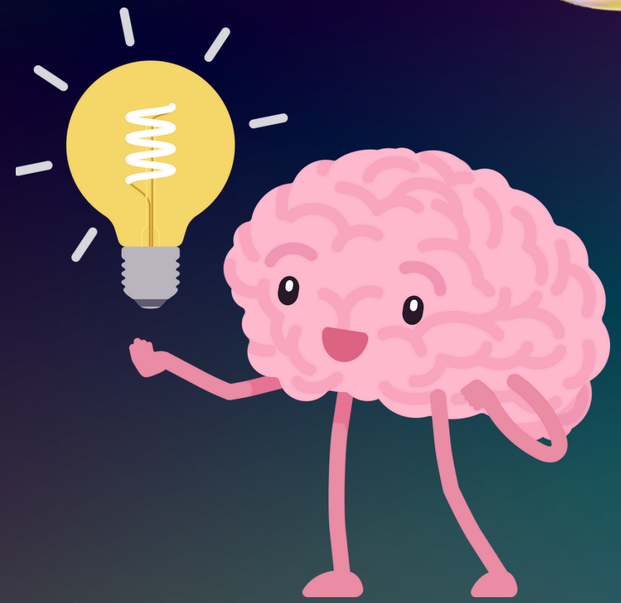
Maze with Mind



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BrainHACK Fall 2025

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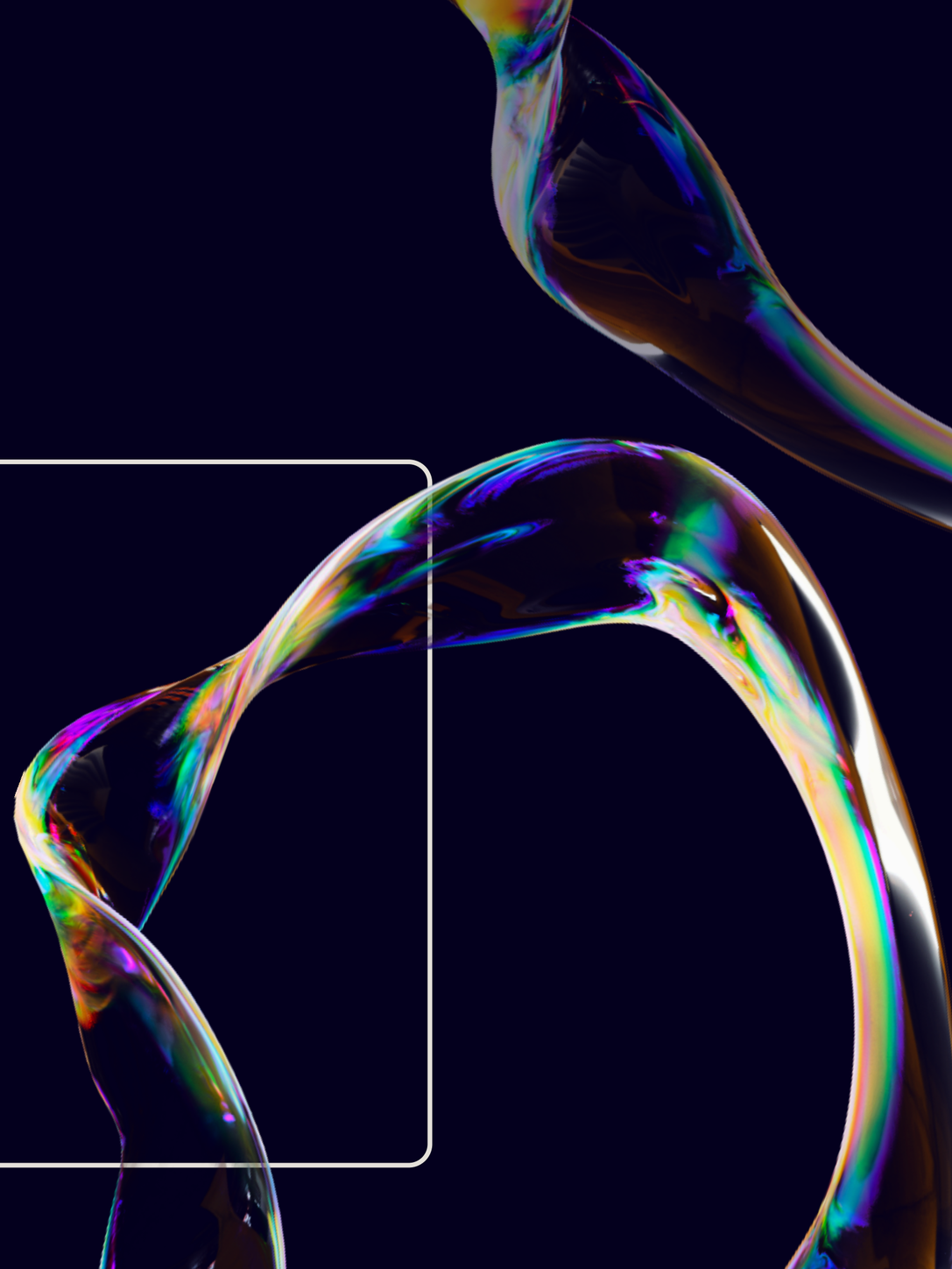
Overview

- Background Knowledge
- Our Goal
- Set Up
- Process
- Results
- Conclusion



First things First

BCI (Brain-Computer Interface)

- Direct communication between the brain and a computer
- Brain generates electrical signals when we think or move

What is SSVEP?

- Steady-State Visually Evoked Potentials are brain responses to visual stimuli flashing at a constant frequency.

- When the retina is stimulated by a flickering light , the brain generates EEG signals at that same frequency (and its harmonics).

- These signals are strongest over the occipital lobe (visual cortex)

https://www.researchgate.net/publication/336549040/figure/fig1/AS:871225031155717@1584727642597/Example-of-Brain-Computer-Interface.jpg

Using SSVEP for BCI

- If multiple targets flicker at different frequencies, a user's brainwaves will naturally "lock onto" (entrain to) the frequency of whichever target they are attending to. By analyzing the EEG for frequency content, we can determine which stimulus the person is looking at.

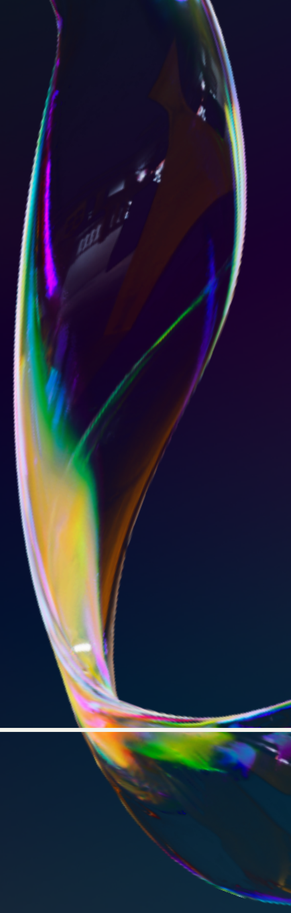
- In other words, the flicker frequency acts as a built-in code for the user's choice – the brainwave contains a peak at that frequency for the attended target.

https://www.researchgate.net/publication/336549040/figure/fig1/AS:871225031155717@1584727642597/Example-of-Brain-Computer-Interface.jpg

What is Maze with Mind

As the name suggests, we will try to solve a maze with telekinesis.

Only if it was so easy to master it but worry not becasue we have BCI.



01

Game Premise: Maze with Mind is a simple maze navigation game where the player's avatar is controlled by brain signals rather than a keyboard or controller.

02

Flickering Directional Cues: We placed four visual stimuli corresponding to the four directions (up, down, left, right) on the screen.

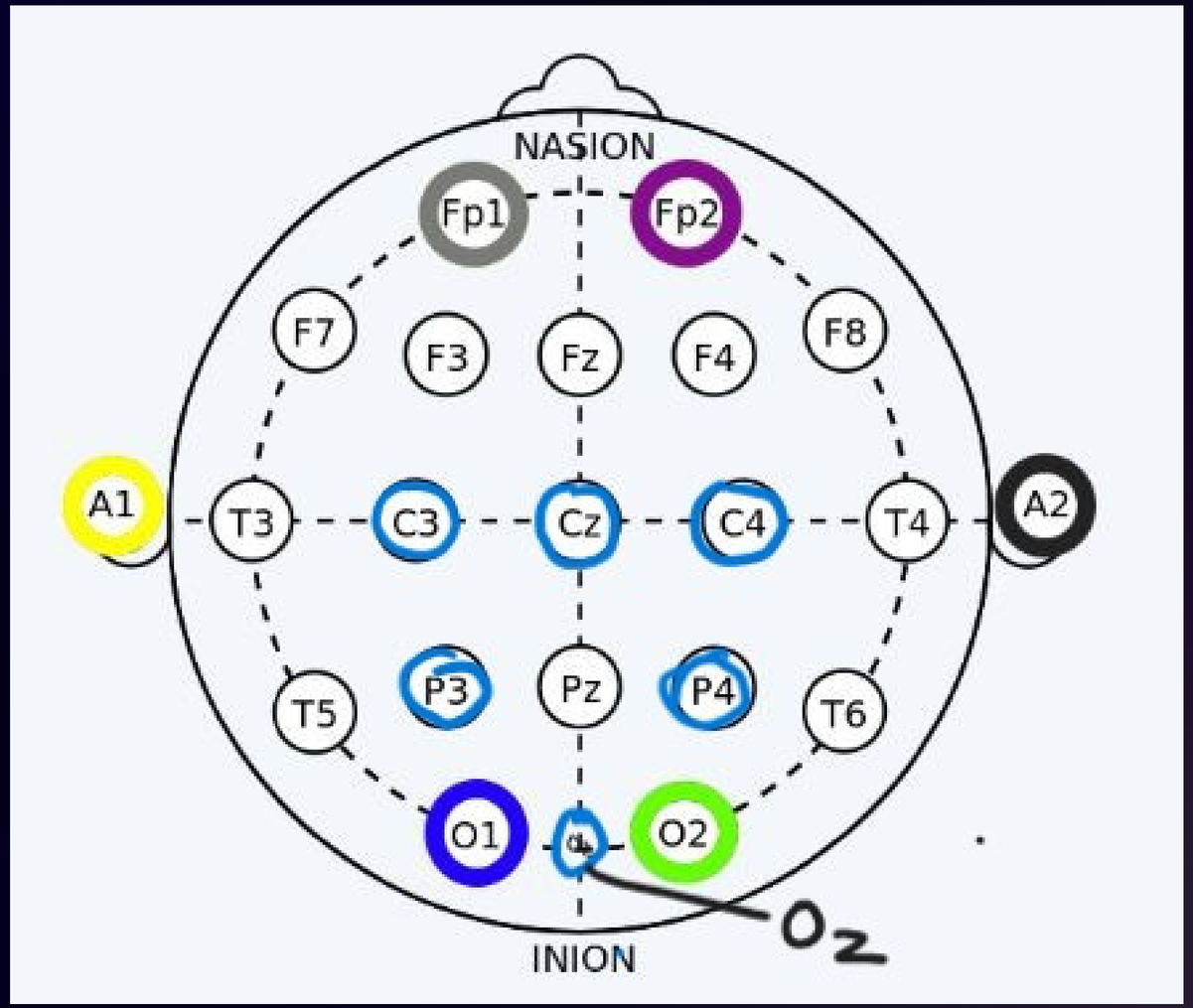
03

Control Mechanism: The player simply looks at the cue for the direction they wish to move.

04

Visual Feedback: The maze and avatar are displayed on the same screen, behind or alongside the flickering cues. When the system detects a direction, the avatar moves one step in that direction

Set Up



01

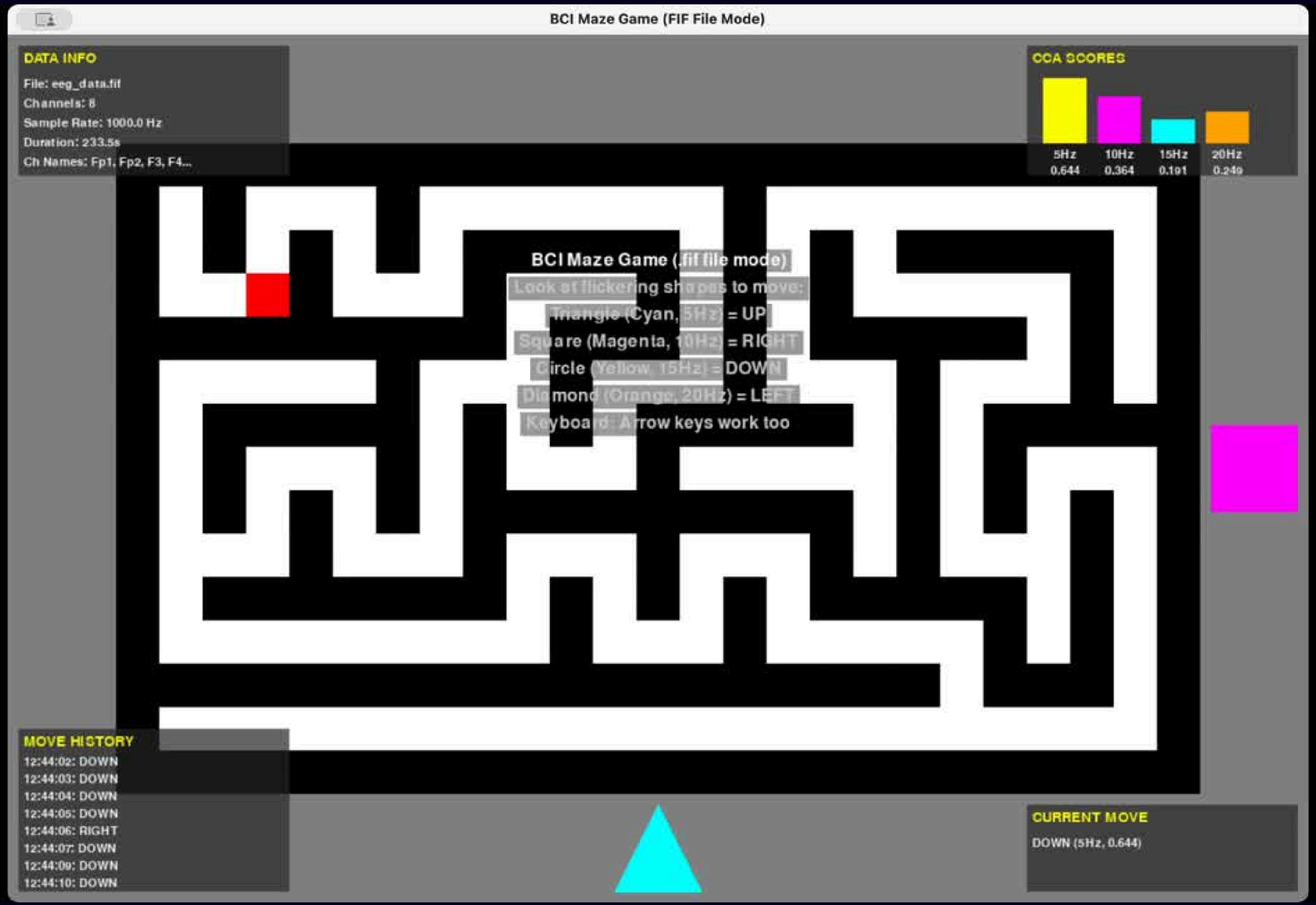
Signal Acquisition — 8-channel EEG focused over occipital sites (O1, Oz, O2, etc.), ~250 Hz sampling, low-impedance contacts (dry OK) to capture SSVEP reliably.

02

Preprocessing — Band-pass 5–50 Hz + 60 Hz notch; suppress blinks/EMG; analyze sliding ~1.0 s windows (with harmonics) for responsive yet stable frequency evidence.

03

Frequency Decoding (CCA) — Correlate multi-channel EEG with sine/cos reference pairs at each target frequency (f, 2f); pick max correlation ⇒ intended direction. Zero-training, robust in noise.


BCI Maze Game (FIF File Mode)
DATA INFO
File: eeg_data.fif
Channels: 8
Sample Rate: 1000.0 Hz
Duration: 233.5s
Ch Names: Fp1, Fp2, F3, F4...
CCA SCORES
5Hz
0.644
10Hz
0.364
15Hz
0.191
20Hz
0.249
BCI Maze Game (.fif file mode)
Look at flickering shapes to move:
Triangle (Cyan, 5Hz) = UP
Square (Magenta, 10Hz) = RIGHT
Circle (Yellow, 15Hz) = DOWN
Diamond (Orange, 20Hz) = LEFT
Keyboard: Arrow keys work too
MOVE HISTORY
12:44:02: DOWN
12:44:03: DOWN
12:44:04: DOWN
12:44:05: DOWN
12:44:06: RIGHT
12:44:07: DOWN
12:44:09: DOWN
12:44:10: DOWN
CURRENT MOVE
DOWN (5Hz, 0.644)

Key Innovations

01

Hands-free control: Pure EEG → game; no controller/eye-tracker—demonstrates true no-contact interaction and accessibility.

02

Real-time CCA decoding: Multi-channel CCA with harmonics for robust, zero-training SSVEP classification—even on 8 channels.

03

Intuitive gaze UI: “Look = move” mapping (four flicker targets) lowers learning curve; users feel seamless, natural control.

04

Accessible build: Low-cost headset, dry electrodes, laptop + standard display; open-source stack (EEG → CCA → game).

Challenges, Solutions & Outcomes

01

Noisy EEG (blinks/EMG): Band-pass + notch + windowing; coach relaxation → stable SSVEP peaks.

02

Few electrodes (8ch): Occipital montage (O1/Oz/O2/POz) + CCA spatial leverage → reliable detection.

03

Visual fatigue: Comfortable frequencies (~7.5–12 Hz), small peripheral cues, short runs → good tolerance.

04

Flicker timing: 60 Hz-aligned frequencies + frame-locked updates → precise stimuli, better accuracy.

The End

Special Thanks to Max, Can, and Jordan for the help and support, and for hosting this