Salivary alpha-amylase levels and rejection of unfair offers in the ultimatum game

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Abstract

OBJECTIVES: This study aimed to examine the role of emotions in rejection of unfair offers in an ultimatum game, which is of interest in neuroeconomics of fairness.
METHODS: Thirty-seven participants played a one-shot ultimatum game as responders and decided whether to accept or reject the unfair offers by the proposers. Salivary alpha-amylase (sAA) was assessed before and after the ultimatum game.
RESULTS: Forty-four percent of the participants rejected the unfair offers. While sAA levels of the participants who rejected the unfair offers increased between pre- and post-experiment, sAA levels of the participants who accepted the unfair offers remain unchanged.
CONCLUSIONS: Emotional stress response was observed when participants rejected the unfair offers. Our results indicated that rejection of the unfair offers is a reflection of emotional arousal associated with adrenergic activations.

INTRODUCTION

Recent studies in neuroeconomics have focused on the biological substrate of human economic decision-making, and neuroimaging, psychophysiological, and neuroendocrinological studies have been conducted (Sanfey *et al.* 2003; Van't Wout *et al.* 2006; Glimcher *et al.* 2008; Tabibnia *et al.* 2008). One important topic in this field is to elucidate the neural/physiological mechanisms of responding to unfair allocation of resources in an economic game which is known as the ultimatum game. The ultimatum game, which is a simple two person game, has often been employed to examine the response to unfairness (Güth *et al.* 1982; Roth *et al.* 1991). At the beginning of the ultimatum game, the proposer receives the amount of money from the experimenter and decides how to divide the amount of money between him- or herself and the partner (the responder). Then, the responder decides whether to accept the proposer's offer or reject it. When the responder accepts the offer, both the responder and the proposer receive the amount of money according to proporser's offer. However, when the responder rejects the offer, both of them receive nothing. Rational decision-theory based on a neoclassical economic model, in which humans are supposed to maximize own benefit, predicts that the responder should accept any offer above zero and the proposer should

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propose the minimum possible offer to the responder. However, a considerable number of behavioral experiments have shown that people have a tendency to care not only their own benefit but also other's benefit: the responders frequently reject the extremely unfair offers below 20 % of resources to a responder (Camerer, 2003; Yamagishi *et al.* 2009).

Some neuroeconomic studies have examined the mechanism of decision-making of responders in the ultimatum game and shown that negative emotions, like anger and disgust drive rejection behavior (Sanfey *et al.* 2003; van't Wout *et al.* 2006; Tabibnia *et al.* 2008). Using a functional magnetic resonance imaging (fMRI) technology, Sanfey *et al.* (2003) showed that the activation of the anterior insula which is related to emotional awareness was observed when participants faced the unfair offers in the ultimatum game and the magnitudes of the activation of the anterior insula were positively correlated with rejection rates of unfair offers. Moreover, a psycho-physiological study also showed the importance of emotions in rejection behavior in the ultimatum game. Van't Wout *et al.* (2006) measured participants' skin conductance response (SCR) during the ultimatum game as responders and showed that the magnitudes of activation of SCR were also positively correlated with rejection rates of unfair offers. SCR has been widely used as an indicator of the activation of the sympathetic nerve system and reflect participants' emotional arousal (Bouscein, 1992). Thus, these three studies mentioned above consistently demonstrated the importance of emotions in rejection behavior in the ultimatum game.

Neurochemically, low serotonin levels were shown to associate with rejection of unfair offers in the ultimatum game (Crockett *et al.* 2008; Emanuele *et al.* 2008). Moreover, a depletion of the serum omega-3 fatty acids was associated with rejections of unfair ultimatum offers (Emanuele *et al.* 2009). However, no study to date has examined the roles of the sympathetic-adrenal-medullary (SAM) system in economic decision-making in the ultimatum game.

Salivary alpha-amylase and psychological stress

Salivary alpha-amylase (sAA) as a physiological marker has received more attention in recent neuroendocrinological studies. A large number of experimental studies have shown that sAA is related to psychological and physical stress (Nater *et al.* 2005; Nater *et al.* 2009). Nater *et al.* (2005) used a psychosocial stress test to examine the effect of a psychological stressor on sAA levels. While a significant change was observed under the stress condition (participants conducted tasks in front of the audience), no significant change was observed under the non-stress condition. Such sAA activations occur through the operation of the sympathetic-adrenal-medullary (SAM) system, which is distinct from another stress system, i.e., the hypothalamic-pituitary-adrenal (HPA) system

In this study, we treated the salivary alpha-amylase (sAA) level as an indicator of SAM activation and examine the roles of emotional arousal in rejection of unfair offers in the ultimatum game. Because emotional arousal induced as a stress response is related to the activation of the SAM system (Nater *et al.* 2005; 2009), it is sufficiently valid to regard the sAA level as an indicator of emotional arousal when participants face and reject the unfair allocation of resources. Although some researchers had attempted to examine the relationship between stress or sex hormones and economic decision-making (Takahashi, 2004; Kosfeld *et al.* 2005; Burnham 2007; Takahashi *et al.* 2007a; Takahashi *et al.* 2007b), to the best of our knowledge, so far no study has examined the relationship between sAA levels and rejection of unfair offers in the ultimatum game. Thus, it is important to examine the relationship between sAA and economic decision-making, for a better understanding of the neuroendocrine basis of emotional responses to unfairness. We hypothesized that the elevation in sAA levels in participants who reject the unfair offers should be higher than that in participants who accept the unfair offers.

MATERIAL & METHODS

Participants

Thirty-seven healthy undergraduate students (22 females; age range: 18–21; mean age: 18.46) from Kansai University of Welfare Sciences participated in this study. All participants were informed not to drink or eat anything 30 minutes prior to the experiment. All participants submitted an informed consent form prior to the experiment and this study was conducted under a protocol approved by the Ethical Committee of the University.

Assessment of salivary alpha-amylase

In order to examine the SAM activation, we assessed participants' sAA levels at the time-points of pre- and post- experimental procedure (pre sAA and post sAA). Two times assessments were conducted before the ultimatum game, and the obtained two sAA levels were averaged. The averaged sAA level was defined as a Pre-Exp sAA level. Similarly, two times assessments were conducted after the ultimatum game. The higher sAA level of the two assessed sAA levels at the time-points after the ultimatum game was defined as a Post-Exp sAA level. For the assessment of sAA level, we utilized a commercially available hand-held monitor of sAA (Salivary Amylase Montor, Nipro Co. Ltd, Japan). This sAA monitor has been shown to accurately and rapidly (within about 3 min) measure participants' sAA levels associated with the SAM activity (Yamaguchi *et al.* 2006) and we have previously shown the relationship between sAA levels and economic decision-making by utilizing the same methodology (Takahashi *et al.* 2007a; Takahashi *et al.* 2007b).

Ultimatum game

All participants played a one-shot ultimatum game as responders. First, the participant received \1,000 (about US$ 10) from the experimenter and decided how to divide \1,000 between the two players. In this study, the proposer was absent and proposer's decision was determined by the experimenter in advance. All participants faced an unfair allocation (the proposer: \800, the responder: \200). Second, the responder decided whether to accept or reject the proposer's offer. When the responder accepts the proposer's offer, both receive money according to proposer's offer. However, when the responder rejects the offer, both receive nothing.

Experimental Procedure

The experiment was conducted between 8:00–11:00am. First, all participants received \300 (about US$ 3) as show-up fee. Participants' sAA levels were assessed on their arrival as the first time assessment. Participant completed the experiment individually in a small experimental booth equipped with an individual computer. At the beginning of the experiment, participant was provided with the instructions which explained the rule of the ultimatum game and told that the partner is in another experimental room. Actually, the partner was absent and partner's decision was preprogrammed. When participant finished reading the instructions, participants' sAA levels were assessed as the second time assessment and the ultimatum game started immediately. After finishing the ultimatum game, participants' sAA levels were assessed as the third and fourth time assessments and then participants completed the post-experimental questionnaire. Finally, they were thanked and paid.

RESULTS

According to the post experimental questionnaire, eight participants (six males and two females) were excluded from following analysis, because they suspected the actual existence of the partner (the proposer). Thirteen out of twenty-nine participants (44.83 %) rejected the unfair offers.

Salivary amylase levels on decision-making

Because the distributions of sAA levels were skewed, we transformed them logarithmically. The sAA levels of the participants are shown in Figure 1. Pre-Exp shows the mean sAA level of first and second time assessment and Post-Exp indicates that the peak sAA level out of two sAA levels at the third and fourth time assessments. The Pre-Exp sAA level was 32.5 ± 6.1 kU/l, which value was similar to previous studies employing the same sAA assessment procedures (Takahashi *et al.* 2007a; Takahashi *et al.* 2007b; Yamaguchi *et al.* 2006). We conducted a 2 (decision: accept *vs.* reject) × 2 (timing: Pre-Exp *vs.* Post-Exp) analysis of variance with repeated measure on the timing factor. This analysis revealed an interaction effect for decision × timing ($F(1,27) = 5.21$, $p<.05$). The main effects of decision and timing were not significant. A simple main effect test revealed that the Post-Exp sAA levels of participants who rejected the unfair offers was higher than the Pre-Exp sAA levels ($F(1,27) = 5.18$, $p<.05$), but there was no significant difference between the Post-Exp and Pre-Exp levels in participants who accepted the unfair offers.

DISSCUSSION

This is the first study to report the relationship between sAA levels and rejection of unfair offers in the ultimatum game. Our results showed that the sAA levels increased when participants rejected the unfair offers in the ultimatum game. The sAA level after the ultimatum game was higher than that before the ultimatum game, but this pattern was not observed when participants accepted unfair offers. These results indicate that emotional arousal associated with the activation of the SAM systems occurred when participants faced and rejected the unfair offer, highlighting the importance of emotional stress in decision-making in the ultimatum game. This study provides the first piece of evidence showing the importance of emotion in rejection of unfair offers at the neuroendocrinological level.

A recent psychoneuroendocrinological study demonstrated that low serotonin levels were associated with an exaggerated sAA elevation induced by a psychological stressor (van Veen *et al.* 2009). Furthermore, neuropharmacological studies revealed that low serotonin levels were associated with rejection behavior in the ultimatum game (Crockett *et al.* 2008; Emanuele *et al.* 2008). Our present study further demonstrated that

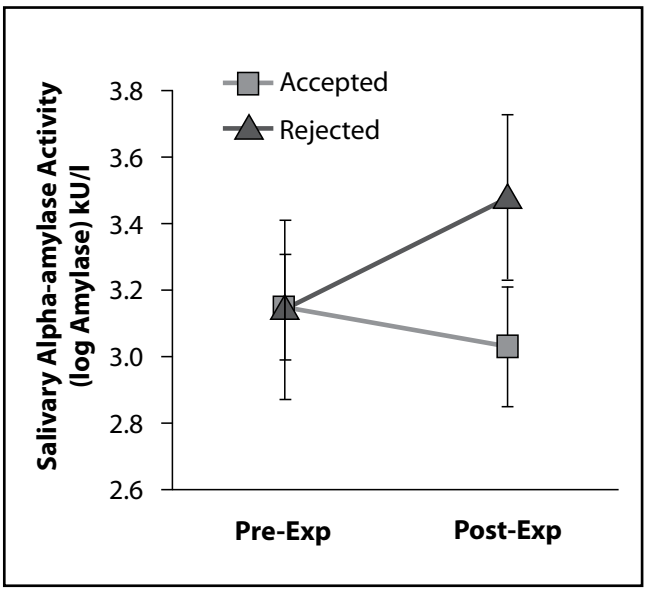

Fig. 1. Mean Level and Standard Error of sAA. Vertical bar indicates the magnitude of activation of sAA and horizontal bar indicates the timing of measurement.

an adrenergic response to unfair offers (indicated by a sAA elevation), rather than a baseline adrenergic activity (indicated by a Pre-Exp sAA level), was associated with rejection behavior in the ultimatum game. Taken together, these results imply that a low serotonergic activity and a high adrenergic responsivity may be associated with rejection of unfair offers in the ultimatum game. Future neuroeconomic studies should examine how low serotonergic levels may cause exaggerated adrenergic responses to unfairness.

Because the relationship between the types of emotion and neuroendocrine (stress) responses are still unknown, our study could not specify what types of negative emotion (i.e., anger, disgust, fear and surprise) are evoked by an unfair offer-induced stress response which resulted in rejection behavior. Although Pillutla and Murnighan (1996) reported that anger is a strong predictor of rejection behavior by the behavioral experiment and the post experimental questionnaire, other studies analyzing participants' facial expression showed that participants exhibited emotion of disgust (Chapman *et al.* 2009). Further research is needed to specify both the neurobiological substrates and the type of negative emotion by combining both neurobiological/psychophysiological measures and psychological questionnaires.

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