Optimizing the face Paradigm for BCI systems with the modified Mismatch Negativity paradigm

S. Zhou[1], B. Z. Allison[3], I. Daly[2], Y. Zhang, [1] X. Wang[1], J. Jin[1*]

[1] *Key Laboratory of Advanced Control and Optimization for Chemical Processes, Ministry of Education,East China University of Science and Technology, Shanghai, People's Republic of China;* [2] *Brain Embodiment Lab, School of Systems Engineering, University of Reading, Reading, UK;* [3]*Guger Technologies OG, Graz, Austria*

130 Meilong Road, Xuhui district, Shanghai, China. E-mail: jinjingat @gmail.com

Introduction: The modified mismatch paradigm could evoke significantly larger N200 and N400 components compared to the traditional P300 paradigm. Based on previous studies, inverted and upright faces with different expressions were used to design the mismatch inverted face pattern (MIF-pattern). The visual stimulus modality elicits a visual mismatch negativity (i.e. the vMMN). Consistent with the auditory MMN, the vMMN elicits an N200 [1, 2]. Our hypotheses are that the MIF-pattern could yield significantly higher classification accuracy and information transfer rate than the inverted face pattern (IF-pattern).

Material, Methods and Results: In the IF-pattern, an inverted woman's face with negative emotion (i.e., deviant) was presented pseudo-randomly above each of the 12 items (Fig. 1B). The MIF-pattern was the same as the IF-pattern with one exception. When the inverted woman's face was flashed above one of the items, a woman's face with positive emotion (standard) flashed in gray above the other 11 items (Fig. 1C). Several standard stimuli (flashing gray face) appeared before the deviant stimuli (an inverted woman face), thereby producing a "visual mismatch" [3]. Ten subjects participated in this study. The inter-stimulus-interval (ISI) of the stimulus was 100ms and the stimulus onset asynchrony (SOA) was 300ms in both patterns, which was same for the flickering background used in the MIF-pattern.
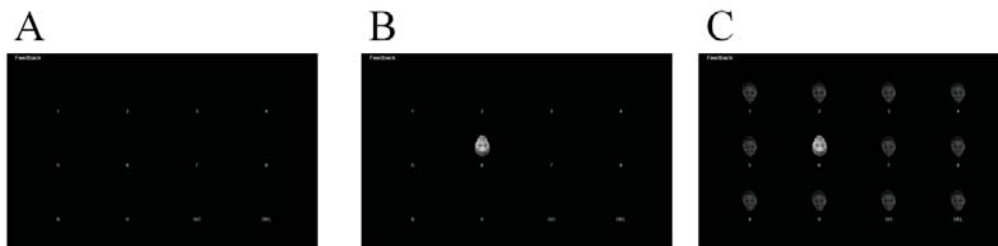

Figure 1.   *The interface that was shown to the subjects. A) The stimulus matrix without stimuli. B) An example of the IF-Pattern. C) An example of the MIF-Pattern. The feedback appeared on the top of the screen in the online session.*

The mean classification accuracy is 97.08% (IF-pattern) and 99.58% (MIF-Pattern), the mean information transfer rate is 25.66 (IF-pattern) bit/min and 27.78 bit/min (MIF-Pattern), and the mean trials per average is 2.19 (IF-pattern) and 2.13 (MIF-Pattern). Since the classification accuracy did not meet the normal distribution, a non-parametric Kendall test was used to show the difference in classification accuracy between the IF and MIF patterns. The classification accuracy of the MIF pattern was significantly higher than that of the IF pattern ($p<0.05$). A paired samples t-test was used to show the differences between the MIF-pattern and IF-patterns in bit rate. The raw bit rate of the MIF-Pattern was significantly higher than that of the IF-pattern ($t=-2.7$, $p<0.05$).

Discussion: A mismatch negativity (MMN) was elicited when a stimulus was incongruent with the sensory memory of a standard stimulus. The result showed that higher classification accuracy and information transfer rate could be obtained from the MIF-pattern on health patients. We will further verify this paradigm on patients in future research.

Significance: The new approach introduced in this study could improve the performance of a visual P300 brain computer interface. Results could also be adapted to auditory or other modalities.

References
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