



# Cooperative context is a determinant of the social influence on outcome evaluation: An electrophysiological study



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## ABSTRACT

The present study examined whether or not a cooperative context is a determinant of the social influence on the evaluation of two action outcomes: a monetary outcome and a conflict of opinion with other group members. In the present study, three-person groups were randomly assigned to be either a cooperative or individual group and asked to perform a gambling task. The monetary outcomes in the cooperative group were interrelated among group members, whereas those in the individual group did not influence each other. The present results showed that monetary outcomes elicited feedback-related negativity (FRN) and a conflict of opinion with other group members elicited FRN-like negativity, which reflect an evaluation of the motivational significance of action outcomes. The FRN elicited by monetary outcomes was reduced when participants shared decisions with other group members only in the cooperative group, indicating that the cooperative context reduced the motivational significance of monetary outcomes through the diffusion of responsibility. The FRN-like negativity elicited by a conflict of opinion showed a different pattern between the cooperative and individual groups, indicating that the cooperative context can influence the evaluation of a conflict of opinion, possibly via the modulation of group cohesiveness or conflict processing. The present results suggest that a cooperative context, rather than the social setting, is a determinant of the social influence on outcome evaluation.

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## 1. Introduction

### 1.1. Outcome evaluation reflected in feedback-related negativity

In everyday life, the accurate evaluation of action outcomes is fundamental for making successful and efficient behavioral adjustments. However, the evaluation of outcomes is not always accurate and can be influenced by many situational factors. Recent studies have indicated that the social context, such as the mere presence of others, and cooperating or competing with other people, dramatically changes the evaluation of action outcomes (e.g., Itagaki and Katayama, 2008; Koban et al., 2012; Leng and Zhou, 2010).

Event-related brain potentials (ERP) have been used to elucidate the electrophysiological correlates of outcome evaluation in action monitoring. Several ERP studies have reported that a monetary loss or a negative performance feedback, compared to a monetary gain or a positive performance feedback, elicited a negative-going ERP component called feedback-related negativity (FRN) at around 250–300 ms after onset of the action outcome (e.g., Gehring and Willoughby, 2002;

Miltner et al., 1997). To exclude the potential effects of other ERP components such as the P300, FRN has been typically evaluated with a difference wave approach (e.g., Holroyd and Krigolson, 2007), in which a difference wave is created by subtracting ERPs elicited by positive feedback (e.g., monetary gain) from ERPs elicited by negative feedback (e.g., monetary loss). FRN has a fronto-central distribution and likely reflects neural activity generated in the anterior cingulate cortex (ACC; Gehring and Willoughby, 2002; Miltner et al., 1997; Ridderinkhof et al., 2004). A series of studies have suggested that the processes that generate FRN are involved in quickly evaluating the motivational significance of ongoing events (e.g., Boksem et al., 2011; Gehring and Willoughby, 2002; Yeung et al., 2005). Another line of research has suggested a reinforcement learning model of the FRN, which states that the FRN reflects negative prediction error or salience prediction error signals conveyed from the mid-brain dopamine system to the ACC (e.g., Holroyd and Coles, 2002; Pfabigan et al., 2011; Talmi et al., 2013).

### 1.2. Outcome evaluations in a social context

Several studies have reported that a cooperative context could modulate the outcome evaluation reflected in the FRN (for a review, see Koban and Pourtois, 2014). A cooperative context is defined as a

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situation where a pair or a group of participants is rewarded based on their joint performance. Li et al. (2010) asked participants to perform a gambling task either individually or in a three-person group. The FRN elicited by monetary outcomes was smaller when participants performed the task in a three-person group. This suggests that sharing actions with other group members can reduce the motivational significance of action outcomes. Their results can be explained by the diffusion of responsibility, which is a well-known social phenomenon whereby a person is less likely to feel personal responsibility for action when he/she works with others (e.g., Latané and Darley, 1968). Accordingly, in this paper, we define the diffusion of responsibility as a reduced sense of personal responsibility through the sharing of actions or decisions with others. Our previous study examined outcome evaluation in a group decision-making task in which a three-person group chose one of two cards based on majority rule and received monetary gains and losses according to this group decision (Kimura and Katayama, 2013). This study revealed that the FRN elicited by monetary outcomes was reduced when group members chose the same card, indicating that making the same decision as others reduced the personal responsibility for the outcomes associated with the group decision. These previous findings suggest that the outcome evaluation reflected in the FRN is sensitive to the modulation of personal responsibility.

In social situations, a conflict of opinion with others can elicit FRN-like negativity, which has been shown to have a morphology and latency similar to those for FRN elicited by monetary outcomes and performance feedback (e.g., Kimura and Katayama, 2013). The presence of FRN-like negativity has been reported when the opinions of participants differed from those of a normative group (Shestakova et al., 2013) and from those of the other group members (Chen et al., 2012; Kimura and Katayama, 2013; Kimura et al., 2013). These results suggest that a conflict of opinion is an important action outcome and is detected by the generic action-monitoring system. Since FRN-like negativity increased as the number of group members who made different decisions increased (Chen et al., 2012), this negativity, like the FRN elicited by monetary outcomes, is thought to reflect the evaluation of motivational significance of a conflict of opinion.

### 1.3. Present study

The present study focused on the effect of a cooperative context on the FRN elicited by the monetary outcome and the FRN-like negativity elicited by the presence of a conflict of opinion. An important question is whether or not a cooperative context is a determinant of the effect of a diffusion of responsibility on outcome evaluation. Previous studies have shown that performing a gambling task in a three-person group (Li et al., 2010) and having the same decision as others (Kimura and Katayama, 2013) decreased the sense of personal responsibility for the action outcome and hence the FRN. However, these studies did not distinguish between the effects of a cooperative context and those of the social setting; i.e., the mere presence of other group members, joint actions, concurrent engagement in tasks, and so forth. Therefore, it remained unclear whether the effects of a cooperative context on the FRN are due to the cooperative context itself or are merely due to the social setting.

The purpose of the present study was to examine whether or not a cooperative context is a determinant of the social influence on the outcome evaluation. To this end, we needed to compare a cooperative context condition with a valid control condition in which the group members' action outcomes would not influence each other, while the physical situation and the participants' motor actions were the same. In the present study, three-person groups performed a gambling task in which the participants were presented with the decisions and outcomes of other group members. Participants were randomly assigned to a cooperative or an individual group. In the cooperative group, participants were rewarded based on their joint performance in the gambling task. In the individual group, the physical conditions

and the participants' motor actions were exactly the same as those in the cooperative group, but the participant's monetary outcomes were not interrelated. In this gambling task, a participant's choice was classified into one of three trial types: unanimous, majority, or minority. In unanimous trials, the three group members choose the same card; in majority trials, a participant made the same choice as another group member; and in minority trials, the participant's choice was different from those of the other group members. If a cooperative context is of crucial importance for the reduced motivational significance of monetary outcomes due to a diffusion of responsibility, the FRN elicited by monetary outcomes in the unanimous and majority trials should be reduced in the cooperative group, but not in the individual group. Further, if a cooperative context influences the evaluation of a conflict of opinion with other group members, the FRN-like negativity elicited by a conflict of opinion should show different patterns between the cooperative and individual groups.

## 2. Method

### 2.1. Participants

Participants ( $N = 42$ ) were recruited from Kwansei Gakuin University and divided into 14 gender-matched three-person groups. The groups were randomly assigned to cooperative (1 male and 6 female groups; range = 18–23 years,  $M = 19.71$  years) or individual (1 male and 6 female groups; range = 18–23 years,  $M = 19.29$  years) conditions. All participants were right handed, had normal or corrected to normal vision, and did not have a history of neurological or mental diseases. The Kwansei Gakuin University (KGU) Research Ethics Review Board approved the study under the KGU Regulations for Research with Human Participants. Written informed consent was obtained from all the participants. Participants were paid 1000 Japanese yen (approximately US \$9) and a bonus based on their performance. Data from two participants in both groups had to be excluded from the ERP analysis because of excessive movement artifacts. Thus, the electrophysiological data are reported for the remaining 19 participants in each group.

### 2.2. Experimental task and procedure

The participants engaged in a gambling task in which participants in a three-person group individually chose one of two cards and received a monetary gain or loss in each trial. The presentation of visual stimuli and recording of the participants' responses were controlled with Presentation software (Neurobehavioral Systems). All visual stimuli were presented via a projector (Sight3D, Solidray) onto the center of a screen (2.4 m × 1.8 m; Kikuchi Science Laboratory) located approximately 2 m in front of the participants.

Fig. 1a shows a schematic diagram of the present task. In the beginning of each trial, the names of the three participants and two white rectangles (approximately 25 cm × 46 cm) with a thin black border were displayed. Participants were instructed that these two rectangles were cards indicating small monetary gains and losses. After 500–1500 ms, the fixation cross turned red and the instruction, "Choice!!", was presented above the cards. During this period, each participant was asked to choose the left or right card by pressing a left button with the left thumb or a right button with the right thumb, respectively. Once all of the participants had chosen a card, the color of the fixation cross returned to black and the instruction above the cards disappeared. After 750 ms, black circles (approximately 8 cm) superimposed on the corresponding card adjacent to the participants' names indicated the choice of each participant (others' choice onset). After 1000 ms, the black circles disappeared, and the two cards and the fixation cross remained for 1000 ms. Both cards were then covered with translucent red or blue rectangles and the text "+ 10 yen" or "− 10 yen" was shown above them (monetary outcome onset). Thus, both the color

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