# Modelling the effect of perceived ownership on reward evaluation

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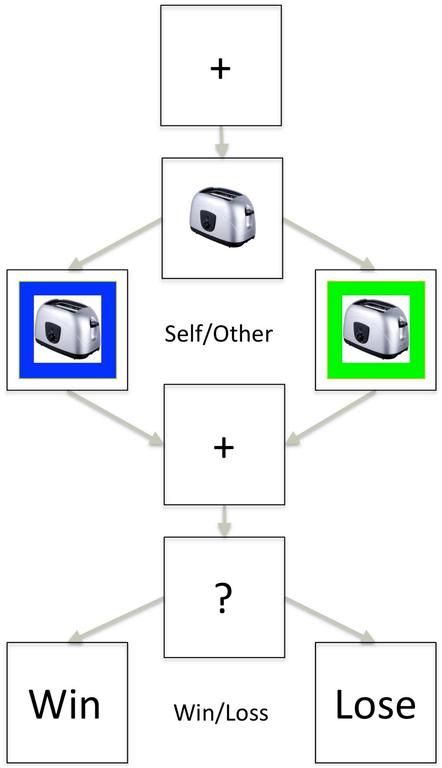
## INTRODUCTION

Perceived object ownership biases attentional processing (Turk et al., 2011). It also biases reward processing (Krigolson et al., 2012). In particular, perceived self ownership appears to enhance the output of the medial-frontal reinforcement-learning (RL: Sutton & Barto, 1998) system, as observed in event-related potential (ERP) neuroimaging data. An object lost for someone else elicits a reduced feedback error-related negativity (fERN: Miltner et al., 1997), compared to an object lost for one's own self.

## OBJECTIVES

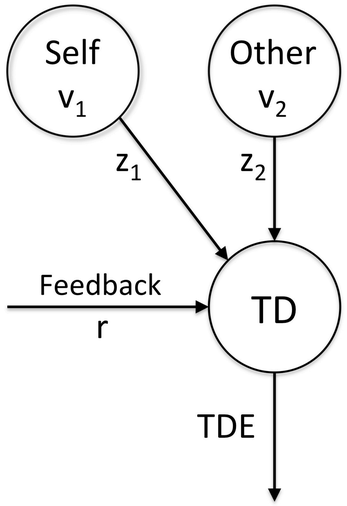
Our goal was to model the effects of perceived ownership on the output of the medial-frontal reward-evaluation system. The model's validity was tested by matching its output to human ERP data collected during a gambling task.




*Original study. In this gambling task participants were shown an object they would be playing for, followed by a coloured border indicating that they were playing for themselves or someone else.*

## METHODS

We adapted a previous model used by Holroyd and Coles (2008) by adding two cue nodes to represent self and other ownership.




*Ownership model adapted from Holroyd and Coles (2008). "Self" and "Other" represented a value layer with activation states $v_1$ and $v_2$, and weights $z_1$ and $z_2$.*

At each time step t, the value of the system's current state, V, and the temporal difference error, δ, were computed according to:

$$\hat{V}_t = \sum_{i=1}^{2} z_{i,t} v_{i,t} \qquad \delta_t = \hat{V}_t + r_t - \hat{V}_{t-1}$$

*Model 1: Equivalent Rewards*

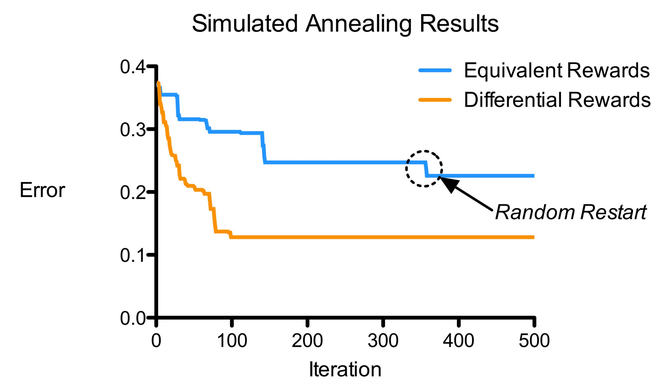
- Equivalent self and other feedback
- Parameters: $[z_1\ z_2\ r]$
- $z_1$ - "self" node weight
- $z_2$ - "other" node weight
- r - feedback (±r for both self and other)

*Model 2: Differential Rewards*

- Different self and other feedback
- Parameters: $[z_1\ z_2\ r_{ws}\ r_{ls}\ r_{wo}\ r_{lo}]$
- $r_{ws}$ - win-self feedback
- $r_{ls}$ - loss-self feedback
- $r_{wo}$ - win-other feedback
- $r_{lo}$ - loss-other feedback

## RESULTS

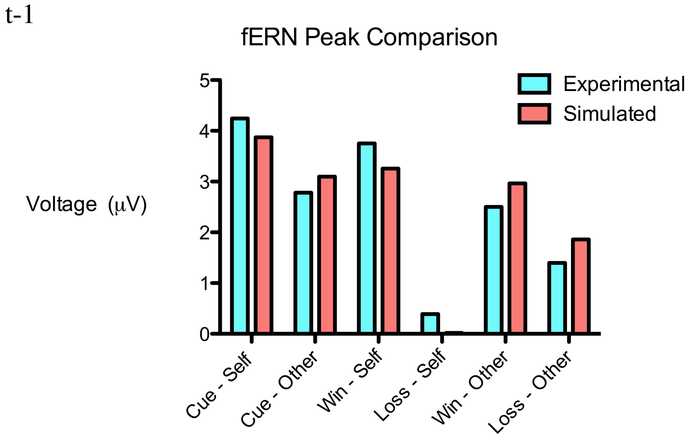
Simulated annealing with random restarts was used to fit the model output to the human ERP data.




*The equivalent rewards model resulted in greater output error compared to the differential rewards model.*

*Final Tuned Parameter Values*

| | |
|---|---|
| $z_1$ ("self" node weight) | **+0.32** |
| $z_2$ ("other" node weight) | **+0.20** |
| $r_{ws}$ (win-self feedback) | **+0.30** |
| $r_{ls}$ (loss-self feedback) | **-0.68** |
| $r_{wo}$ (win-other feedback) | **+0.01** |
| $r_{lo}$ (loss-other feedback) | **-0.15** |




*Experimental (human) and simulated (model) ERP data. The fERN is thought to reflect the magnitude of the prediction error δ (Holroyd & Coles, 2008).*

## CONCLUSIONS

Perceived object ownership biases reward processing. We modelled this effect by making two assumptions. First, separate cue nodes ensured different responses to self- and other- ownership cues. Second, different reward values for self and other rewards allowed for an even closer fit between model output and human data. Interestingly, the model predicted a correlation between cue response and feedback response. That is, when the model showed an enhanced cue response, it later gave a diminished feedback response.

We plan to investigate potential human variability in responding to self/other ownership cues, and to use the current model to predict individual feedback responses (fERNs). If the human data confirms this relationship, it will refine our understanding of how ownership might bias decision making.

## REFERENCES

- Holroyd, C. B., & Coles, M. G. H. (2008). Dorsal anterior cingulate cortex integrates reinforcement history to guide voluntary behavior. Cortex, 44(5), 548–559.
- Krigolson, O.E., Hassall, C.D., and Turk, D.J. (2012). Object ownership biases reward evaluation within medial-frontal cortex. Poster presented by O.E. Krigolson at the 2012 Cognitive Neuroscience Society meeting, Chicago, IL.
- Miltner, W. H. R., Braun, C. H., & Coles, M. G. H. (1997). Event-Related Brain Potentials Following Incorrect Feedback in a Time-Estimation Task: Evidence for a "Generic" Neural System for Error Detection. Journal of Cognitive Neuroscience, 9(6), 788–798. doi:10.1162/jocn.1997.9.6.788
- Sutton, R. S., & Barto, A. G. (1998). *Reinforcement learning: an introduction*. MIT Press.
- Turk, D. J., van Bussel, K., Brebner, J. L., Toma, A. S., Krigolson, O., & Handy, T. C. (2011). When "it" becomes "mine": Attentional biases triggered by object ownership. Journal of Cognitive Neuroscience, 23(12), 3725–3733.

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