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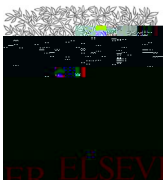

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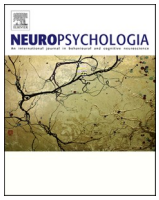

Interpersonal neural synchronization could predict the outcome of mate choice

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ABSTRACT

Although mate choice is crucial for adults, its neural basis remains elusive. In the current study, we combined the functional near-infrared spectroscopy (fNIRS)-based hyperscanning and speed-dating to investigate the inter-brain mechanism of mate choice. Each participant was paired with two opposite-sex partners (participants) in separate speed-dating sessions and was asked to decide whether to engage in a further relationship with the paired partner after each session. The physical attraction of the daters was rated by their partners at the beginning of the dating whereas the social attraction was rated after the dating. Interpersonal neural synchronization (INS) at the dorsolateral prefrontal cortex during speed-dating rather than reading task predicts the outcome of mate choice. Moreover, social attraction rather than physical attraction affects INS during speed-dating. These findings demonstrate for the first time that INS predicts the outcome of mate choice of interacting daters in ecologically valid settings during their initial romantic encounter.

1. Introduction

Mate choice is a fundamental process of species evolution (Darwin, 1871). Humans choose their mates by rejecting some potential candidates while accepting or soliciting others (Crawford and Krebs, 2013). Many factors can influence mate choice. Among them, physical attraction and social attraction of potential partners, which are the two dimensions of interpersonal attraction concerning with "the judgment of whether people 'like' another or whether people feel good in another's presence" (Berscheid and Hatfield, 1969; McCroskey and McCain, 1974), play important roles in determining whether the potential partners will be chosen. The effect of physical attraction refers to the fact that one with attractive physical appearance would be preferred in mate choice (Janz et al, 2015; Luo and Zhang, 2009; Todd et al., 2007). Social attraction is based on social considerations, such as social status (Katsena and Dimdins, 2015), perceived similarity with oneself (Tidwell et al., 2013), etc. Social attraction of potential partners can motivate individuals to establish social associations with their partners and further sustain the associations in future (Edles and Appelrouth, 2015; Hogg, 1992).

In addition, neuroimaging studies examined the neural correlates of mate choice–the insula, paracingulate cortex, and prefrontal cortex were identified as crucial brain regions of mate choice under relatively unnatural settings (Turk et al., 2004; Cartmell et al., 2014; Cooper, Dunne, Furey and O'Doherty, 2012). For instance, participants were asked to make their mate choice from a set of opposite-sex face photos rather than partners in real life (Funayama et al., 2012; Turk et al., 2004; Cartmell et al., 2014). Since a successful date usually begins with a mutual choice, mate choice contains social interactions that involve two individuals acting upon each other via inter-individual correlations of behavior and neural activity (Hari et al, 2015; Koike et al., 2015). Such a complex mutual interaction cannot be reduced to the summation of effects in single isolated brains. Previous neuroimaging studies have not adequately addressed the question of how two brains interact with each

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other during the ecologically valid dating process. In this study, we took advantage of the functional near-infrared spectroscopy (fNIRS)-based hyperscanning technique, which used fNIRS to record two-brain activity simultaneously during mate choice, to investigate the inter-brain neural mechanism underlying mate choice.

The interpersonal neural synchronization (INS), which computes the correlation between the hemodynamic signals of two brains, has been observed in many successful interactions, including joint action (Funane et al., 2011), and verbal or emotional understanding (Liu et al., 2017; Anders et al., 2011). Especially, the INS emerged between romantic couples when they conducted gestural communication or held hands during pain administration (Goldstein et al., 2018; Schippers et al., 2010).

3.2. Date outcomes at the dyad level

Based on the date decision questionnaire after each session, dyads were divided into two groups: (1) successful date group, in which both paired participants answered “yes" to the question (i.e., “Yes-Yes"); and (2) unsuccessful date group, in which [illegible]

"No–No" dyads. Then, a mixed-effects linear regression model was used to measure the effects of difference of interpersonal attraction rating on difference of INS. The model was fitted with the difference of physical attraction and difference of social attraction as fixed effects, and group as a random factor.

4. Results

Based on participant's future date decision in the post-event questionnaire, 45 participants accepted both of their assigned opposite-sex daters; 16 participants rejected both of their assigned opposite-sex daters; 15 participants accepted only one opposite-sex dater out of the two. From 76 pairs in total, 35 successful dates (SD) and 35 unsuccessful dates (USD) were identified.

4.1. Interpersonal attraction and future date decision

In the mixed effects binary logistic model, social attraction rating was a significant predictor for the future date decision ($\beta = 0.12$, $F(1,149) = 17.55$, $p < 0.001$). However, physical attraction rating could not significantly predict the future date decision ($\beta = 0.35$, $F(1,149) = 2.58$, $p = 0.110$). See Fig. 3.

4.2. Interpersonal neural synchronization of mutual mate choice

During the 5-min speed-dating task, dyads (N = 76) showed significant INS (relative to zero) at channel 3 (M = 0.029, SD = 0.076, $t(75) = 3.275$, $p_{corr} = 0.022$, ES = 0.376) located at orbitofrontal area, as well as CH13 (M = 0.025, SD = 0.077, $t(74) = 2.866$, $p_{corr} = 0.0367$, ES = 0.325), CH17 (M = 0.033, SD = 0.082, $t(73) = 3.463$, $p_{corr} = 0.022$, ES = 0.402), and channel 21 (M = 0.028, SD = 0.091, $t(72) = 2.672$, $p_{corr} = 0.050$, ES = 0.308) located at the right dorsolateral prefrontal area (Fig. 4A). Moreover, during the 5-min reading task, dyads (N = 76) only showed significant INS at Channel 22 located at the right dorsolateral prefrontal area (M = 0.041, SD = 0.088, $t(75) = 4.124$, $p_{corr} = 0.002$, ES = 0.466, Fig. 4B).

To examine whether INS could predict the date outcome, we conducted a binary logistic multilevel (mixed-effects) model with task (speed-dating and reading), channel (CH3, CH13, CH17, CH21, and CH22), INS, task × INS, channel × INS, and task × channel × INS as fixed effects and group as the random factor. There was no significant main effect of task ($F(1,676) = 0.062$, $p = 0.803$), channel ($F(4,676) = 0.342$, $p = 0.850$), and INS ($F(1,676) = 1.625$, $p = 0.203$). There was no significant two-way interaction effect of task × 0.20 ($F(1,676) = 0.197$, $p = 0.657$) and channel × INS ($F(4,676) = 0.812$, $p = 0.517$), either. However, the three-way interaction effect of task × channel × INS was significant ($F(4,676) = 2.502$, $p = 0.041$). Especially, INS at CH21 during speed-dating rather than reading could predict the date outcome ($\beta = 10.764$, SE = 4.047, t = 2.660, $p = 0.008$). These findings suggested that INS at the right dorsolateral prefrontal area (CH21) during speed-dating could discriminate the date outcome.

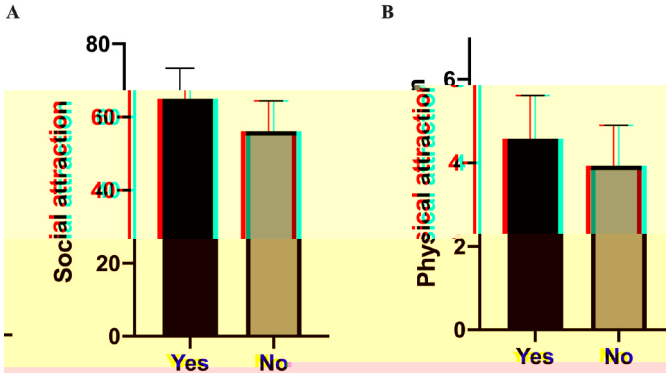

Fig. 3. Social attraction and physical attraction rating after speed-dating. (A) Social attraction rating for different future date decisions. (B) Physical attraction rating for different future date decisions. The error bars indicate the standard deviations.

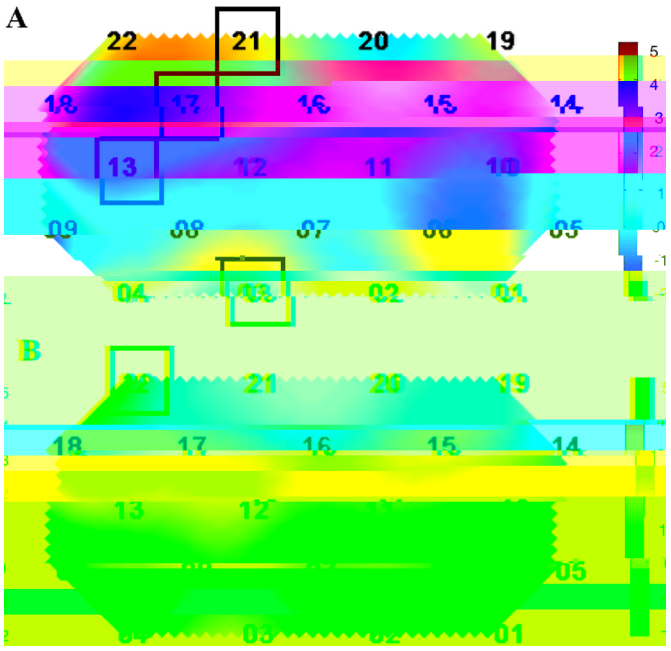

Fig. 4. Interpersonal neural synchronization. (A) t-map for all dyads (N = 76) during speed-dating. (B) t-map for all dyads (N = 76) during the reading task.

4.3. Interpersonal attraction and INS

Mixed-effects linear regression model was used to measure the effect of interpersonal attraction ratings on INS during speed-dating. The difference of social attraction was a significant predictor for difference of INS at CH21, $\beta = 0.007$, $F(1,56) = 21.37$, $p < 0.001$, Fig. 5A. However, the difference of physical attraction could not significantly predict difference of INS at CH21 during speed-dating, $\beta = 0.001$, $F(1,56) = 0.007$, $p = 0.934$, Fig. 5B. These results showed that social attraction, rather than physical attraction could predict interpersonal neural synchronization during speed-dating. In addition, the Spearman correlation analysis showed a significant positive correlation between the difference of social attraction and the difference of physical attraction, r = 0.298, $p = 0.016$.

5. Discussion

In the current study, we used the fNIRS-based hyperscanning technique to explore the neural basis of mate choice during speed-dating under a natural condition. Interpersonal neural synchronization (INS) at the dorsolateral prefrontal cortex (DLPFC) during speed-dating rather than reading task predicts the outcome of mate choice. Moreover, we found that social attraction, rather than physical attraction could predict INS during the initial encounter. These findings extend our understanding of the neural basis of mate choice with a high-level ecological validity.

Kinreich et al. (2017) observed the neural synchronization at temporal-parietal regions when romantic dyads, instead of stranger dyads, conducted verbal communications. Our findings extended the previous findings by showing that not only existing romantic relationships but also potential romantic relationships influence inter-brain synchronization. In the current study, we only focused on the INS at the prefrontal cortex and identified the DLPFC as a key region for mate choice in potential romantic relationships. The neural synchronization

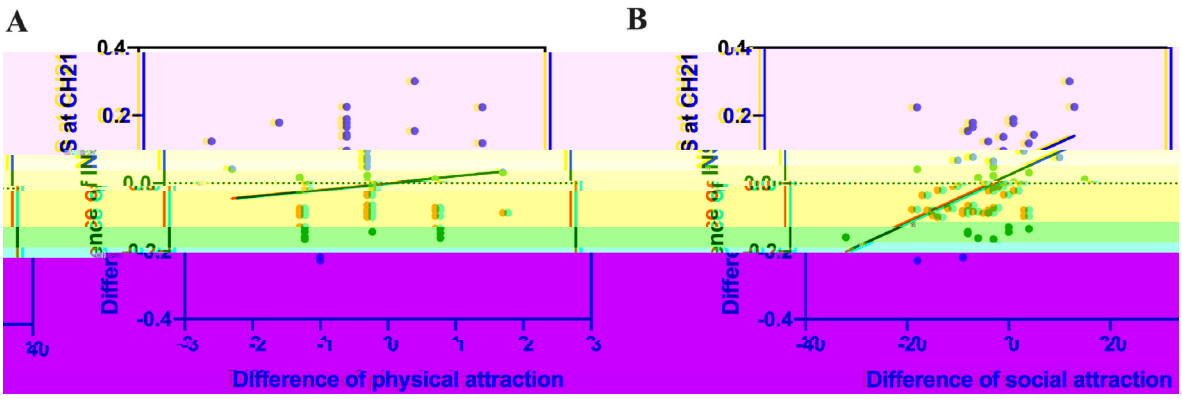

Fig. 5. Scatter plots indicate (A) the relationship between the difference of social attraction and difference of INS at CH21, and (B) the relationship between the difference of physical attraction and difference of INS at CH21.

at the DLPFC has been found in previous social interaction studies. For example, it emerged with a time lag between a speaker and a listener during successful verbal communication, and the listener's brain activity preceded the speaker's brain activity (Stephens et al., 2010). It has also been found in a bonded group during an out-group attack (Yang et al., 2020). In the current study, INS emerged at the DLPFC offers support for the bonding between potential lovers during their verbal communication.

Interpersonal attraction has been well demonstrated to be an important determinant of successful date (Eastwick et al., 2014; Lundy et al., 2010; Cotton et al., 2006). However, in the current study, social attraction rating rather than physical attraction rating influenced one's future date decision. In our study, speed-dating was conducted in a natural setting. Compared to previous studies in which the participants could only see photos of their partners, participants in our study had the opportunity to interact with their partners face-to-face during which they could dynamically receive and update social information from each other. It is not strange that social attraction outweighed physical attraction in initial romantic interaction, explaining why "love grows over time". However, our results did not negate the importance of physical attraction during mate choice. In the previous speed-dating studies, a dating event usually included more than 20 participants (Valentine et al., 2014; Luo and Zhang, 2009). In the present study, only four participants were included in an event. The effect of physical attraction on mate choice in our study might be relatively too small to reach a significant level. Moreover, we used difference of interpersonal attraction and difference of INS to examine the effect of interpersonal attraction on INS, which allowed us to reduce the dimension of data to meet the independent assumption. Such a method might underestimate the inter-individual differences and the effect of physical attraction on INS.

Moreover, the current study found that social attraction significantly predicted INS at the DLPFC during initial romantic interaction. In the previous studies, INS has been widely proved to be correlated with interpersonal indicators. For example, the strength of speaker-listener coupling during verbal communication was highly correlated with the level of understanding (Stephens et al., 2010). The strength of oscillatory coupling between couples during romantic kissing was reliably correlated with partner-oriented kissing satisfaction (Muller and Lindenberger, 2014). The neural synchronization between lovers during cooperation was correlated with their cooperation performance (Pan et al., 2017). The correlation between INS and social attraction in our study highlights the relation between INS at DLFPC and social interactions.

Limitations need to be noted for this study. First, "No–No" dyads were not analyzed in the current study due to insufficient sample size. Second, the patch only covered the prefrontal cortex in the current study because of the restriction on the number of optode probes. Subcortical brain structures which are also closely related to mate choice such as the amygdala and insula (Cartmell et al., 2014) cannot be measured by fNIRS. The role of these brain structures during dating needs to be studied using other approaches. Third, our ecologically valid settings sacrificed the control of environmental variables to some extent. The screen between two pairs in each group could not prevent audio interference from each other pair during interaction although we checked the video to ensure that each participant focused on the partner instead of others.

To conclude, our findings demonstrate that INS could be a neural marker to predict the outcome of mate choice and shed light on the importance of social attraction during the dynamic initial encounter.

Credit author statement

Xianchun Li, Di Yuan and Yanmei Wang designed research; Di Yuan and Danyang Feng performed research; Xianchun Li, Di Yuan, Ruqian Zhan and Jieqiong Liu analyzed data; Xianchun Li, Di Yuan and Xiaolin Zhou wrote the paper; and all the authors edited the paper.

Declaration of competing interest

The authors declare no competing interests.

Acknowledgments

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.neuropsychologia.2021.108112.

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