Memory for Feedback Events Depends on Feedback Valence and Timing: Evidence from Event-Related Potentials

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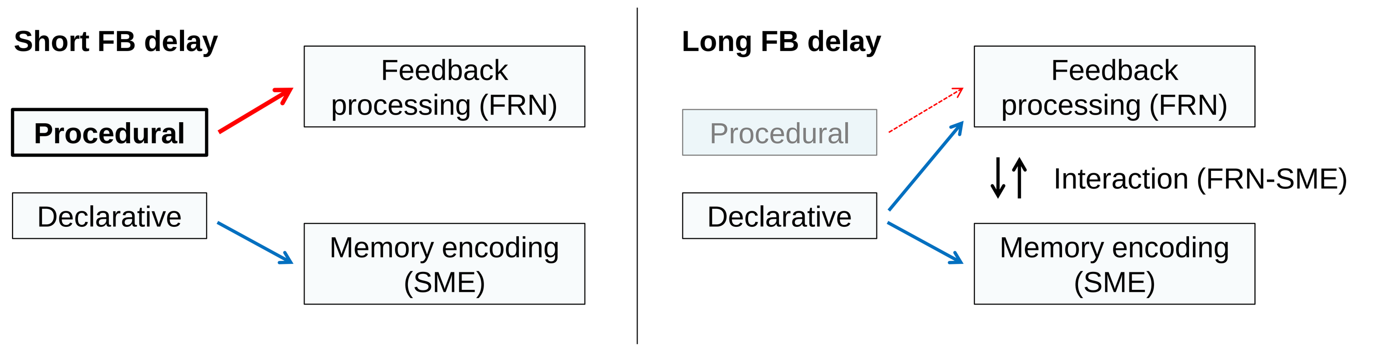
1 Introduction

- The brain systems associated with feedback-based learning and declarative memory have been disclosed (1, 2), but it is less clear how these learning systems interact.
- We used a feedback delay manipulation to dissociate the contributions of both learning systems to feedback-based learning (3).
- Motivational and attentional confounds were controlled for by probing memory for task-irrelevant scene pictures presented together with feedback in a probabilistic learning task (4).
- We explored ERP correlates of two functionally distinct aspects of feedback processing: General expectancy violations as reflected in the FRN_{peak} (5) and positive reward prediction errors as reflected in the FRN_{diff} (6).



2 Methods

Learning phase:

- Probabilistic feedback learning task: Participants learned associations between four different Chinese characters and two response keys. Two characters were assigned to each of the two feedback delay conditions (short: 500 ms, long: 6500 ms).
- **Exp. 1:** Scene pictures presented simultaneously with positive or negative feedback.
- **Exp. 2:** Scene pictures coded feedback valence (outdoor = correct, indoor = incorrect).

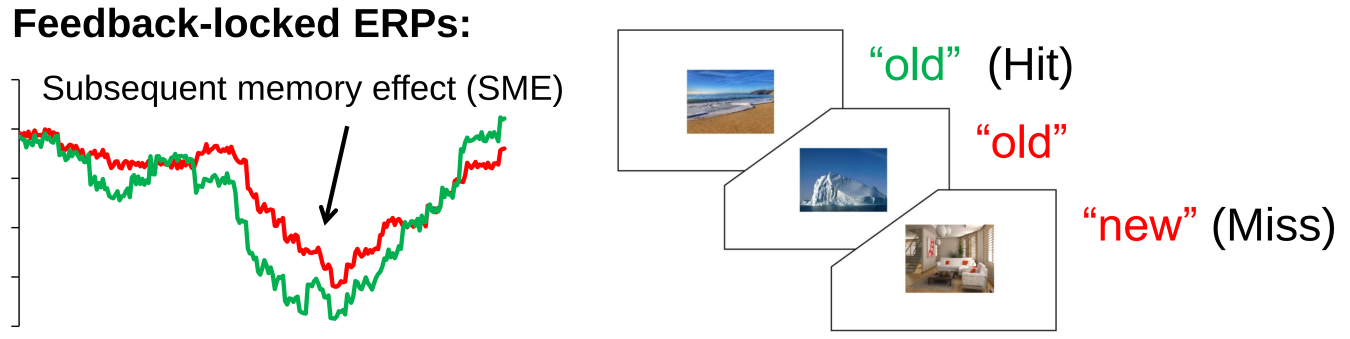
Test phase (appr. 20 min later):

- Surprise memory test , old/new decision (six-step confidence scale).

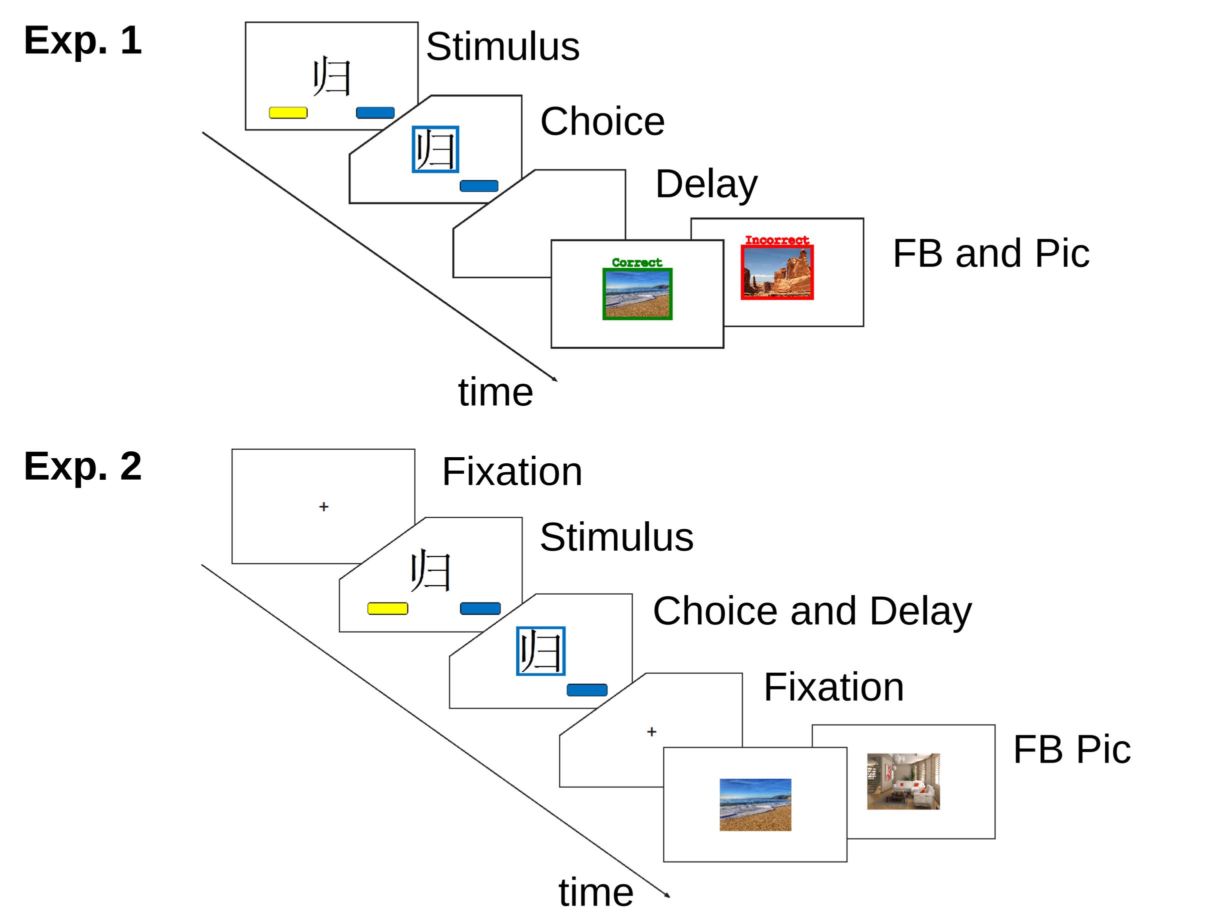
EEG recordings (learning phase)

- 28 electrodes, mastoid reference, ICA-based occular artifact correction.
- ERPs: Subsequent Memory Analysis (> 7 trials per condition).
- Correlations between single trial EEG data and reward prediction error (RPE) estimates derived from a computational reinforcement learning model (7).

Feedback-locked ERPs:

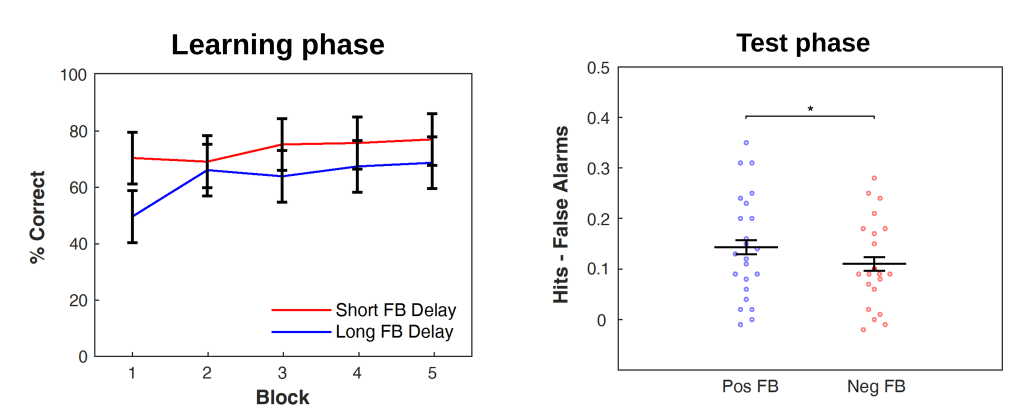


Trial procedure in the probabilistic feedback learning task:



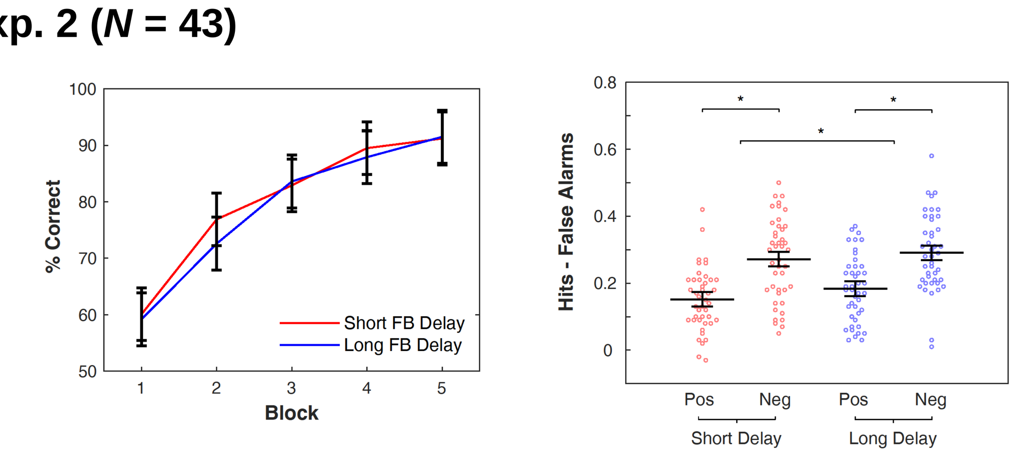
3 Behavioral Results

Exp. 1 (*N* = 23)



- Feedback delay did not affect learning and memory.
- Positive FB pictures were remembered better than negative ones.

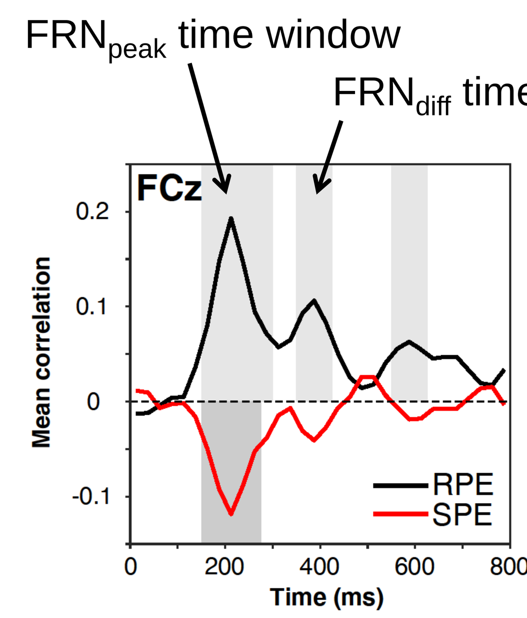
Exp. 2 (*N* = 43)



- As expected, long delayed feedback pictures were remembered better than shortly delayed ones.
- Indoor scene pictures (negative FB) were associated with better memory than outdoor scene pictures (positive FB).
- Error margins are 95% CIs based on the mean square error of the depicted effect (8).

3 EEG/ERP Results

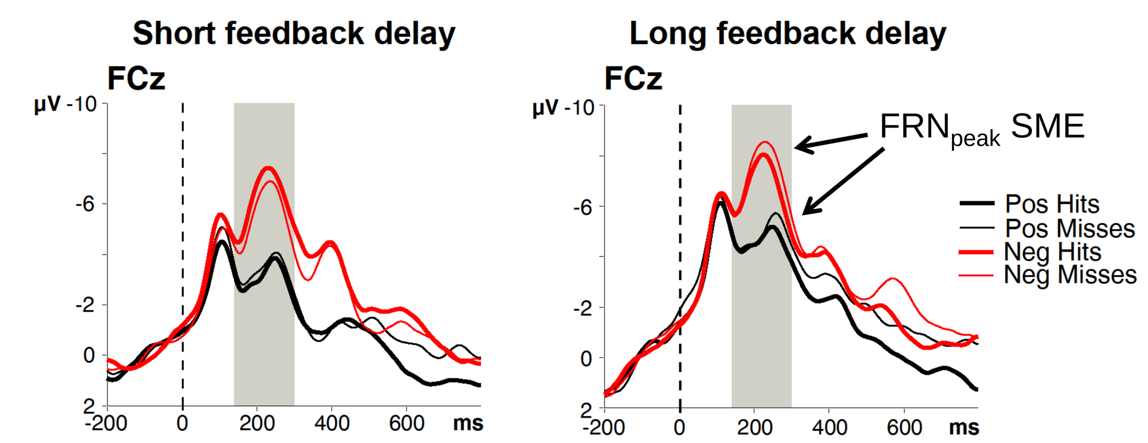
Model-based single trial EEG analysis



- Model-derived RPE estimates strongly correlated with single trial EEG data.
- Significant correlations with unsigned prediction errors (expectancy violations) only in the early FRN_{peak} time window.

Early FRN_{peak} time window

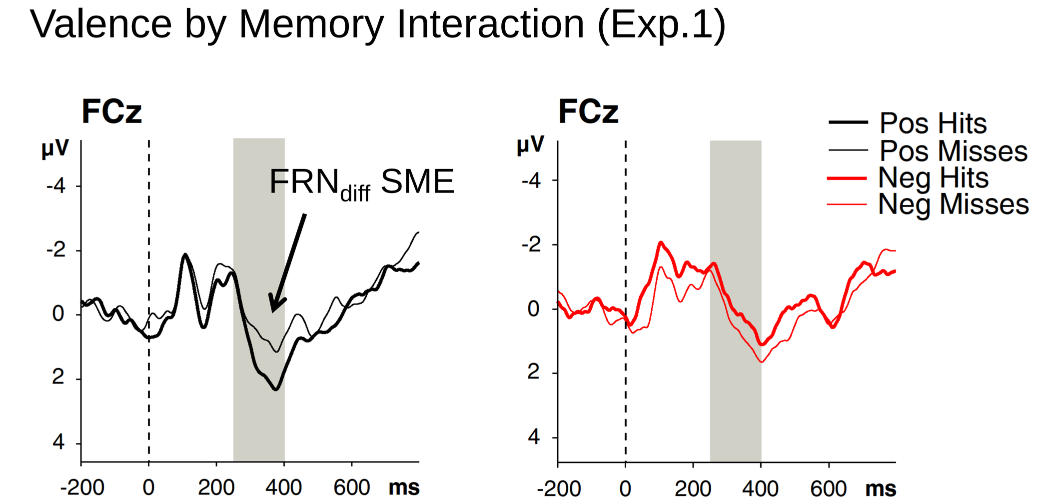
Delay by Memory Interaction (Exp.2)



Subsequent memory for feedback pictures was associated with diminished FRN_{peak} amplitudes, but only in the long FB delay condition.

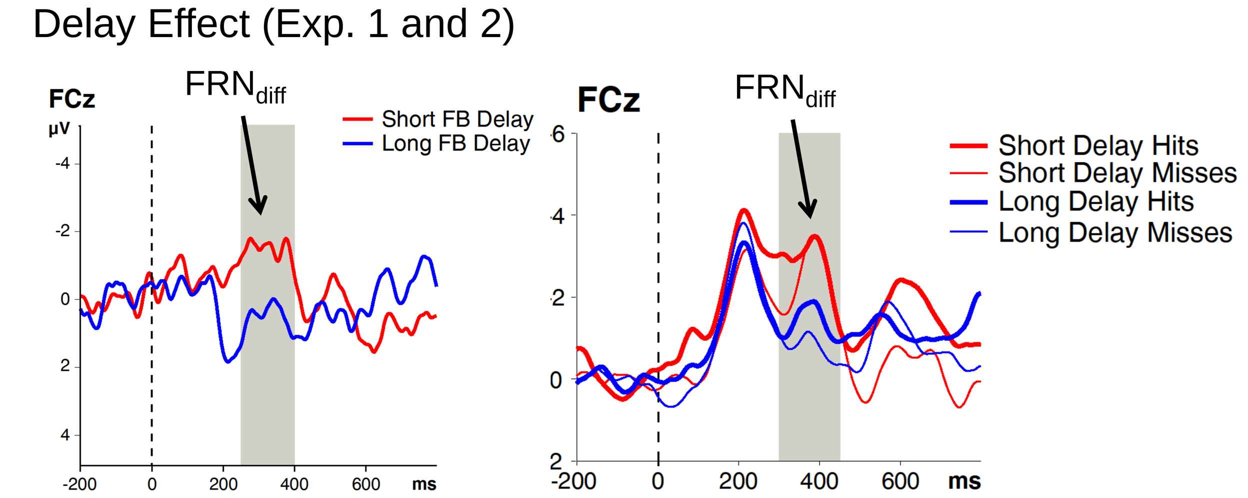
Late FRN_{diff} time window

Valence by Memory Interaction (Exp.1)



ERP mean amplitudes in the FRN_{diff} time window predicted memory for positive, but not for negative feedback pictures.

Delay Effect (Exp. 1 and 2)



In both experiments, shortly delayed FB elicited larger FRN_{diff} amplitudes than long delayed feedback.

4 Discussion

- Better memory for long delayed FB pictures only when picture content had to be processed (Exp. 2).
- As evidenced by a Delay by Memory interaction in FRN_{peak} amplitudes (Exp. 2), enhanced memory for delayed feedback events comes at the cost of diminished feedback processing. This suggests that when feedback is delayed, feedback processing and memory encoding compete for similar neural processing resources (9).
- The results of the model-based single trial EEG analysis confirm that the processing of general expectancy violations (unsigned prediction errors) is primarily reflected in the early time window in which FRN_{peak} effects were present (9).
- As evidenced by large FRN_{diff} amplitudes, the processing of shortly delayed FB strongly relied on the procedural learning system.
- When feedback processing focused on FB valence (Exp. 1), positive FB pictures were remembered better than negative ones. In conjunction with the Valence by Memory interaction obtained in FRN_{diff} amplitudes, this suggests that the processing of positive reward prediction errors boosts memory for task-irrelevant scene pictures (10).

References

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