

Reward prediction error is modulated by cooperation in group task



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Background

Outcome evaluation

- Monitoring system rapidly evaluates action outcome for appropriate behavioral adjustment.
- Feedback-related negativity (FRN) is observed following the outcome (Miltner et al., 1997).
- Reinforcement learning (RL) theory suggests that FRN reflects reward prediction error (RPE; difference between actual and predicted rewards) (Holroyd & Coles, 2002).

Outcome evaluation in group situation

- When an outcome is determined by group performance in gambling task, significance of the outcome and FRN amplitude decreases (Kimura & Katayama, 2013; Li et al., 2010).

Present study

- investigated outcome evaluation in a time-estimation task with three people, set comparable individual situation to reveal the effect of presence of other people (Experiment 1), and set comparable group situation to examine the effect of cooperation in the task (Experiment 2).

Methods

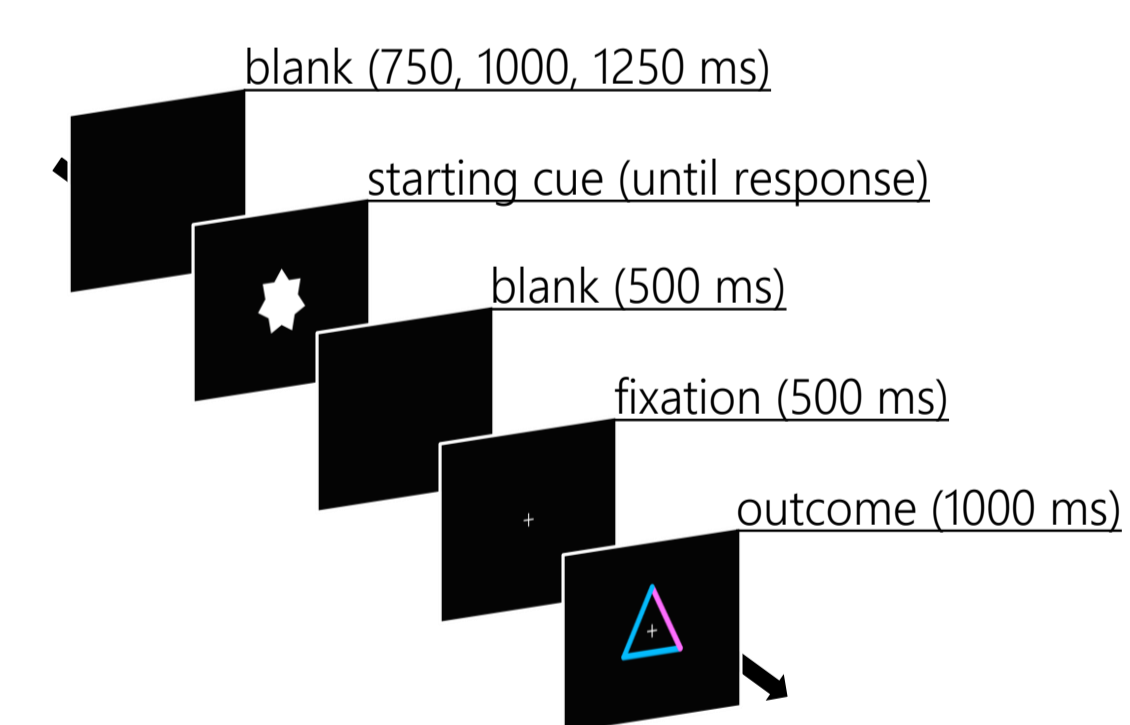


Figure 1. Sequence of a trial.

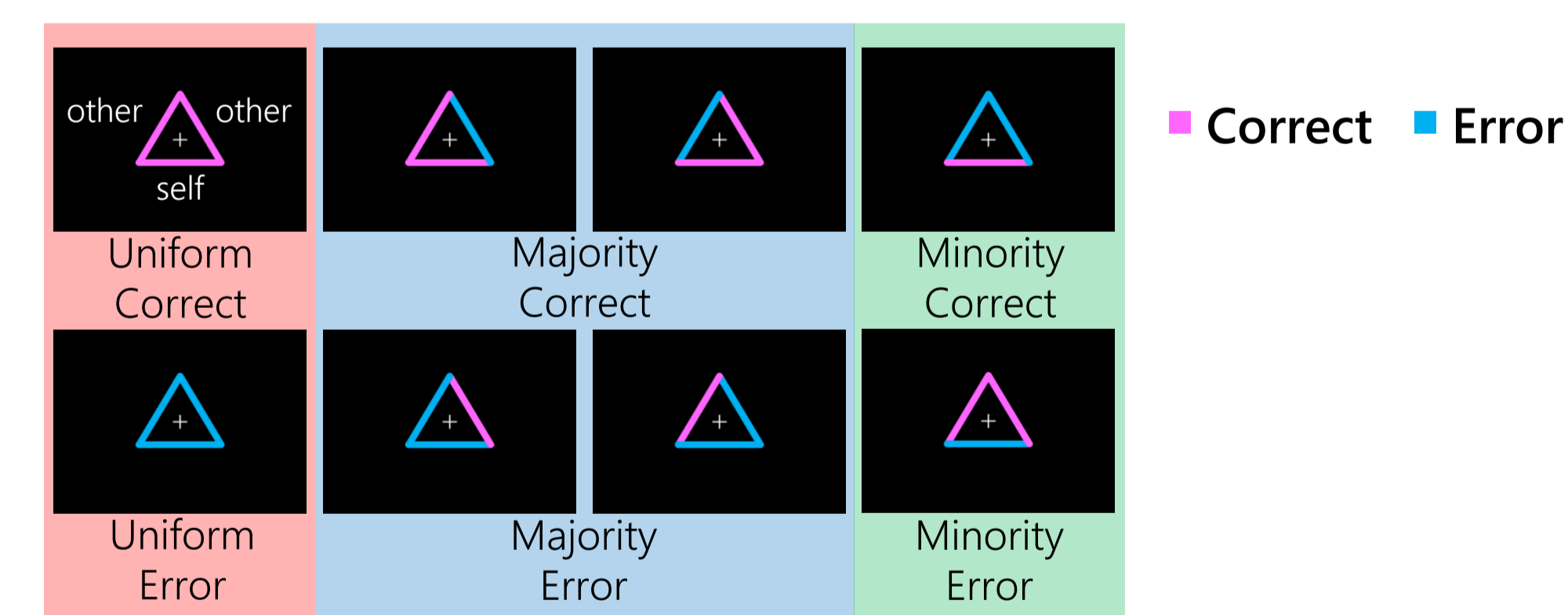


Figure 2. Possible outcomes.

Participants & Procedure

- **Ex1: In the group condition:** Sixty participants (37 females, aged 18–27 years) were assigned to equally over group and individual conditions in the experiment 1. **In the group condition**, participants played three-people time-estimation task. They were asked to push a button after 1 second following a starting cue (Figure 1). When two or more responses were correct (error), they all gained (lost) 10 JPY in a trial (see Figure 2 for an overview). At the beginning of the experiment, time range for the correct response was ± 100 ms around the 1 second. The time range was increased and decreased 10 ms by error and correct, respectively. Data from four people were rejected by computer malfunction, excessive artifact, and knowledge of the time range control. **In the individual condition**, participants followed the same procedure but the two other responses were randomly generated by a computer.
- **Ex2:** Thirty participants (16 females, aged 18–33 years) participated. They did the same procedure with group condition in the experiment 1 except that their monetary results were decided independently.

EEG recoding and analysis

- EEG signals were recorded from 32 sites (sampling rate: 1000 Hz, online filter: 0.01-100 Hz, offline filter: low-pass 20Hz, Ref: Nose, Gnd: AFz). An ICA was conducted to remove eye artifacts. Trials that exceeded $\pm 100 \mu\text{V}$ were subsequently discarded. Mean amplitude of ΔFRN (Error trials – Correct trials: 220 to 320 ms) were computed in each trial type at FCz.

Results

Behavioral results (Experiment 1)

- Percentages of six trial types and earned money between conditions were not different ($p < .67$).
- Response times in both condition (group: 1025 ms, individual: 1040 ms) were not different ($p = .40$).
- Change in response time after erroneous trial was larger than correct trial ($p < .001$).

Behavioral results (Experiment 2)

- As with Ex1, change in response time for the error trial was larger than for correct trial ($p < .001$).

ERP results (Experiment 1 (figure a and b) & 2 (figure c and d))

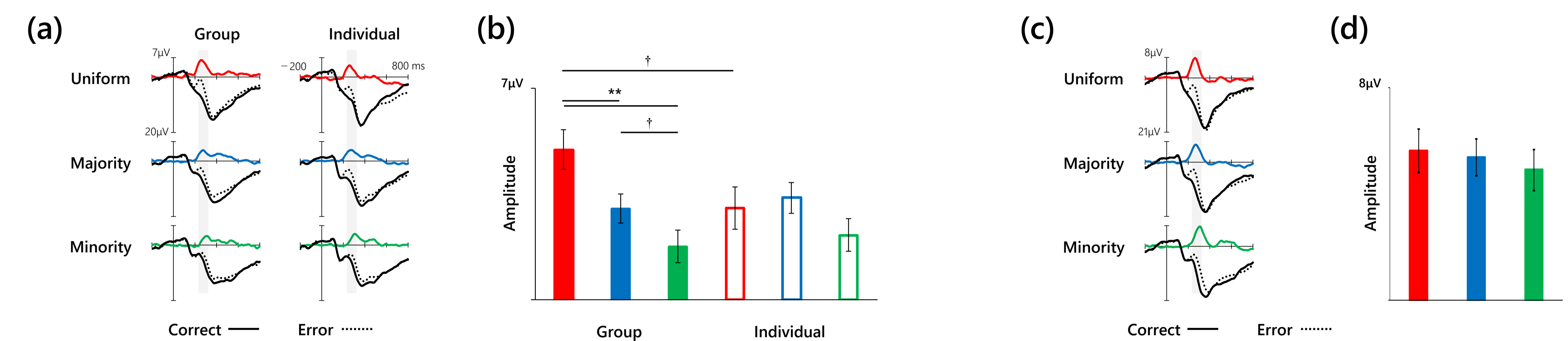


Figure 3. **[Experiment 1]** Grand-averaged ERP waveforms for both conditions and each trial type (a) and amplitudes of difference FRN (b). Interaction of condition (group/individual) and stimulus type (uniform/majority/minority) was significant ($p = .03$). FRN amplitude for the uniform trial was larger than that of majority and minority trials in the group condition, not in the individual condition. **[Experiment 2]** Grand-averaged ERP waveforms for each trial type (c) and amplitudes of difference FRN (d). There was no main effect of trial type ($p = .22$). ** $< .01$, † $< .10$.

Discussion

Overlapping of self and other's reward prediction errors

- In the "cooperative" group condition, FRN amplitude for the uniform trial was larger. Possible account is the overlapping of RPEs of self and other's outcomes. Studies that reveal observer FRN support this notion (Yu & Zhou, 2006; Marco-Pallares et al., 2010).

Difference between behavioral and ERP results

- Despite the larger FRN amplitude for the uniform trial in the group condition, change in response times were not different among trial types. Thus, computed RPE signals for other's outcomes don't affect the behavioral change in the task.