Neural dynamics of predicting others' decisions

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Abstract

Although previous work has found that the same valuation mechanisms are used when making choices for oneself and when predicting the choices of others, other brain signals distinguishing these two types of decisions were also identified. What remains less clear is how these two processes interact and when they emerge. In this study, we used EEG to investigate the dynamics of when these two processes emerge within the course of a decision. Specifically, we compared the event-related potentials (ERPs) of participants when making risky choices for themselves and when predicting the choices of two artificial agents (one with a similar, one with a dissimilar risk preference). We fitted the ERP data with a linear regression model which included the predictors of decision type (self / similar / dissimilar), trial-level option value difference and the interaction between the two. We found evidence for a valuation signal occurring in the frontal, central and parietal channels about 0.8-1s post-stimulus presentation, which did not change across the three decision types. Additionally, centro-parietal activity about 0.6s post-stimulus distinguished choice for a dissimilar agent from choices for self. Our findings suggest that the brain may first encode the perceived self-other similarity of the decision recipient, followed by a domain-general value computation.

Keywords: decision-making; prediction; Theory of Mind; self- other similarity

Introduction

Substantial empirical evidence shows that there is an overlap between the cognitive mechanisms underlying decisions for oneself and predicted decisions of others (Devaine & Daunizeau, 2017; Smith & Krajbich, 2022; Stuchly et al., n.d.). This overlap can be observed on the brain level as well, with the overlapping brain regions (largely centered around the medial prefrontal cortex) being responsible for computing one's own option value when choosing for the self, and the purported other's value when predicting their choice (Nicolle et al., 2012; Piva et al., 2019; Suzuki et al., 2012). On the other hand, a mechanism representing who the decisions are made for is also expected to be present, particularly if the other person has different preferences from ourselves. Indeed, neural populations that distinguish between “self” and “predicted” decisions were identified in animal studies (Falcone et al., 2017; Grabenhorst et al., 2019) and in humans, the amygdala and the temporo-parietal junction seem to play an analogous role (Ma et al., 2024).

It is less clear whether one of these processes precedes the other one within the course of a single decision, or whether they co-occur. Harris et al. (2018) have compared the event-related potentials when participants were making food choices for themselves and when predicting the food choices of two distinct decision-makers. The strength of preference for a particular item (a proxy for value) was reflected in the 500-600ms post-stimulus ERP, regardless of whether participants were deciding for themselves or predicting the decision of another person. Additionally, an earlier ERP (350-400ms after stimulus presentation) over the central channels has signalled when a decision is being predicted for a dissimilar other (as opposed to a similar other/self), suggesting that a self-other distinction may occur before a domain-general value computation process becomes engaged. However, because the degree of self-other similarity between the participants and agents was not directly measurable, it is not clear whether the signals are attributable solely to the type of decision or to the difficulty of making such decisions.

Our study extended these findings by comparing the ERPs of 54 participants (recorded with a 64-channel EEG system with active electrodes) when they made risky choices for themselves and when they predicted the choice of two distinct (artificial) agents, while we strictly controlled the self-other similarity in risk preference across participants (Figure 1). To disentangle the unique influence of decision type (self / similar other / dissimilar other) and decision difficulty, we analysed the stimulus-locked ERP data with a regression model which included the categorical predictors of decision type (*similar* other; *dissimilar* other), the continuous predictor of trial-level decision difficulty / subjective value difference ($|sVD|$) and the interaction terms between these variables ($similar{*}|sVD|$ and $dissimilar{*}|sVD|$) which denote whether decision difficulty has a different effect in the predicted similar / dissimilar decisions, compared to self decisions

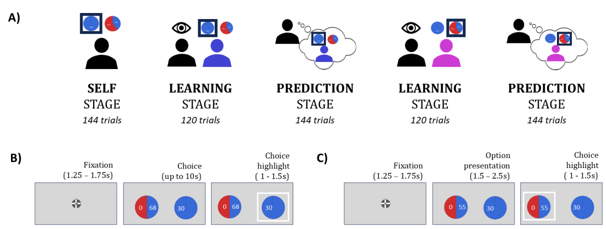

Figure 1: Experimental procedure. A) Participants first completed a set of choices between a safe and risky option for themselves. Then they observed the choices of one agent (similar / dissimilar) and finally, predicted the agent's choices on the option set from the self stage. Subsequently, participants observed and predicted the choices for the other agent (dissimilar / similar). B) and C) show the time-course of a single trial in the self/prediction and observation stages, respectively.

Results

Using a one-way within-subjects ANOVA, we tested whether our two subgroups, who made predictions either for more risk-averse or for more risk-seeking others, indicated that participants were able to adjust their predictions to the agents' different risk profiles; Post-hoc pairwise comparisons for the risk-averse group: self vs. similar ($t(17) = 4.614$, $\mathbf{p} < .001$), self vs. dissimilar ($t(17) = 7.107$, $p < .001$) and similar vs. dissimilar ($t(17) = 2.733$, $p = .036$). For the risk-seeking subgroup: self vs. similar ($t(34) = 2.464$, $p = 0.049$), self vs. dissimilar ($t(34) = 6.084$, $p < .001$) and similar vs. dissimilar ($t(34) = 4.755$, $p < .001$), suggesting that participants used different risk preferences when choosing themselves and when predicting the two agents' choices.

Figure 2 shows the group-level effect of the regressors on stimulus-locked brain activity across channels and timepoints. First, |*sVD*| showed a significant effect in the frontal, central and parietal channels, around 0.8-1.1s post-stimulus. Because the interaction terms between *similar* / *dissimilar* and |*sVD*| did not reach significance, decision difficulty seems to be represented similarly regardless of the decision type. In addition, an earlier signal (onset of approx. 0.6s post-stimulus), mostly over the central and parietal channels, distinguished the *similar* from the self

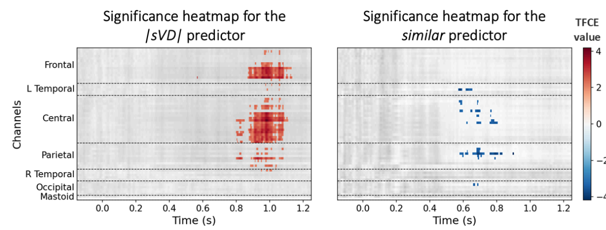

Figure 2: Significance heatmaps showing the group-level effects of statistically significant predictors on stimulus-locked ERPs. Each row corresponds to a single channel and each column corresponds to a single time-point (duration approx. 6ms). Coloured cells indicate p < .05 after a spatiotemporal cluster-corrected one-sample permutation t-test with TFCE.

decision type. No statistically significant signal distinguishing the *dissimilar* from the self decision types was identified.

In general, our results broadly align with previous work (Harris et al., 2018). We identified a fronto-centro-parietal effect of decision difficulty that was present regardless of the decision type. In addition, we found an earlier signal with a centro-parietal focus, which signals whether the decision is being made for a similar other. No consistent effect distinguishing the dissimilar and self were identified, however, suggesting that the distinction does not operate on a continuous self-other similarity basis, but may instead help prevent the self-other mergence in specific cases. Altogether, our findings suggest that the brain first distinguishes the identity of the decision-maker and how different they are from the self, followed by a more general process of computing the option value.

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