

Background

Temporal discounting is the decrease in subjective value of an outcome or reward that will occur in the future. While discounting is widespread, the extent to which an individual discounts depends on many factors, including emotional state and personality traits. Greater discounting is often referred to as *impatient* or *impulsive*, consistent with its association with negative outcomes in a wide range of wellbeing and life success measures.

Gratitude has been shown to reduce discounting: those induced to experience heightened gratitude are more willing to choose delayed larger rewards over immediate smaller ones (DeSteno, Li, Dickens, & Lerner, 2014). The question addressed here is whether gratitude-related changes in decision making are also reflected in electrophysiological activity of the brain, assessed using event related potential (ERP) methodology.

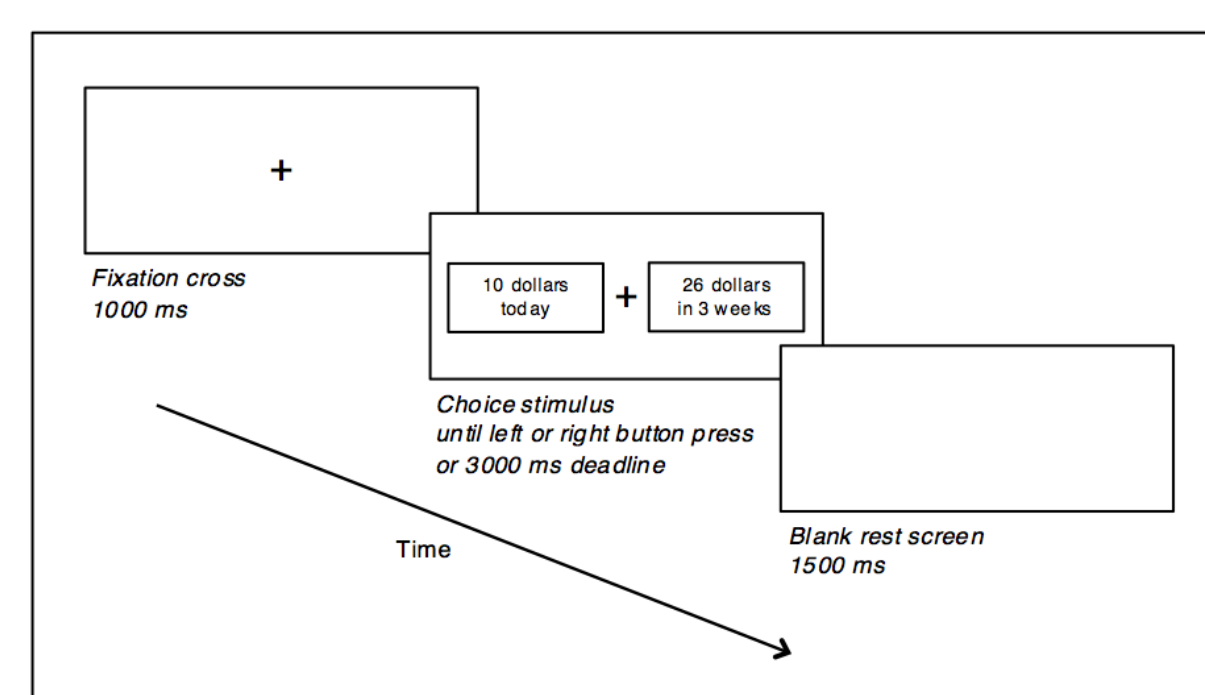
Hypotheses

Primary hypothesis: Participants (Ps) in a Gratitude (relative to those in a Neutral) condition will have greater P3 amplitudes. This positive deflection of the ERP waveform, which occurs ~300 ms after stimulus presentation at the brain's posterior midline, is thought to index the motivational significance of the stimulus.

Secondary hypothesis: Ps will have higher ERN (error related negativity) amplitudes on trials in which they make their non-preferred response. This negative deflection, which occurs ~50 ms after response, is thought to index response conflict or error detection, and may occur even when error is subjective.

Discounting Task

The decision task involved making 120 unique choices (example below) twice each for a total of 240 trials. All choices were between receiving \$10 today and a larger amount (12 possibilities from \$11-\$30) in the future (10 possibilities, from 1-16 weeks). The task was to choose a preference as quickly as possible.



Study Procedure

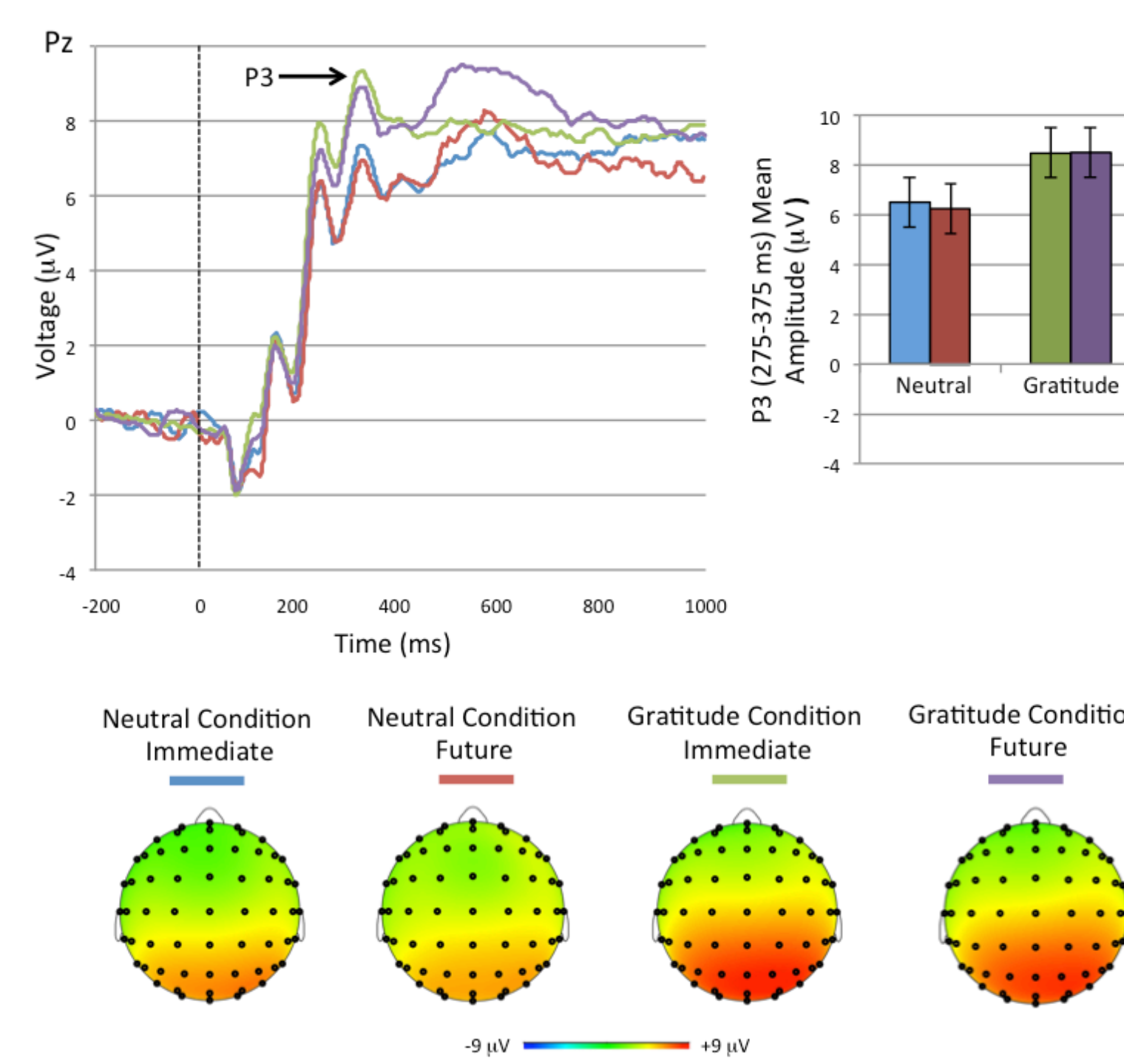
Ps were randomly assigned to either a Gratitude condition ($N = 55$) or a Neutral condition ($N = 53$). After being capped for electroencephalography (EEG) recording, Ps were prompted to recall an event that made them feel grateful (Gratitude condition) or the events of a typical day (Neutral condition) and to spend five minutes typing their recollection. Ps completed a computerized state affect measure, as a manipulation check, and then performed the decision task. They also completed individual difference measures, including anxiety and impulsiveness.

Behavioral Results

Twenty four Ps were excluded, most for insufficient (< 20) trials of one of the response types. Individual discount rate was estimated using a hyperbolic function $1/(1 + k * \text{delay})$ where a larger value of k reflects greater discounting (more immediate choices). Contrary to past work, **gratitude did not influence choice behavior**. Discount rates did not differ between those in the Gratitude ($M = 18, SD = 12, \text{range} = 1.4-48$) and Neutral ($M = 20, SD = 12, \text{range} = .07-45$) conditions, $t(82) = 0.66, p = .511$.

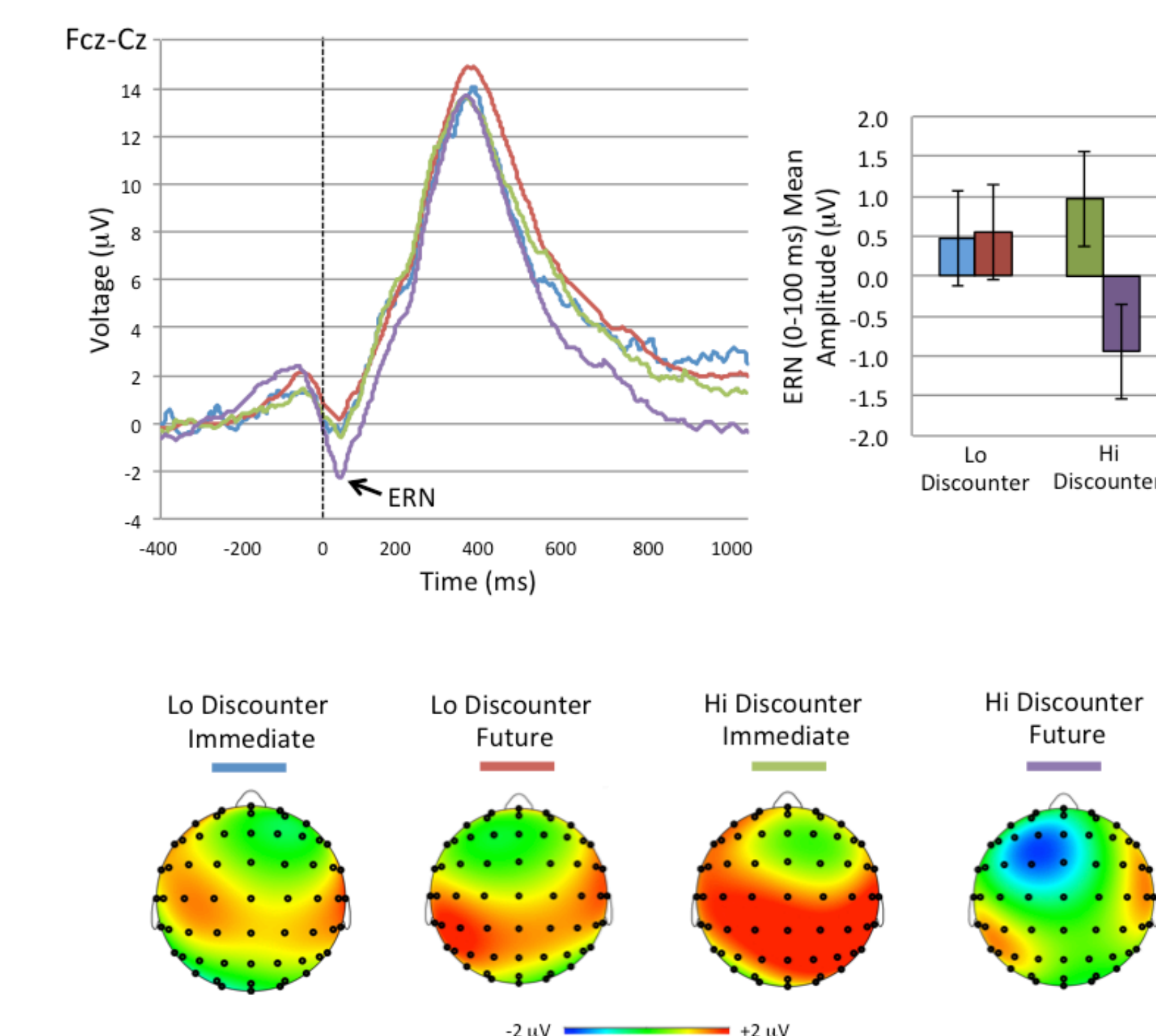
ERP Results: P3

As predicted, **individuals in the Gratitude condition had higher P3 amplitude** (at electrode Pz) than those in the Neutral condition (see below) regardless of choice response (multiple linear regression: $\beta = .33, t = 2.98, p = .004$). Also, individuals with lower trait anxiety had higher P3 amplitude ($\beta = -.34, t = -2.63, p = .010$). Discount rate (k) was not correlated with P3.



ERP Results: ERN

As predicted, **ERNs for future-reward response trials were predicted by discount rate** (multiple linear regression, at Fcz-Cz electrodes: $\beta = -.26, t = -2.54, p = .013$). In other words, individuals who were more impatient decision makers had larger ERNs when they chose a future reward. ERN was also predicted by the attentional subscale of trait impulsivity ($\beta = -.26, t = -2.47, p = .015$). However, ERNs for immediate-reward trials were not related to discount rate.



Discussion

This work provides evidence that gratitude may alter how reward stimuli are evaluated. Positive emotions have been associated with broader attention and more flexible processing. Gratitude has specifically been associated with consideration of long-term benefits of reciprocal trust. Further work is needed to explain the relationship between gratitude, behavior, and P3.

The ERN may reflect the high level of response conflict that exists when one ultimately overrides a dominant preference. Asymmetry may arise because it is more effortful to override the immediate-reward option than to override the future-reward option, regardless of dominant preference. The work provides further evidence of the ERN as a response to subjective (in addition to objective) error.

References and Acknowledgements

DeSteno, D., Li, Y., Dickens, L., & Lerner, J. S. (2014). Gratitude: A tool for reducing economic impatience. *Psychological Science, 25*, 1262-1267.

This work benefited from NSF DRL-1561214 to A.L.P.