**Abstract**

Investigations into action monitoring have consistently detailed a fronto-central voltage deflection following negatively valenced feedback, often termed the Feedback Related Negativity (FRN).

The FRN has been proposed to reflect a neural response to negative prediction errors, yet the single trial relationship between neural activity and the quanta of expectation violation remains untested.

Here we fit performance data on a learning task to an abstract computational model (Q-learning) for calculation of single-trial reward prediction errors.

Although ERP methods are not well suited to single trial analyses, the FRN has been associated with theta band oscillatory perturbations in the medial prefrontal cortex.

Single-trial theta oscillatory activities following feedback were investigated within the context of expectation (prediction error) and adaptation (subsequent reaction time changes).

Results indicate that interactive medial and lateral frontal theta activities reflect the degree of negative and positive reward prediction error in the service of behavioral adaptation.

**Methods**

**Participants**

Participants (N=50, 26 female) were on average 19 years old (SD= 1.35).

**Reinforcement Learning Task**

A probabilistic reinforcement learning task was used (Frank et al., 2004). During the training phase, four pairs of symbols are learned solely by the feedback provided after each forced choice. The feedback is probabilistic and self-contingent. The subject chooses one symbol only 60%, 70% or 80% of the time, depending on the stimulus pair presented.

Learning is assessed in a subsequent test phase, where all possible stimulus pairs are presented and participants must choose the "best one", without feedback. This next phase reveals the bias to learn toward the (new or prior preferred) stimulus.

The FRN has been proposed to reflect a neural component of condition-wide expectancy or due to volume conduction in theta band activity (Frank et al., 2004). During the training phase, four pairs of symbols are learned solely by the feedback provided after each forced choice. The feedback is probabilistic and self-contingent. The subject chooses one symbol only 60%, 70% or 80% of the time, depending on the stimulus pair presented.

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**FRN & mPFC Theta**

FRN power was related to the amplitude of medial PFC theta band activities, which presumably underlie the FRN component, are negatively related to the degree of negative prediction error and subsequent behavioral adaptation.

Multiple neural systems may be involved in the computation of different types of prediction error for different behavioral adaptations.

**Summary**

- The magnitude of prediction error is related to immediate reaction time slowing following incorrect feedback and speeding following correct feedback.
- Following incorrect feedback, the magnitude of negative prediction error and the amplitude of medial PFC theta were directly related to each other. Both of these measures predicted the degree of immediate reaction time slowing in single trial analyses (median split for display).
- PE does not significantly predict reaction time slowing when shared variance with mPFC theta is accounted for.
- Medial PFC theta power may be a reflection of a system that uses negative prediction errors to immediately adapt behavior.

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