ORIGINAL ARTICLE

Social evaluation-induced amylase elevation and economic decision-making in the dictator game in humans

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Abstract

OBJECTIVE: Little is known regarding the relationship between social evaluation-induced neuroendocrine responses and generosity in game-theoretic situations. Previous studies demonstrated that reputation formation plays a pivotal role in prosocial behavior. This study aimed to examine the relationships between a social evaluation-induced salivary alpha-amylase (sAA) response and generosity in the dictator game. The relationship is potentially important in neuroeconomics of altruism and game theory.

METHODS: We assessed sAA and allocated money in the dictator game in male students with and without social evaluation.

RESULTS Social evaluation-responders allocated significantly more money than controls; while there was no significant correlation between social evaluation-induced sAA elevation and the allocated money.

CONCLUSIONS: Social evaluation significantly increases generosity in the dictator game, and individual differences in trait characteristics such as altruism and reward sensitivity may be important determinants of generosity in the dictator game task.

INTRODUCTION

Neural and neuroendocrine correlates of altruism and social preference have been attracting attention in neuroeconomics [1,2,3]. Most neuroeconomic studies on altruism have rather been focusing on individual differences in trait personality characteristics of altruism, with little concern as to whether social influences modulate altruistic tendency and prosocial behavior; although several evolutionary psychological studies reported that social evaluation increased the degrees of altruism in strategic social interactions such as the dictator game, indicating pivotal roles of reputation formation in altruistic behavior [4]. The previous behavioral and neuro-economic studies observed that individual differences in reward-seeking and other-regarding, and empathetic trait characteristics were associated with altruistic and prosocial behavior in game-theoretic experiments [5] (Note that "*trait*" indicates a stable and *state*-independent personality). Tellingly, although Fehr's group demonstrated that an

intranasal oxytocin administration increased trusting tendency in the trust game [6] and we reported that social stress-induced cortisol elevation (which reduces social memory [7]) was negatively associated with subject's trait personality of trusting tendency [8], no study to date examine the relationship between social evaluation-induced neuroendocrine responses and altruistic tendency in game-theoretic situations. Also, little is known as to whether individual differences in personality traits are stronger determinants of degree of altruistic behavior in game-theoretic situations, in comparison to social evaluation. Therefore, it is now important to examine the relationship between social evaluation-induced neuroendocrine response (e.g., salivary alpha-amylase elevation) and altruistic behavior.

Based on these considerations, we examined the relationship between a social evaluation-induced salivary alpha-amylase response (an indicator of sympathetic-adrenal-medullary (SAM) activation) and a degree of generosity/altruism for other people in a game-theoretic situation. In the present study, for examining the subject's degree of altruism, we employed the single-shot, non-repeated dictator game (explained below), because this game-theoretic decision task is well-established and capable of assessing subject's degree of pure altruistic tendency [5]. It is also to be noted that salivary alpha-amylase is known to be potentiated by social stressors [9].

The present study had two main objectives. First, we examined whether a social evaluation-induced response (indicated with salivary alpha-amylase elevation) increased a degree of altruism in the dictator game at the group level. Specifically, we employed both control and social evaluation condition subjects. The control subjects performed the dictator game task without social evaluation; while the social evaluation group's subjects conducted the dictator game task immediately after experiencing a social evaluation. In order to confirm the experimental group consisted of subjects who had neuroendocrine response to social elevation, we defined the experimental group subjects as social evaluation responders (the criterion will be introduced below). If there is a group difference in altruism between the control and the experimental groups, the effects of social evaluation on altruism would be confirmed at the neuroendocrinological level. As the second objective of the present study, we examined a correlation between social evaluation-induced salivary alpha-amylase elevation and degrees of altruism in the dictator game at the individual level. Importantly, if (a) the result of the first objective reveals a significant group difference between the social evaluation responders and non-evaluated control groups, and (b) the result of the second objective demonstrates no significant correlation between social evaluation-induced alpha-amylase elevation and altruism in the dictator game, it may be said that social evaluation is a potent enhancer of altruism but its effect is weaker than trait characteristics (such as reward-seeking and empathy) of each individual.

METHODS

Participants

A total of 31 male healthy university students (age: 21±3.4) participated in the present study. Participants with neuropsychiatric or neuroendocrine diseases were not included in the study. They were asked to avoid physical exercises within 1 hour prior to the participation. The participants were randomly assigned to either the control (N=16) or the social evaluation condition (N=15).

The control condition consisted of a well-established, time estimation task (a computerized task assessing participant's accuracy of perceiving 1 sec-time interval) [10] and a dictator game task (both without social evaluation); while the social evaluation condition consisted of the time estimation task in the presence of social evaluation, and the dictator game. The social evaluation group's participants were, in the beginning, instructed that their time-estimation performance will be evaluated as one type of their cognitive abilities by several psychologists, and asked to try to estimate the time-duration as accurately as possible, in the time-estimation task. Further, the social evaluation group's participants were instructed as "your accuracy of time-estimation so far is below the average score. Try much harder to estimate the 1-sec time-interval more accurately", after monitoring their initial performance. While the social evaluation group's participants conducted the time estimation task, a video camera was put in front of them and recorded the participants' actions, for effectively inducing the perception of being socially evaluated. For the controls, the video camera was not utilized. In order to test whether the social evaluation was effective, we assessed participants' sAA change between pre- and post- experiment.

Assessment of salivary alpha-amylase

In order to examine whether participants in the social evaluation condition had neuroendocrine response (specifically, sympathetic-adrenal-medullary (SAM) activation) to the social evaluation manipulation, we assessed the participants' salivary alpha-amylase (sAA) levels at the time-points of pre- and post- experimental procedure (pre sAA and post sAA). We defined "social evaluation responders" as participants who had non-negative sAA changes; i.e., sAA elevation:=[(post sAA)–(pre sAA)] ≥0. Consequently, ten subjects of the 15 social evaluation group participants were classified as the "social evaluation responders". Moreover, pre and post sAA were also assessed in the control subjects, in order to confirm that (i) the pre sAA were not significantly different between the control and social evaluation groups, and (ii) post sAA were significantly larger in social evaluation responders than controls.

For the assessment of sAA, we utilized a commercially available hand-held monitor of sAA (cocoro meter, Nipro Co. Ltd, Japan). This sAA monitor has been shown to accurately and rapidly (within about 3 min) measure subjects' sAA levels associated with SAM activity [11] and

we have previously shown that subjects' self-controlled economic decision-making was positively associated with their baseline sAA [12].

Dictator game (DG)

In order to assess participants' degrees of generosity (altruism) in game-theoretic social interactions, we conducted the dictator game with hypothetical money. All participants played roles of the "allocators" in the dictator game. Namely, they were instructed as (in Japanese): [Suppose that you have now been endowed with ¥1,000 from the instructor and there is another participant. You have an option to allocate ¥0–¥1000 of the endowed money to the other participant who is a perfect stranger to you. Please choose the amount of money you want to allocate from the list below. Please suppose as if your decision is regarding the allocation of real money] (Note that ¥1000 is approximately equivalent to US$ 10). Then, the participant selected the amount of money he wanted to allocate from the list of the amounts of money ranged ¥0–¥1000. The amount of money which the participant answered to allocate was defined as "allocation" (=X). The amount of money which the participant would keep and obtain is therefore ¥ [1000–X]. The name of the "dictator game" comes from the nature of the game-theoretic decision task that the receiver has no right to reject the allocator's proposal or punish the allocator [5]. It is important to note that a larger allocation indicates more generous/altruistic behavioral tendency of the participant, because the allocated money will not be returned or pay even in the long run [5].

Experimental procedure

All experimental procedures were conducted within 13.00–18.00. Participants' sAA were assessed on arriving (pre sAA). After the first assessment of sAA (pre sAA), participants read instructions, signed an informed consent form and waited for the onset of time estimation task while the experimenter set experimental equipments (e.g., computers, a video camera). Then, participants performed the time-estimation task (about 20–30 min) with or without social evaluation, in the social evaluation and the control groups, respectively. Next, immediately before conducting the dictator game, participants' sAA were again assessed (post sAA), in order to test whether the social evaluation was effective. Finally, the participants were asked to conduct the dictator game task (about 1–3 min). The time-interval between pre and post sAA assessments was typically about 1 hour.

Statistical analysis

All statistical procedures were conducted with R statistical language. Data are expressed as mean ± SEM. Significance level was set at 0.05 throughout.

RESULTS

Characteristics of sAA

The characteristics of sAA levels are presented in Table 1. There was no significant difference in pre sAA between the control and the social evaluation responders. The social evaluation responders had significantly larger post sAA than controls, indicating that the present social evaluation significantly induced sAA response in the 10 subjects (social evaluation responders) out of the social evaluation group.

Difference in generosity in DG between control and social evaluation responders

Next, we compared the allocated money in the DG task at the group level. Note that larger allocation indicates more generous and altruistic behavioral tendency. We observed that social evaluation responders allocated significantly larger amounts of money to a stranger ("another participant" in the instruction) in comparison to the control subjects (Table1, $p<0.05$). This indicates that social evaluation increased altruistic behavior in the DG. However, we did not observe a significant correlation between social evaluation-induced sAA elevation and the allocation, indicating that individual differences in trait characteristics of altruism may be stronger than those in social evaluation-induced sAA elevation (sensitivity to social evaluation). Likewise, there was no significant difference in the allocation between social evaluation non-responders (in the social evaluation group) and the controls ($p>0.05$).

Table 1. Characteristics of sAA levels and allocation in control and social evaluation responders.

	Control (N = 16)	Social evaluation responders (N = 10)
Pre sAA (kU/L)	33.5±7.1	24.0±4.4
Post sAA (kU/L)	24.6±5.1	46.0±6.9*
Allocation (¥)	400±50.0	550±52.2*

* significantly larger than control ($p<0.05$). Social evaluation responders allocated significantly more money to another person. Note that larger allocations indicate higher degrees of generosity/altruism in the dictator game.

DISCUSSION

This study is the first to report that social evaluation responders in terms of sAA showed higher degrees of generosity in the DG. Several evolutionary theoretical studies state that a motivation towards reputation formation under social evaluation plays a pivotal role in altruistic behavior [4]. The present study is the first evidence of the hypothesis at the physiological and neuroendocrinological level. Furthermore, previous studies indicated the importance of individual differences in trait characteristics of reward dependency and social preference in determining the degree of generosity/altruism in game-theoretic behavior [5]. The

present results that there was no significant correlation between social evaluation-induced sAA elevation and the allocation of money to a stranger supports this proposal. Furthermore, because it is well known that social stressors such as Kirschbaum's Trier Social Stress Test (TSST) dramatically potentiate subjects' cortisol levels and sAA [13], future studies should examine whether TSST also enhance altruistic behavior in strategic social interactions. Moreover, it may be considerably important to examine what neurobiological and genetic factors determine the individual differences in altruistic behavior, independently of the influences of social evaluation.

Limitation and future directions

In this study, we only employed male subjects. Because there may possibly be gender differences in altruism in strategic social interactions, future studies should employ females. Also, because our present study utilized hypothetical money, real money should further be utilized in future studies on the relationship between social evaluation-induced physiological and neural responses and altruistic behavior. Moreover, we did not assess personality scales (measures of trait characteristics) related to prosocial behavior. Future behavioral game-theoretic studies should examine the relations between them. Because previous neuroendocginological studies reported that baseline cortisol levels and social stress-induced cortisol elevation are associated with subjects' trait personality and cortisol levels are also related to self-controlled economic decision-making [14,15], future studies should examine how individual differences in trait personality-related cortisol responses are associated with those in game-theoretic behavior.

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