

Evidence for parietal reward prediction errors using great grand average meta-analysis

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Rationale

- Two ERP components, the FRN and P3, have been repeatedly implicated in outcome processing. However, due to inconsistent quantification across studies, it has been unclear whether they encode a reward prediction error (RPE); where there is sensitivity to both prediction error valence and size.
- Sambrook and Goslin (2015) used a novel method, great grand averaging (GGA), to quantify published waveforms, finding frontocentral RPE encoding (the FRN) in the interval 240-340ms following feedback. The current study used the same strategy to establish if there is an RPE encoding at parietal sites.
- Following a review by San Martin (2012), the P3 has been consistently associated with a sensitivity to outcome magnitude and valence, however it has remained unclear whether these are combined into a reward prediction error.

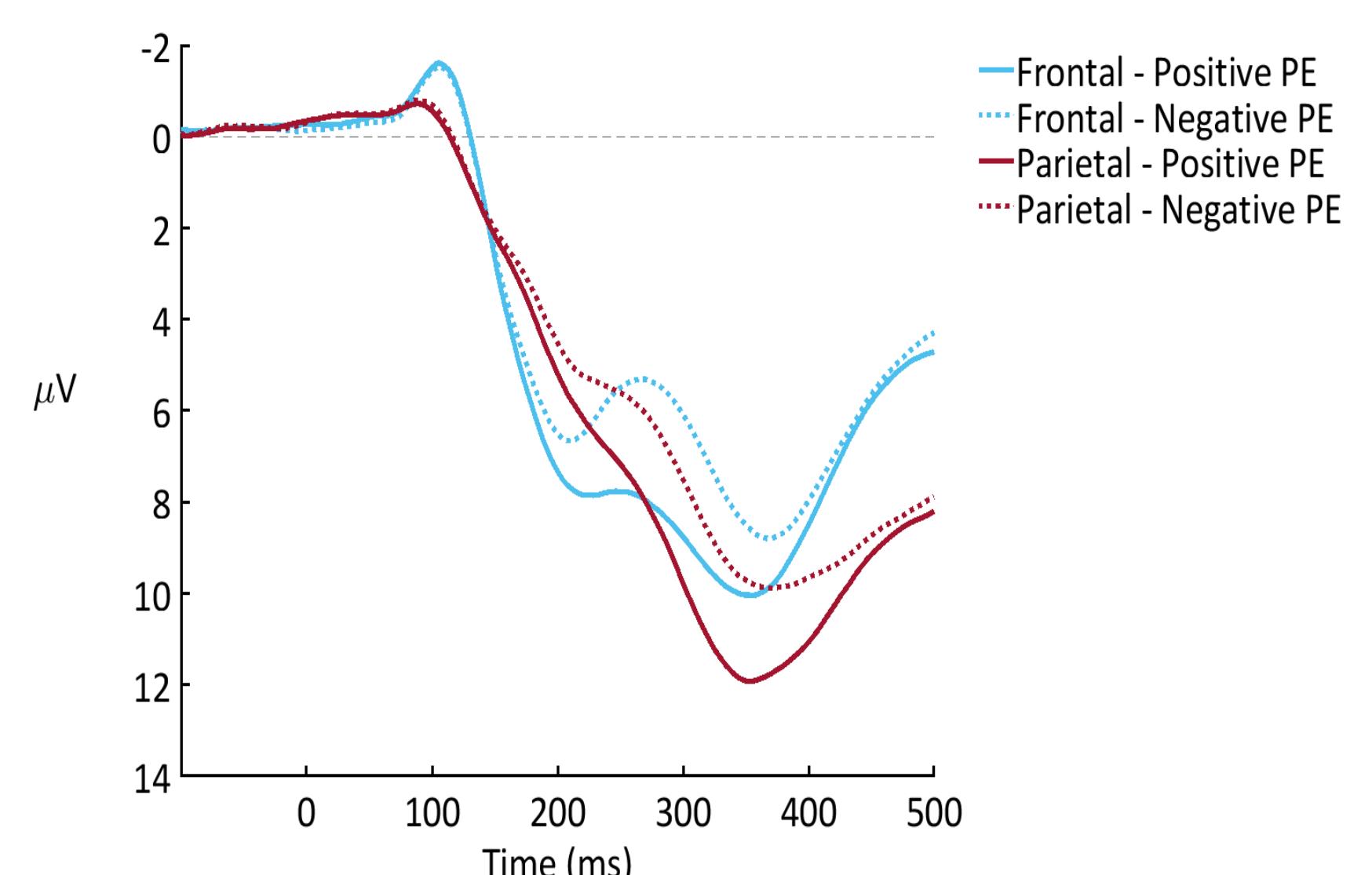


Figure 1. Great grand average simple waveforms for positive and negative reward prediction errors at frontal and parietal sites.

Method & Results

- The GGA technique uses data taken directly from reported grand average waveforms, creating composite waveforms that make up the study sample.
- Waveforms from 33 papers were used in the final sample, all fitting a factorial design of outcome valence (good/bad) x outcome size (large/small).
- A significant valence effect was found exclusively at parietal sites in the interval 400-442ms (Figure 2), and a significant RPE effect was found exclusively at parietal sites in the interval 356-418ms (Figure 3).
- These effects are both demonstrated by a positivity in voltage following better than expected outcomes.

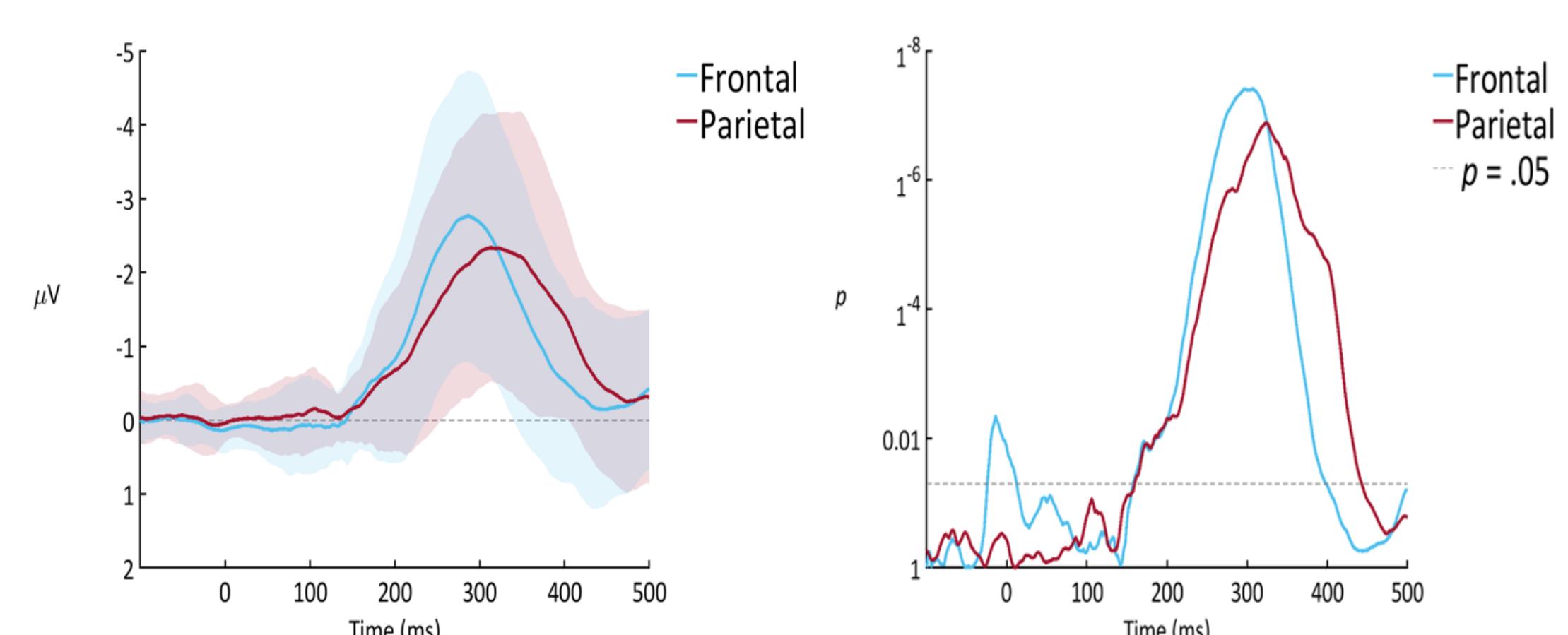


Figure 2. Effect of valence (negative – positive difference wave) at frontal and parietal sites with standard deviations shown in shadow. a. Great grand average voltage. b. Significance of each difference wave under a one-sample t test over experiments.

Conclusions

- Here we show a second component encoding reward prediction error, overlapping with the FRN, but parietally expressed in the interval 350–420ms.
- These parietal effects lie within the range of activity typically associated with the P3, providing counter evidence for claims that the P3 codes only for prediction error size.
- Future studies can use the present findings to begin to better understand human reinforcement learning, following the provision of a parietal RPE encoded in the interval 350–420ms following feedback.
- Key reference: Sambrook, T. D., & Goslin, J. (2015). A neural reward prediction error revealed by a meta-analysis of ERPs using great grand averages. *Psychological Bulletin, 141*(1), 213–235.

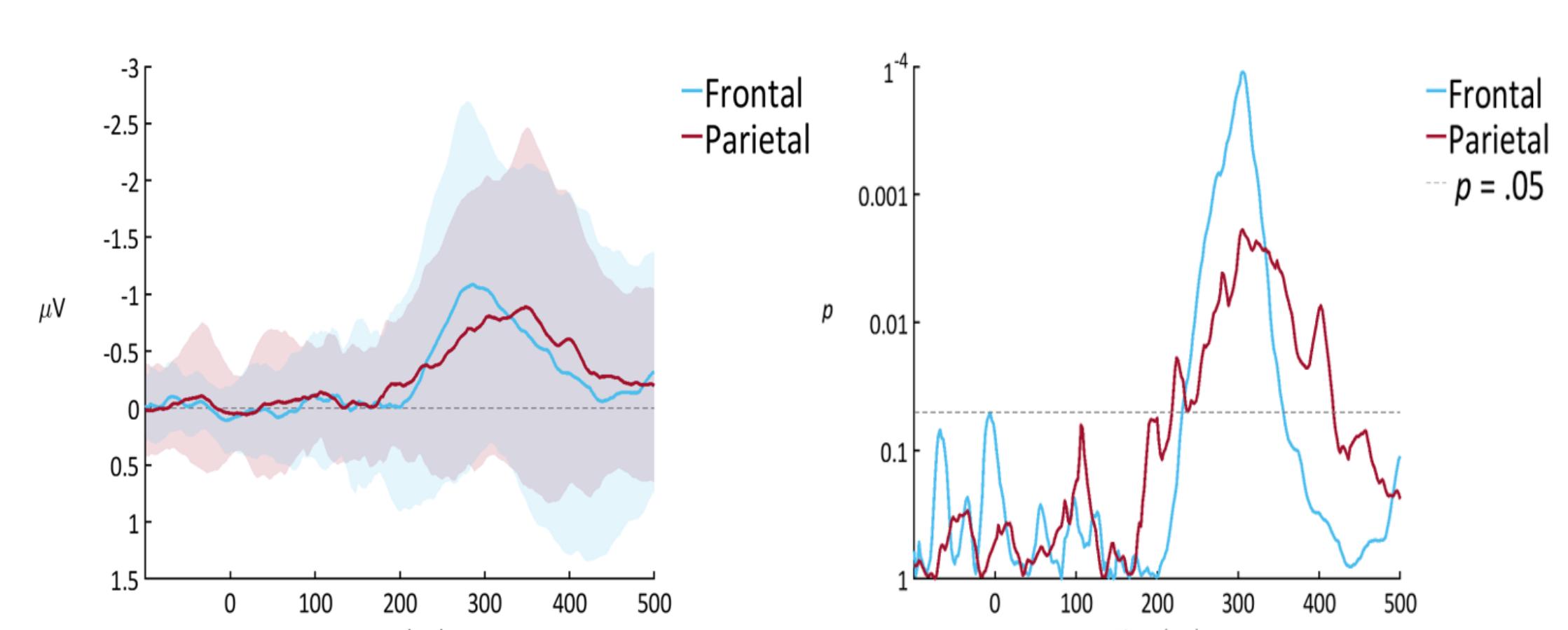


Figure 3. Effect of RPE encoding (small negative – small positive difference wave) – (large negative – large positive difference wave) at frontal and parietal sites with standard deviations shown in shadow. a. Great grand average voltage. b. Significance of each difference wave under a one-sample t test over experiments.