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Research report

The sweet side of inequality: How advantageous status modulates empathic response to others' gains and losses

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HIGHLIGHTS

- Advantageous status modulates empathic response to monetary gains and losses.
- Feedback-related potential (FRN) could reflect empathic responses.
- FRN and P300 have dissociated roles in social decision making.

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ABSTRACT

In the past decade, considerable amounts of studies have explored the neural underpinnings of empathic response toward the positive and negative feelings of others, such as pain and social exclusion, in the field of neuroeconomics. In addition, empathic response of observing other's financial gains and losses have recently started to gain increasing attention in this interdisciplinary field. However, the effects of inequality-averse social preference on individuals' response toward other's gains and losses have not yet been clearly characterized. This work conducted an electrophysiological study with a simple gambling task to explore how inequality aversion matters in modulating neural temporal dynamics toward self and others' gains and losses using scalp-recorded event-related potentials (ERPs). The electrophysiological data demonstrated increased amplitude of P300 toward self's monetary gains and losses independent of advantageous and disadvantageous status. Intriguingly, subjects in the high pay group evoked more pronounced gain loss disparity of feedback-related negativity (FRN) amplitude toward others than themselves. Meanwhile, such a pattern was not observed among the subjects in the low pay group. Therefore, the current double dissociation results of FRN and P300 may indicate that advantageous status enhances subjects' empathic response toward others' pecuniary outcome, giving a direct electrophysiological evidence for the economic modeling on inequality aversion behavior.

1. Introduction

Human beings by nature are social creatures. In addition to caring about their own personal interests, individuals are also concerned with the fortune and misfortune of others in dynamic interpersonal interactions. Empathy, or the capability to experience and share with what others feel, is vital in the social context. Philosophers and psychologists have paid attention to this aspect for centuries. In addition, in the past decade, a growing number of studies have investigated its neural mechanism [1–4]. At present, numerous studies have paid close attention to the empathic response of pain and found that the passive observation of others in pain evoked a largely similar neural pattern compared to incurring the pain in a direct manner, indicating the "shared representations" of others' suffering. Similar with the empathic response toward the negative stimuli (i.e., pain), recent studies have also revealed that individuals empathetically respond to others' financial reward. For instance, a recent functional magnetic resonance imaging (fMRI) study investigated how individuals empathize with others' monetary reward [5]. They found that the subjects had greater reward region activation when they observe another subject who was socially similar with themselves win at gambling, as opposed to those who were socially dissimilar. Such results indicate that positive monetary reward could also be mirrored in the brain, which is analogous to electric-induced pain.

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In light of the modulatory factors of empathy, many social factors are involved in modulating the empathic response toward others, of which a very important one is inequality. In a pioneering study, Sanfey et al. asked the subjects to act as the recipient in a one-shot ultimatum game while their brain underwent scanning in fMRI [6]. They found that regions related with negative emotion, namely, anterior insula (AI), anterior cingulate cortex (ACC), were more responsive to unfair offers compared with fair offers from a proposer. Singer et al. (2006) extended the aforementioned study to examine how such unkind behavior from others modulated individuals' empathic response when they observed others experienced pain. They found that the subjects, especially males, had gloating attitudes toward those who treated them unfairly in a game before the empathic task. Instead of these empathic regions (i.e., AI, ACC), the reward-related region (i.e., the ventral striatum) was involved when they saw that the betrayers experienced electric shock [7]. Therefore, as an important situational context factor, this acquired social image modulates individuals' empathic response toward others.

However, most contemporary neuroeconomic studies have mainly centered on the neural response of individuals under disadvantageous inequality [6,8–11]. Only a few studies have focused on the instinct motivation of human beings to reduce the inequality of distributional outcome [12]. In the original inequality framework for economic modeling developed by Fehr and Schmidt [13], they posited that humans are inequality-averse and egalitarian; the coefficient "alpha" in the model indicates that the envy originated from disadvantageous inequality, and the coefficient "beta" embodies the guilt aversion from the advantageous status of the decision makers [14]. Adopting a simple and ingenious design, a recent study explored this possible neural evidence of inequality-averse social preference existing in the brain [15]. Paired subjects were recruited; at the beginning of the experiment, they randomly endowed one subject from each pair with a large amount of money from a lucky draw. Afterward, the paired subjects were asked to evaluate further monetary transfer to both subjects in the scanner using a dictator game. They found that although subjects from the high pay group scored their higher monetary transfer as more satisfactory in their self-reported ratings, the increased reward-related regions (the ventral medial prefrontal cortex and striatum) were recruited when they saw that their disadvantageous counterparts won a larger amount of money compared with the amount they received. This study was the first to provide direct evidence for the existence of advantageous inequality aversion in the brain. Inspired by this study, by adopting an electrophysiological approach, the present study intends to integrate status manipulation with a financial empathic paradigm to explore how advantageous status modulates subsequent empathic response to others' financial gains and losses.

With the rapid development of the interdisciplinary field of neuroeconomics, decision making under social context has also elicited considerable attention in electrophysiological studies. Two event-related potential (ERP) components, namely, feedback-related negativity (FRN) and P300, especially the former, are the key foci of studies under this theme. Mounting evidence indicates that FRN, a component distributed over the frontal area of the scalp and peaking at approximately 200–300 ms following the revelation of unfavorable feedback, reflects the correctness of the decision that subjects made [16,17]. In an early study, Gehring and Willoughby (2002) adopted a gambling task in which subjects were instructed to make a trade-off between options with small and large stakes, which may result in a corresponding win or loss; the uncertainty of both options was resolved as long as the choices were made by the subjects. They explored the stimuli-locked ERP amplitude at the stage of outcome revelation and found a prominent differentiated FRN (d-FRN) toward the loss–gain divergence of the results, reflecting the motivational and affective evaluation of the revealed outcome [18].

Moreover, recent scientific attempts have successfully extended the FRN exploration into social context. Electrophysiological studies revealed that the representation of vicariously experienced gains and losses is similar with experiencing their own wins and losses, comparable to those observed in the fMRI studies [5]. In a previous study, Yu and Zhou asked the subjects to perform a gambling task while observing the other subjects' performance of the same gambling task alternatively. They observed that the mere observation of others' performance also induced an increased loss–gain FRN discrepancy, with relatively smaller amplitude but similar morphology and scalp distribution as compared to the FRN divergence of the outcome for themselves [19].

In addition, this socially induced FRN is also modulated by social factors. In a recent report, Marco-Pallarés et al. recruited three groups of paired subjects to participate in a gambling task [20]. In each pair, one subject was assigned as an observer and the other as an executor. The executors were asked to carry out the gambling task in all three pairs, whereas the observers were instructed to passively observe the gambling task in three different scenarios. The gain–loss outcome of the gamble from the executors would entail observers' neutral, parallel, or opposite earnings. They observed that the amplitudes of the FRN of the observers adaptively reacted to discrepant manipulated conditions. The gain–loss discrepancy of FRN was prominent in the neutral condition, which was similar with the FRN under parallel condition and those observed from the executor but not in the opposite condition. Therefore, they concluded that empathic and affective processes might be essential in neutral condition, which is consistent with the motivational theory of FRN [18,21].

Recent studies further confirmed that observation-induced d-FRN is related to the empathic response to others' gains and losses. Fukushima and Hiraki (2009) found that human outcome, rather than that obtained by computers, could evoke the gain–loss discrepancy of FRN toward non-self agent, and this differed FRN amplitude was positively correlated with the empathic traits of the subjects, as measured by a self-reported questionnaire [22]. To confirm this further, Leng and Zhou attempted to explore how the social contexts modulate electrophysiological response of empathy toward others' gain and loss with varied degree of familiarity [23]. In their study, subjects were engaged in a gambling task while they observed two others with differed familiarity perform the same gambling task. Their study revealed that observers exhibited a more prominent P300 toward their friends rather than toward strangers. Such results are in accordance with previous studies that P300 reflects the attentional allocation and motivational salience of the stimuli [24]. Moreover, although the own performance of the subjects induces a larger FRN compared with those of others, no obvious differentiation of FRN was found in the conditions between friend and stranger observation. Our recent study replicated their conclusion that P300 represented the agent difference among self, friend, and stranger [25]. Moreover, our study extended that the unobserved d-FRN difference might be due to the self-involvement of the empathizer. Although the observers themselves did not attend the gambling experiment, we observed a prominent d-FRN between their friends and strangers, and the difference of the P300 remained. Therefore, the amplitude of FRN could actively represent the decreases or increases of others' empathic response in a socially changing context. In general, converging studies indicate that the amplitude of FRN could be flexibly modulated by a specific social context, reflecting the motivational significance of the outcome.

Therefore, to address the potential role of advantageous inequality aversion in modulating the empathic response to others' pecuniary outcome, the present study attempted to explore the