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A visual BCI system using mild peripheral visual field stimulation

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Introduction: Traditional visual Brain-Computer Interfaces (BCIs) often use intense and flickering stimuli in the central visual field to elicit strong brain responses[1,2]. However, for a long-term use, these visual stimuli could be irritating and lead to visual fatigue, headache and mental anxiety. Furthermore, in the scenes of virtual reality and augmented reality, the flash in the central vision would pose a challenge for users to perform other visual tasks. This study aims to develop a visual BCI system that could give users a flicker-free central vision by only presenting weak stimuli in the peripheral visual field.

Material, Methods and Results: Forty alphanumeric characters were arranged as a 5×8 matrix displayed on a computer screen in front of subjects. Stimuli were a white dot that would appear either in the bottom left (defined as digit '0') or right (digit '1') peripheral area (1.1 degrees from the center) for every 100ms for a duration of 33ms. Two basic binary units I and II were designed as a sequence of digits '0101' and '1010', respectively. According to a time-domain coding strategy, 6 units were required to code 40 characters. As the two kinds of digits '0' and '1' would elicit different visual evoked potential (VEP) patterns, target characters could be decoded by finding the best match between VEP and templates. To select a target character, subjects just need to focus their attention on the center of the character while passively receive a sequence of stimuli appearing in the peripheral field. One subject performed an online test to spell 39 characters in a random sequence after ten-minute training, and achieved an information transfer rate of ~50 bits/min.

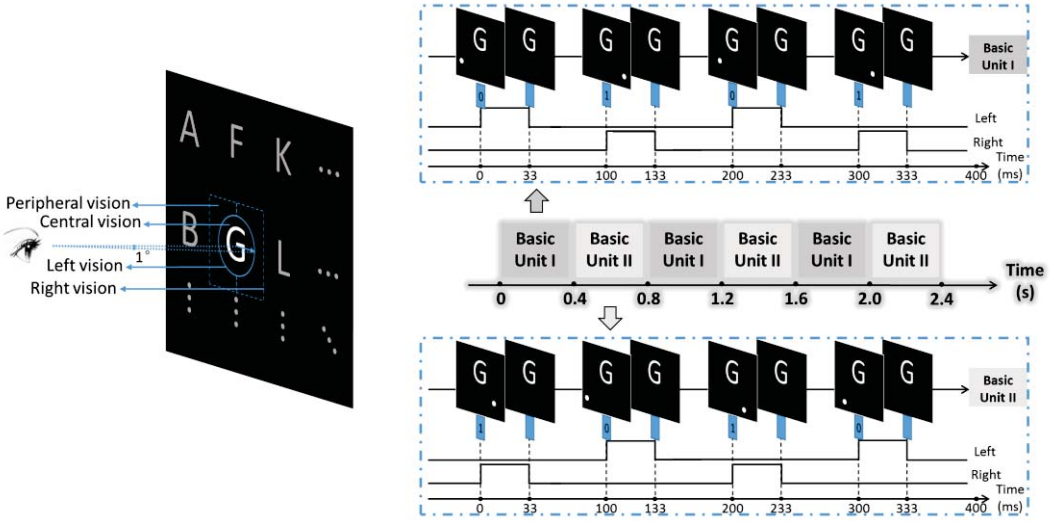

Figure 1. *(Left) Central, peripheral, left and right visions of the target character defined in this study. (Right) Timing sequence of a completed trial for letter 'G' are displayed with the discription of the two basic units.*

Discussion: The study results demonstrated that the peripheral visual BCI system was effective in spelling characters. Moreover, it gave users a more comfortable interface, as the peripheral visual stimulation was weak and mild. Furthermore, in the scenes of virtual reality and augmented reality, the flicker-free central vision could provide users with a clear sight on the outward environment.

Significance: This study develops a new visual BCI system that codes characters with inconspicuous stimuli in the peripheral visual field. It opens a new and promising direction for the research of BCIs.

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