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Neural bases of the adaptive mechanisms associated with reciprocal partner choice

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ABSTRACT

In our society, partner choice is often reciprocal and, therefore, compromising one's choice may be adaptive depending on one's own market price. To reveal the neural mechanisms underlying this adaptive process, functional magnetic resonance imaging (fMRI) was performed on 27 male subjects during virtual partner choice tasks involving a dance-partner choice or a part-time job choice. Following the evaluation of a rival, the subjects chose a partner either in the face of competition with a rival (reciprocal choice condition) or during no competition (nonreciprocal condition). Irrespective of the type of partner choice situation, the posterior cingulate cortex (PCC) and right temporoparietal junction (TPJ) were specifically activated during reciprocal partner choice. The PCC was also activated during the evaluation of a rival relative to the self, which indicates the involvement of this region in the processing of one's own market price. Activation in the right TPJ was related to the individual tendency to avoid choosing a higher-value candidate when the rival-value was high in the reciprocal choice condition, which indicates that this region plays a role in market-adaptive strategy. Taken together with extant anatomical knowledge, the two-component neurobiological structure underlying the adaptive mechanism of partner choice identified in this study seems to represent the hierarchical evolution of the human socio-cognitive system.

1. Introduction

In real societal situations, partner choice is often reciprocal. When an individual chooses from among partner candidates to make an offer, that individual not only evaluates the partner but is also "priced" by the candidates, who have the choice of multiple offers to accept (i.e., "the market"). A male tends to want to make an offer of a romantic relationship to the most beautiful female among the available options, and similarly, she wants to accept an offer from the most attractive male available to her. Similarly, a job applicant wants to apply for the best option among job offers, and the employer seeks out the most qualified option from among the available applicants. It is often a waste of choice opportunities to pursue only options with the highest value when one's value is inferior to one's rivals for that choice (i.e., when one's "market price" is low). Given the limited time and resources that one has to invest in one's own life, it is usually adaptive to compromise one's choice depending on one's own market price (Kirkpatrick and Ellis, 2003; Penke et al., 2007). In economics, optimal partner matching under these types of market dynamics is a central research issue (Kojima and Pathak, 2009; Roth and Sotomayor, 1992). However, the mechanisms used by the human brain to deal with these market dynamics, which may be the result of evolution for social survival (Kirkpatrick and Ellis, 2003), remain poorly investigated.

In an attempt to uncover the neural bases underlying the adaptive mechanisms during reciprocal partner choice, this study focused on two essential components: the processing of one's own price in the market and the strategic choice process that would be adaptive in the market (Kirkpatrick and Ellis, 2003; Penke et al., 2007). The former is the processing of the relative value of oneself among choice rivals; that is, one's own market price from the perspective of partner candidates. The latter is the process of using this self-price information for adaptive choice behavior (i.e., market-adaptive strategy); that is, to consider compromising one's choice to maximize gain expectation when one's own market price is low. Note that in this study we focused on the processes directly relevant to the choice; processes preceding the choice, such as

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computation of one's own market price using perceived information (Farrow et al., 2011; Cartmell et al., 2014), or those following the choice, such as the updating of one's own market price based on feedback (Zink et al., 2008) were outside the scope of this study.

Two functional neuroimaging studies have addressed partner choice but neither study assessed these two essential processes. In one study (Funayama et al., 2012), activation during two types of partner choices (spouse and friend) was compared to activation during a control choice condition (luminance judgment). Although the partner-choice conditions used in that study implied reciprocity, the involvement of these processes was neither warranted nor dissociated from other processes such as the value computations of partner candidates or self. In another study (Cartmell et al., 2014), activation while viewing the face of a partner candidate was compared between when personality compatibility was high and when it was low. High personality compatibility was associated with a high probability of one's offer being accepted, and was thus comparable to a high market price. However, no analyses of brain activation during the actual choice were performed in that study.

In this functional magnetic resonance imaging (fMRI) study, two types of virtual situations involving partner choice (Fig. 1a and b) that included reciprocal (R) and nonreciprocal (N) conditions were employed. Each trial comprised a series of evaluation (E) and choice (C) tasks that temporally dissociated the self-price calculation from choice processes. In the R condition (Fig. 1c), the subjects first evaluated (RE task) the relative value of a virtual rival against their own value (i.e., their own market price). Then they made an offer to one of two candidates (RC task) knowing that competing with a superior rival for a higher-value candidate was likely to result in failing to obtain that partner. In the N condition (Fig. 1d), the subjects first evaluated (NE task) the value of a rival relative to the social standard (i.e., no reference to one's own market price). Then they chose one candidate (NC task) assuming that they had priority in choice over the rival and, therefore, did not make reference to their own market price.

Because we were interested in cognitive processing independent of the type of value or information, the two chosen partner-choice situations differed with regard to the type of value that determined the market price and the type of information that represented the value. In a dance-partner choice situation (Fig. 1a),

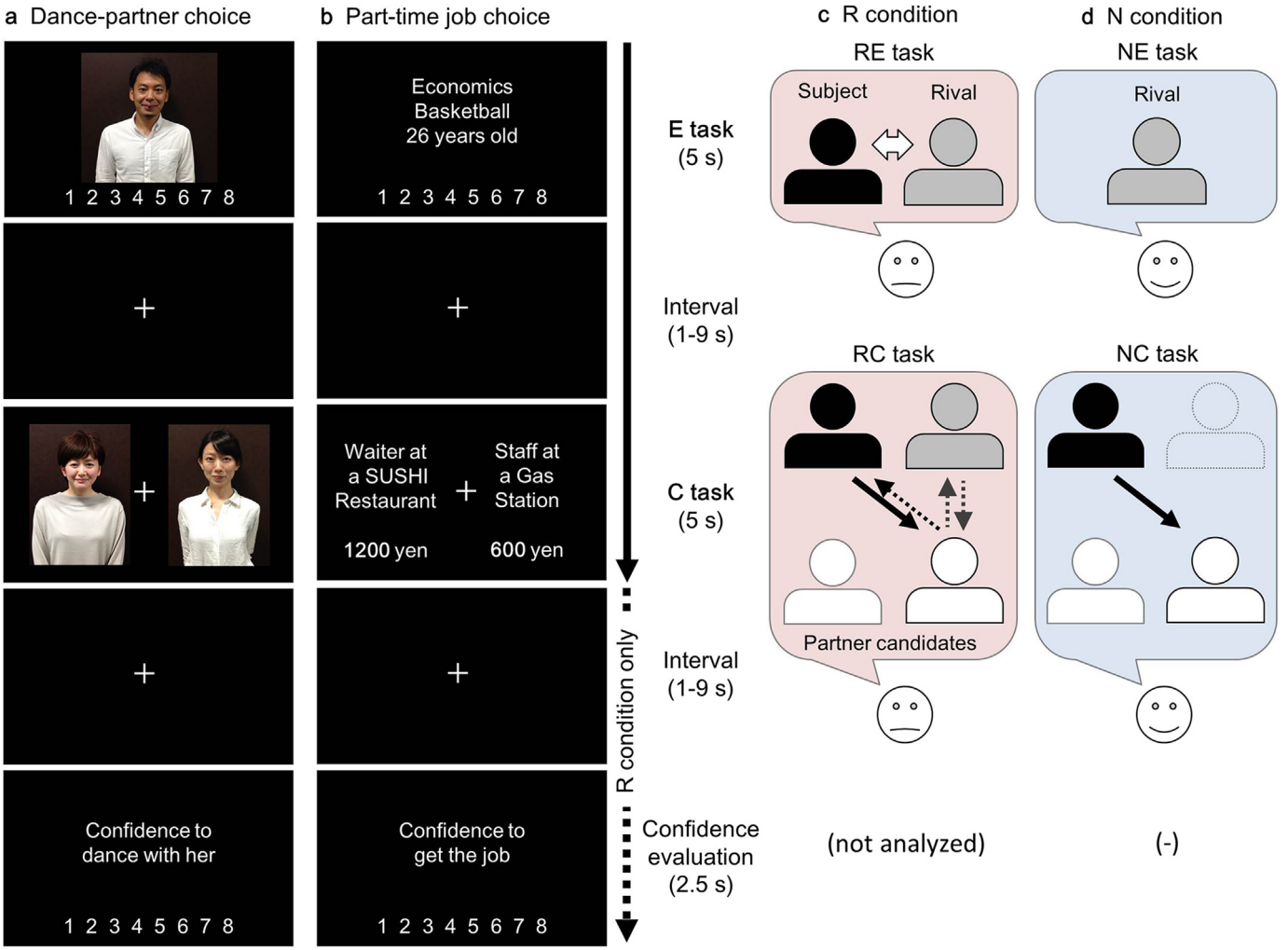

Fig. 1. Experimental tasks. Two types of partner choice situations were implemented: **(a)** a dance-partner choice and **(b)** part-time job choice. There were two conditions for each situation: **(c)** reciprocal (R) condition and **(d)** nonreciprocal (N) condition. Each trial started with the evaluation (E) task in which the subject evaluated the value of the rival relative to himself and to the social standard in the R and N conditions, respectively. In the choice (C) task, the subject chose from one of two candidates and made an offer. In the R condition (i.e., RC task), the subjects knew that competing with a higher-value rival was likely to result in failing to obtain the partner. In the N condition, the subject had priority in his choice over the rival and, therefore, had no need to be concerned with his own market price. In the R condition only, to maintain the subject's involvement and concern for the consequence of the choice, a confidence evaluation task (2.5 s) followed the RC task (**a** and **b**) in which the subject was required to evaluate his degree of confidence regarding whether his offer/application would be accepted. Two consecutive tasks were separated by an eye-fixated rest period that lasted from 1–9 s.