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ISOLATING AFFECTIVE INFLUENCES ON IMPLICIT CURSOR CONTROL

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ABSTRACT

An implicit cursor control experiment has previously demonstrated the use of passive brain-computer interfaces for a primary control loop [1, 2]. Instead of explicitly controlling the cursor, participants were observing an autonomously moving cursor and evaluating each movement as "appropriate" or not, given their current goal. Using a passive brain-computer interface (pBCI), these evaluations were assessed and fed back to the cursor for reinforcement learning. In effect, the participants' evaluations controlled the cursor, but the participants were consciously unaware of having any influence. This highlighted a number of issues with respect to i.a. the nature of interaction, data privacy, and consent.

Data privacy and consent issues are particularly sensitive when the pBCI focuses on personal, subjective interpretations as opposed to more objective (e.g. merely visual) processing of the stimuli. It has been suggested that the response elicited by the implicit cursor control paradigm may contain an interaction between processes related both to salience (i.e. surprise or expectancy), and valence (i.e. the subjective value of an outcome) [3].

We now present an adapted experimental design to investigate these two processes separately. One, larger grid was used in two different conditions, with only its centre node highlighted. In one condition, participants were instructed that the cursor's goal was to reach the centre (the "positive" condition). In another, the goal was to stay away from the centre ("negative"). Thus, equally salient cursor movements are "appropriate" in one condition and "inappropriate" in the other. The conditions were counterbalanced within subjects.

In both conditions, a windowed-means classifier [4] could distinguish between movements away from the centre and towards the centre with significant accuracy. However, in the positive condition, classification accuracy was approximately 10 percentage points higher than in the negative condition, with 83 versus 71% on average ($p < 0.01$). This rules out that classification is done exclusively based on visual salience, as visual stimuli were identical.

Using independent component analysis, we identified components that significantly contributed to classification across conditions [5]. Most of these reflected processes in the visual cortex, while a separate subset of components bore close resemblance to the primary identified processes in the original experiment in the medial prefrontal cortex. After manual clustering, an analysis of these two clusters' event-related potentials revealed the occipital cluster to show consistent significant differences between movements going away from versus going towards the centre, but no such differences between valence conditions. The frontal cluster did show consistent significant differences between valence conditions, as well as between movement conditions, but at later latencies. See figure 1.

This is data based on 8 initial participants. A number of additional effects can be seen in figure 1 that are not readily explained. Although we wait for additional recordings for further analysis, current findings are in line with the suggestion that separate salience and valence processes play a role in the evaluation of events. To the extent that implicit control is based on valence, this again highlights both the possibilities of neuroadaptive technology for personalisation, and the need for clear consent and privacy guidelines.

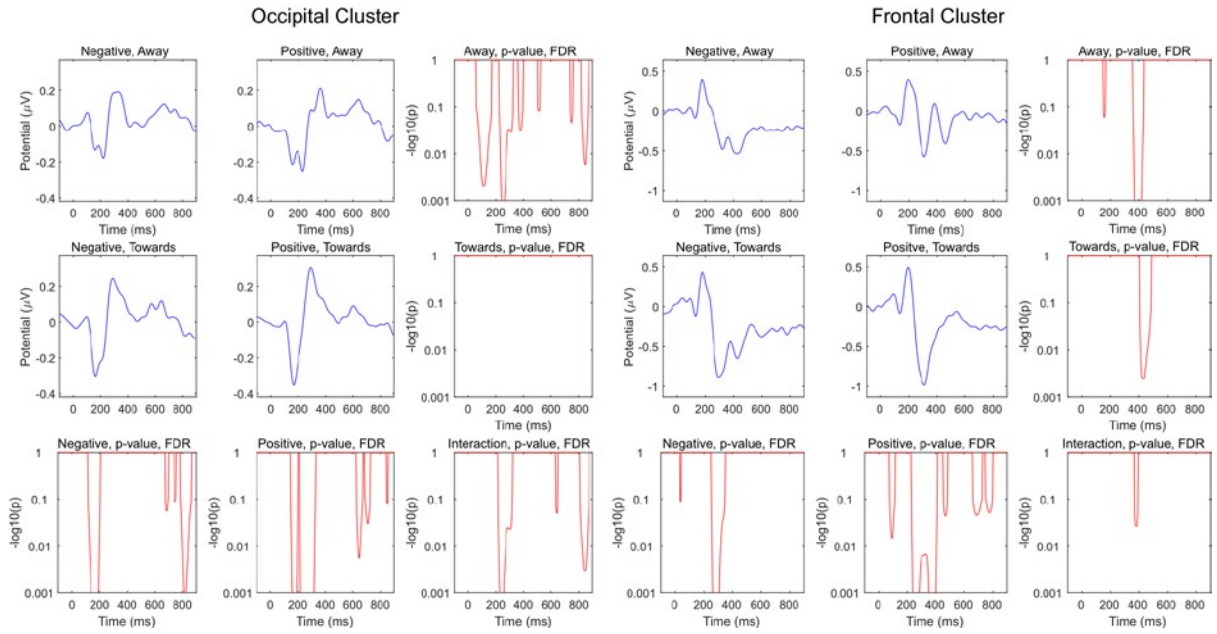

Figure 1. Negative: Cursor movements in the `negative' condition; movements towards the centre were undesirable and vice versa. Positive: Cursor movements in the `positive' condition; movements towards the centre were desirable and vice versa. Away: Cursor movements that went away from the target. Towards: Cursor movements that went towards the target. Blue graphs: Grand-average ERPs of the occipital (left) and frontal (right) clusters separated by condition and movement class. Red graphs: FDR-corrected p-values calculated on the differences between conditions and movement class

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