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The influence of partner trustworthiness and relationship closeness on interpersonal trust in individuals with attachment anxiety: An ERP study

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ABSTRACT

Interpersonal trust (IT) is a combination of individuals' cognitive evaluations of others' trustworthiness and affective considerations related to the relationships. Individuals' trust decisions overly relying on the intimacy of the relationship can be detrimental to their socialization. Attachment styles provide a theoretical framework for explaining individual differences in IT and the balance between cognition control and affective evaluation in social-information processing. However, it remains unclear whether high attachment anxiety (AX) individuals with high interpersonal needs exhibit non-socially adaptive trust decisions, characterized by an over-reliance on relationship closeness (RC), independent of partner trustworthiness (PT). A coin-toss task, combined with event-related potential (ERP), was utilized to explore the performance and temporal characteristics of trust decision-making among individuals with high and low AX under the influence of the two factors. The behavioral results showed that high-AX individuals tended to trust close others regardless of their trustworthiness, while low-AX individuals only trusted close others under low-PT conditions, with no differences in RC for high-PT. The ERP results revealed that high-AX individuals exhibited an enhanced positive P1 by low-trust partners, only discerning differences in RC for high-trust partners (more negative N2 by strangers than friends), reflecting poor conflict-detection abilities confronted with low-trust partners. Low-AX individuals' neural activity showed higher consistency with their behavioral performance, indicating that trust in close others under low-trust conditions was due to the fewer conflicts elicited and higher expectations of them, reflecting smaller N2 and larger P3. Overall, these findings indicated that high-AX individuals' IT decision-making was primarily influenced by their reliance on affective evaluation in information processing and weaker cognitive-control abilities, highlighting the contribution of attachment to social-information processing.

Introduction

Interpersonal trust (IT) is the willingness to entrust personal resources to others and take corresponding risks in uncertain situations (Rousseau et al., 1998), which has a significant impact on individual socialization and social harmony (Kim et al., 2015). Trust in others is a blend of cognitive evaluations of their trustworthiness and considerations of the relationship between the two parties (Lewis & Weigert, 1985). Therefore, partner trustworthiness (Mayer et al., 1995) and relationship closeness (Wang et al., 2016; Burns et al., 2006) are important factors that influence whether individuals trust their partners. Excessive reliance on the affective characteristic of RC in social-information processing is considered a maladaptive strategy (Dunbar, 1998). Attachment styles can effectively explain individual differences in IT (Mikulincer, 1998; Simmons et al., 2009) and provide a theoretical framework for the balance between cognition control and affective evaluation in social-information processing (Long et al., 2020; Vrtička & Vuilleumier, 2012; White et al., 2023). Due to unmet attachment needs from their attachment figures, high-AX individuals experience heightened affective dependence on intimate partners (Cooper et al., 2018; Schumann & Orehek, 2019). This may lead them to make trust decisions based on the RC in their relationships to fulfill their need for closeness. However, it remains unclear whether the trust decisions of them are maladaptive, relying solely on RC rather than considering the PT. Thus, in this study, high temporal-resolution, event-related potential (ERP) technology and a coin-toss task are combined to explore the effects of PT and RC on IT in individuals with AX, as well as the time-course characteristics, in order to reveal the IT features of individuals with AX.

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Attachment styles

Individual differences in attachment styles are measured in two orthogonal dimensions, AX and attachment avoidance (Brennan et al., 1998), which establish different information-processing patterns (Dykas & Cassidy, 2011) and interpersonal attitudes (Griffin & Bartholomew, 1994; Shaver et al., 2019) for individuals. Those who experience caregivers as consistently rejecting or insensitive score high in AV, tend to deny attachment needs, and are highly dependent on themselves; they are characterized by the avoidance of proximity and intimacy and a negative attitude toward others. Individuals who experience their caregivers as inconsistent in terms of availability and responsiveness score high in AX. On the one hand, they suspect others' intentions due to their negative self-pattern; on the other hand, they worry about being abandoned and desire to be close to others (Cooper et al., 2018; Harms et al., 2016). When an individual's attachment needs are consistently and effectively met by their caregivers, they score low in both anxiety and avoidance, have a positive attitude toward both themselves and others (Mikulincer et al., 2003; Shaver et al., 2019), and can maintain emotional balance when processing social information (Mikulincer & Shaver, 2007b) due to their secure base strategy (Mikulincer et al., 2003). Altogether, this study only focused on the influences of PT and RC on IT among individuals with high- and low-AX based on the higher stability of IT among high-AV individuals (Bao et al., 2022) and their avoidance of interpersonal interaction.

The influence of PT, RC and attachment anxiety in trust decision-making

Trust decision-making, as a form of risk decision-making, often involves individuals relying on available cues in the situation to reduce risks and protect their own interests. The integrated model of trust (Mayer et al., 1995) posits that PT indicates the extent to which partners are deemed trustworthy, and trusting high-trustworthiness partners can reduce the risk of betrayal (Biele et al., 2011; Delgado et al., 2005). Therefore, people tend to trust high-trustworthy individuals more (Chang et al., 2010; Jenq et al., 2015; Jessen & Grossmann, 2019; Leng et al., 2020; Li et al., 2022; van 't Wout & Sanfey, 2008). In addition, interpersonal trust itself constitutes a form of interpersonal relationship, with studies indicating that RC significantly influences trust decisions (Weiss et al., 2021). Individuals tend to trust those with whom they have closer relationships (Fareri et al., 2015). According to the individual-situation interaction theory, trust decisions are influenced by both situational factors and individual traits. Previous research has shown that individual attachment styles shape their positive or negative views of themselves and others (Griffin & Bartholomew, 1994), thus laying the foundation for their trust inclinations and serving as important factors affecting their trust decisions (Collins & Read, 1990; Mikulincer, 1998; Simmons et al., 2009).

Attachment styles guide individuals' processing of information through an "if-then" cognitive schema (Dykas & Cassidy, 2011), shaping how situational factors influence individual behavior. Therefore, we argued that the influence of PT and RC on individuals' trust decisions was moderated by attachment styles. Individuals with high-AX tend to have lower interpersonal expectations towards others based on their generally negative relationship pattern (Rodriguez et al., 2015; Shaver et al., 2019). Frazier et al. (2015) and Harms et al. (2016) found that they perceive others to have lower trustworthiness. The positive self-other schema and secure base strategies enable low-AX individuals to effectively cope with threats (Mikulincer & Shaver, 2007a). Their reduced cognitive impairment allows them to effectively perceive others' trustworthiness in risky trust decisions (Frazier et al., 2015). This suggested that individuals with low-AX would make trust decisions based on PT, while trust decisions of those with high-AX were not influenced by this factor. However, it is currently unclear whether trust decisions of individuals with high- or low-AX are based on RC. Individuals with high-AX have a heightened need for closeness (Cooper et al., 2018; Schumann & Orehek, 2019) and tend to excessively focus on the intimacy in relationships between themselves and others (Gillath et al., 2017). This motivation leads them to develop emotions and behaviors aimed at maintaining relationships (Mikulincer et al., 2010). Therefore, they may base their trust decisions on RC. Moreover, it is important to note that they had negative interactions primarily with close others, which might have led to more negative expectations and less trust in them. Research has found that they tend to have lower levels of trust in their mates (Ickes et, al.,2003). This indicated that RC did indeed play a role in their IT, although the precise nature of this influence required further exploration.

In real-life situations, both the PT and RC coexist in trust games. Isolating their individual influences on trust decisions among individuals with high- and low-AX would inevitably hinder our comprehensive understanding of their trust decision characteristics. The functional neuro-anatomical model of human attachment (NAMA) (Long et al., 2020; Vrtička & Vuilleumier, 2012; White et al., 2023) suggests that a dynamic balance between the affective evaluation system, crucial for social cognitive processing, and the cognitive control system; the high arousal of the affective evaluation system in high-AX individuals will lead to a compromise in their cognitive control system function, which makes their information processing mainly dependent on the affective evaluation system, resulting in high vigilance towards affective cues and poor cognitive control ability; in contrast, the balance between the two systems in low-AX individuals demonstrates their high cognitive control ability, which allows them to approach perceived information with openness and maintain emotional equilibrium. Based hereon, we proposed that the IT of high-AX individuals was primarily influenced by RC rather than by PT, which demonstrated lower flexibility, while these two factors impacted low-AX individuals' IT, indicating their more flexible pattern of IT decision-making. In the sole study examining this issue by Corriveau et al.'s (2009), individuals with high-AX demonstrated higher trust in their mothers regardless of informational cues, whereas those with low-AX were able to make accurate judgments based on the cues. Due to the current lack of exploration on this issue, it remained unclear how PT and RC influenced their trust decisions, especially regarding the underlying cognitive neural mechanisms.

Event-related brain potentials (ERPs) can measure the cognitive processes of behavioral responses and have been used to examine neurocognitive mechanisms underlying IT decision-making (Boudreau et al., 2009; Olcaysoy Okten et al., 2020; Wang et al., 2016) and social cognitive processing in individuals with AX (Chavis & Kisley, 2012; Dan & Raz, 2012; Li et al., 2022; Mark et al., 2012; Zhang et al., 2008; Zilber et al., 2007). By examining the differences in the components of early attentional engagement (e.g., P1; Jessen & Grossmann, 2019; Marzi et al., 2014), conflict detection (N2; Declerck et al., 2013; Wang et al., 2016), and motivational enhancement (P3; Boudreau et al., 2009; Li et al., 2022) induced by partners, the neural mechanisms underlying trust decision-making influenced by two types of features in individuals with high- and low-AX can be revealed.

According to the NAMA model and the hyper-activation strategies of high-AX individuals, the impact of these two features on trust decisions among individuals with high- and low-AX is primarily reflected in early attention engagement and N2 and P3 amplitudes. Currently, no research has found that the influence of RC on trust behavior is reflected in early attention investment, but previous studies have shown that the influence of PT on trust behavior is reflected in early attention investment (Boudreau et al., 2009). P1 is related to individuals' allocation of attention resources to stimuli or decision tasks, and low-trustworthy partners elicit higher threat perception (more positive P1) in individuals (Jessen & Grossmann, 2019; Marzi et al., 2014). The hyper-activation strategy causes high-AX individuals to be more sensitive to threat information, exhibiting heightened attention alertness (larger P1 and N1) (Dan & Raz, 2012). Therefore, we hypothesized that compared to high-trustworthy partners, low-trustworthy partners would elicit more positive P1 in them. Trust decision is a risky behavioral decision based on positive expectations of others (Evans & Revelle, 2008; Mayer et al., 1995; Rousseau et al., 1998). The decision-making process is closely related to conflict detection (Declerck et al., 2013; Martin & Potts, 2004; Potts, 2004) and motivation enhancement (Boudreau et al., 2009). N2 is considered to reflect conflict monitoring and behavioral inhibition during individual information processing, with a more negative N2 indicating stronger cognitive conflict (Gajewski & Falkenstein, 2013; van Veen & Carter, 2002), whereas a more positive P3 is associated with higher trust motivation and late-stage allocation of attention resources (Boudreau et al., 2009; Li et al., 2022). When facing a high-trustworthy partners, individuals perceive lower risk of betrayal and higher potential benefits, leading to weaker cognitive conflict during trust decisions (Wang et al., 2017). Given the positive other model of low-AX individuals, we proposed that decisions involving high-trustworthy friends versus strangers did not lead them to differential cognitive conflict and emotional engagement (similar N2 and P3). However, the heightened emotional arousal and greater need for closeness in individuals with high-AX would lead them to trust friends more, experiencing lower conflict compared to interactions with strangers (more positive N2). Trusting low-trustworthy strangers still entails putting oneself at risk (Thielmann & Hilbig, 2015; Wang et al., 2017). Low-AX individuals with higher cognitive control ability and positive expectations for others might experience higher cognitive conflicts (more negative N2) and exhibit higher emotional engagement (more positive P3) when making trust decisions under these conditions. According to the NAMA model, individuals with high-AX exhibited weaker cognitive control and hyper-activation strategies, leading them to deplete cognitive resources when dealing with threats posed by low-trustworthy partners. Therefore, when interacting with low-trustworthy strangers or friends, they did not experience differential cognitive conflict (similar N2). Furthermore, given the generally lower interpersonal expectations of others among individuals with high-AX (Rodriguez et al., 2015; Shaver et al., 2019), we posited that their trust decisions with any type of partners did not exhibit higher emotional engagement (similar P3).

Method

Participants

We recruited 360 college students to complete the Chinese version of the Experience in Close Relationships (ECR) Scale (Li & Kato, 2006) which was used to assess the participants' attachment styles prior to the experiment. Sixty participants (45 females), mean age 19.67 ± 1.69 years, were eventually selected based on their attachment scores. Based on the screening criteria (Chavis & Kisley, 2012), the participants were allocated to two attachment groups. Individuals scoring higher than 1 SD above the mean on the ECR anxiety scale and simultaneously scoring below the mean on the ECR avoidance scale were categorized as high-AX individuals ($n = 30$; 24 females). Those scoring lower than the mean on both scales were categorized as low-AX individuals ($n = 30$; 21 females).

A prior power analysis conducted by G*Power showed that the three-way, mixed-design interaction of attachment groups ×PT × RC could detect a medium effect (effect size $f = 0.25$) with a sample size of 18 (36/2) participants in each group ($\alpha = 0.05$, $1\text{-}\beta = 0.95$, number of groups = 2, numbers of measurements = 4, analysis of variance (ANOVA): repeated measures, within-between interactions). The sample size for each attachment group was thus sufficient to obtain meaningful results in the current study. All participants were healthy, right-handed, and none of them had a prior history of neurological or psychiatric disorders. All provided informed consent and participated in this experiment for monetary compensation. The experiment was approved by the local Human Ethics Committee for Human Research (H22083).

Attachment questionnaire

The ECR scale (Brennan et al., 1998), including the two major dimensions of AX and AV, is a 36-item, self-report questionnaire that measures adult attachment styles. Participants use a 7-point Likert scale to rate the extent to which they agree or disagree with each item. The subscale for anxiety, including 18 items, reflects individuals' concerns about rejection and abandonment, while the avoidance dimension reflects the degree of avoidance of intimacy and interdependence. The reliability of the two scales in this study was $\alpha = 0.92$ for AX and $\alpha = 0.88$ for AV.

Materials and apparatus

The experiment was conducted on a 17-inch (1280×1024 pixels; 75 Hz refresh rate) liquid-crystal display (LCD) monitor. Stimulus presentation and behavioral recording were conducted using E-Prime 2.0. In the coin-toss game, following Boudreau et al.'s (2009) procedure, the participants received a statement from a friend or stranger who was assigned to either a common-interests or a conflicting-interests condition, indicating whether a coin tossed had landed on a flower or a number; they then decided whether to believe the truthfulness of the statement. In the "common-interests" condition, participants were told that both they and their partners earned money when they correctly guessed the outcome of the coin toss. In the "conflicting-interests" condition, when the participants correctly guessed, only they earned money, while only the partners earned money when they guessed incorrectly.

The procedure included four facial photographs that were the same gender as the participant, two pictures of unfamiliar faces, and two pictures of the faces of the participants' friends. Four strangers' pictures, two males and two females, from the Chinese Facial Affective Picture System (CFAPS; Gong et al., 2011), were selected by 15 participants who were not involved in the formal experiment. These selected pictures were of moderate emotional valence, facial trustworthiness, and attractiveness. The two pictures of the participants' friends were provided by the participants themselves and they ensured that friends could participate in the experiment together with them, either by going to the laboratory together or by participating online together. Each of the participants' friends would gain 5 yuan (RMB) in monetary compensation.

The picture stimuli presented in the experiment were composite pictures that contained the facial figures (sized at 207×252 pixels) and information regarding common ("共同利益") or conflicting ("冲突利益") interests between the figures and the participants, displayed below the facial image in white color in the Songti font style. The stimuli were presented against a black background during the experiment.

Procedure

On entry into the lab, the participants were asked to predict whether several practice coin tosses landed on numbers or flowers and were paid 0.5 yuan (RMB) for each correct prediction they made. The purpose of this was to ensure that they understood that they would earn extra reward based on the choices they made. To guarantee that the participants believed that two strangers and their friends would simultaneously participate in the experiment, the assistant would lead the participants to another laboratory and inform them that partners could know the result of each coin toss through the experimental equipment and relay the results to the participants. When friends could not go to the laboratory, the experimenter would create a temporary chatting-room in internet consisting of the experimenter, the participant, and the friends. By informing the friends of the experimental instructions, the participant was led to believe that the friend was participating in the task together with them.

The participants were seated in a quiet room approximately 80 cm from a computer screen and were required to try their best to avoid eye blinks and head movements. Their left and right index fingers were placed on the “S” and “K” keys, respectively. The formal task comprised six blocks, with each block containing eight trials for high-trust (common-interests) friends, high-trust strangers, low-trust (conflicting-interests) friends, and low-trust strangers. Within each block, the 32 trials were randomly presented. In total, 192 trials were conducted in the experiment. After completing each block, the participants were allowed to take a self-determined rest period before starting the next block’s task.

As shown in Fig. 1, each trial started with a random presentation of a picture of flipping a coin followed by a 2000 ms appearance of a display of the partner’s face and their statement about the orientation of the coin. Each presentation lasted from 1 s to 3 s. The composite picture of stimuli was then replaced by a blank screen (200 ms–1000 ms). Following the blank screen display, the composite picture would be presented again for 2000 ms to ensure that the participants remembered the partners and their statements. During the time, the participants were required to decide whether they trusted the statement by pressing either the “S” or “K” key. Half of the participants pressed the “S” key to indicate their trust in the partner’s statement, while the other half pressed the “K” key. After a waiting period of 200 ms–800 ms, the outcome of each participant’s guess regarding the orientation of the coin was presented as feedback for 2000 ms. In the feedback, whether the participant’s guess regarding the orientation of the coin was correct (“正确”) or not (“错误”) was presented with a probability of 50 %. If the participate did not press a key, the feedback is null.

Prior to the formal experiment, PT was rated on a 7-point scale and we assessed RC via a simple measure comprising pairs of overlapping circles, one labeled “self” and the other labeled “other”, using the Inclusion of Other in Self Scale (IOS; Aron et al., 1992). Increased overlap suggested increased closeness.

EEG recording and preprocessing

EEG data were collected using standard 64 in-cap Ag/AgCl electrodes based on the extended international 10–20 system (Brain Products GmbH, Germany). During data acquisition, all signals were recorded at a sampling rate of 500 Hz, referenced online to the FCz electrode, and filtered with a 0.01–100 Hz bandpass. Vertical and horizontal electro-oculograms (EOGs) were recorded below the left eye and over the outer canthus of the right eye. The impedance of all electrodes was maintained below 5 kΩ throughout the recording process.

The preprocessing of EEG data was performed using EEGLAB v14.1.2b and ERPLAB v8.3.0 running in MATLAB R2018b. Offline data were re-referenced to the mean of TP9 and TP10 and filtered using a 0.1–30 Hz bandpass filter using a basic finite-impulse response filter. Continuous EEG data were segmented from − 200 ms to 1000 ms using correct epochs locked to the first presentation of a picture stimulus, and epochs were baseline-corrected using a – 200 ms to 0 ms baseline window. Eye movements and blinks were corrected based on independent component analysis, and epochs with other artifacts were excluded from averaging whenever the voltage exceeded ±80 μV. We then calculated the average ERP waveforms of valid trials for each condition across each group.

Statistical analysis

Behavioral-data analysis

In the coin-toss game, the rate of participants’ trust in the partners’ statements was used as an indicator of their trust level. The RTs of decision and rates were entered into a 2 × 2 × 2 mixed-design, repeated-measures, three-way ANOVA with PT (high vs. low) and RC (stranger vs. friend) as the within-participants factors and individuals’ attachment anxiety (high vs. low-AX) as the between-participants factor.

ERP analysis

Based on previous studies, grand average waveforms and mean mapping, the peak amplitudes of P1 were calculated using a time window of 50 ms (100 ms–150 ms after stimulus onset) at parieto-occipital electrodes (P3/4, PO3/4, P5/6, PO7/8, and P5/6); the N2 within 280 ms–360 ms were scored as the mean amplitudes at fronto-central electrodes (F3/4, FC1/2, and FC3/4); the mean amplitudes of P3 (350 ms–500 ms) were evaluated from the Midline electrode (Fz, Cz, CPz, Pz, POz). Analyze the above components similar to behavioral data. The *p*-values for all effects were corrected using the Greenhouse-Geisser method, and the effect sizes were presented as η_p^2,. In all post-hoc comparisons, the Bonferroni correction was applied where appropriate and only significant results were reported.

Results

Independent samples *t*-tests were conducted to compare AX, AV scores, and age between the two groups of participants, and a chi-square test was performed to examine the gender distribution. The results revealed a significant difference in AX scores ($t_{58} = 16.39$, $p < 0.001$), no difference in AV ($t_{58} = 1.07$, $p > 0.05$), age ($t_{58} = 1.776$, $p = 0.081$), and gender ($\chi^2 = 0.8$, $p = 0.371$). These indicated the effective screening of participants for this study.

Experimental manipulation check

Paired-samples *t*-tests were conducted to assess participants’ ratings of PT regarding partners under both common and conflict interest conditions, as well as RC with friends and strangers. The results revealed that participants perceived the partners under common interest conditions as significantly more trustworthy than under conflict interest conditions ($t_{59} = 11.062$, $p < 0.001$), and rated intimacy with friends higher than with strangers ($t_{59} = 10.315$, $p < 0.001$). The above results indicated that the manipulation of PT and RC were effective in this study.

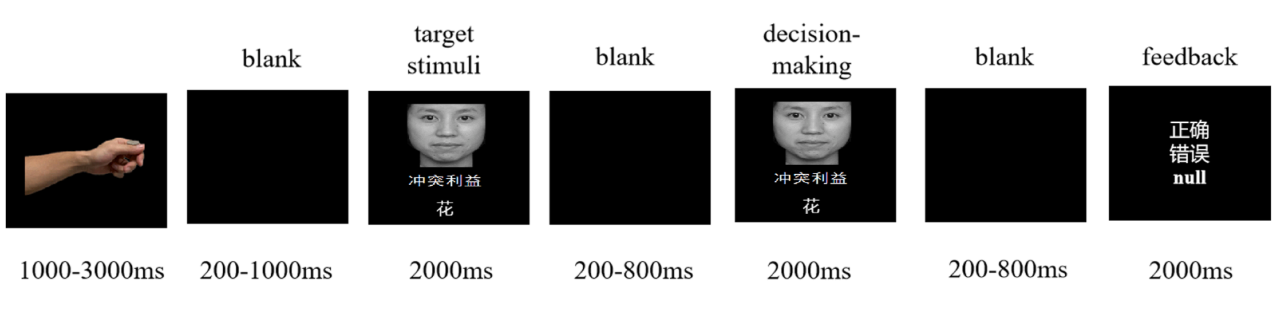

Fig. 1. Experimental procedure of the coin-toss task.

Behavioral-analysis results

An ANOVA of the rate of trusting (%) (see Table 1, 2) partners' statements about the orientation of the coin revealed the main effect of PT, $F_{(1, 58)} = 82.61, p < 0.001, \eta_p^2 = 0.59$; the trust rate for partners in the common-interests condition (high trustworthiness; $M \pm SE$, 73.5 ± 2) was higher than for partners in the conflicting-interests condition (low trustworthiness; 48.3 ± 1.7); The main effect of RC was also significant, $F_{(1, 58)} = 25.26, p < 0.001, \eta_p^2 = 0.3$; the participants trusted friends (67.2 ± 2.2) more than strangers (54.6 ± 1.3). The interaction between PT and RC was significant ($F_{(1, 58)} = 29.55, p < 0.001, \eta_p^2 = 0.34$). A follow-up analysis of this interaction indicated that individuals trusted low-trust friends more (60.3 ± 2.7) than low-trust strangers (36.3 ± 2.4), while there was no difference in trust rates between high-trust strangers and friends (p = 0.673, 95 % CI = [−0.041, 0.062]). In addition, the three-way interaction reached significance ($F_{(1, 58)}$ = 6, p < 0.05, η_p^2 = 0.09). On a further simple-effect analysis, we found that low-AX individuals exhibited significantly higher trust rates in low-trust friends than in low-trust strangers (p < 0.001). However, there was no difference in trust rates between friends and strangers for high-trust partners ($p = 0.17$). High-AX individuals showed higher trust rates in friends than in strangers, regardless of the level of their trustworthiness (Fig. 2), indicating that high-AX individuals tended to prefer trusting closer people more.

Regarding the RTs, ANOVA revealed that the main effects of AX ($F_{(1, 58)} = 4.91, p < 0.05, \eta_p^2 = 0.08$), PT ($F_{(1, 58)} = 7.47, p < 0.01, \eta_p^2 = 0.11$), and RC ($F_{(1, 58)}$ = 48.92, p < 0.001, η_p^2 = 0.46) were significant. Specifically, the RTs of low-AX people (508.04 ± 23.07 ms) were faster than those of high-AX people (580.35 ± 23.07 ms); the RTs when interacting with friends (525.89 ± 16.19 ms) and high-trust partners (533.74 ± 16.98 ms) were also faster than when interacting with strangers (562.5 ± 16.85 ms) and low-trust partners (554.65 ± 16.53 ms). Notably, the interaction between RC and AX was significant ($F_{(1, 58)} = 4.54, p < 0.05, \eta_p^2 = 0.07$). Post-hoc tests showed that, for interacting with friends, the RTs did not differ between high- and low-AX individuals. In contract, for interacting with strangers, low-AX individuals' RTs (520.77 ± 23.82 ms) were faster than those of low-AX people (604.23 ± 23.82 ms) (p = 0.016).

ERP results

P1

For peak amplitude of P1, ANOVA revealed the main effects of PT ($F_{(1,58)}$= 6.66, p < 0.05, η_p^2 = 0.103) and the interaction between PT and AX ($F_{(1,58)}$= 5.88, p < 0.05, η_p^2 = 0.092) at the PO7/8 electrodes. Post-hoc tests showed that the P1 amplitude evoked by low-trust partners (4.87 ± 0.36 μV) was greater (more positive) than that evoked by high-trust partners (4.55 ± 0.34 μV); the effect of PT only occurred in high-AX individuals, with low-trust partners (5.56 ± 0.51 μV) eliciting a higher P1 than high-trust partners (4.92 ± 0.48 μV), see Fig. 3.

Table 1
Means and standard error of trusting rates (%) and RTs (ms) in coin-toss task as a function of the partners trustworthiness and relationship closeness.

Attachment styles	Friends		Strangers	
	Low-trust	High-trust	Low-trust	High-trust
Low-AX	61.9 (3.9)	70.7 (3.6)	33.7 (3.4)	75.8 (3.1)
	506.46	484.16	524.62	516.93
	(23.93)	(24.18)	(23.98)	(25.48)
High-AX	58.8 (3.9)	77.5 (3.6)	38.9 (3.4)	70.2 (3.1)
	576.47	536.46	611.04	597.43
	(23.93)	(24.18)	(23.98)	(25.48)

Note. Upper is means and standard error of trusting rates, below is means and standard error of RTs.

Table 2
Results of the main effects and interaction effects in the analysis of variance for trusting rates and RTs.

Behavioral indicator	effects	F	p	η_p^2
trusting rates	PT	82.61	< 0.001	0.588
	RC	25.26	< 0.001	0.303
	PT × RC	29.55	< 0.001	0.338
	AX × PT × RC	6.003	< 0.05	0.094
RTs	AX	4.912	< 0.05	0.078
	PT	7.472	< 0.01	0.114
	RC	48.924	< 0.001	0.458
	AX × RC	4.537	< 0.05	0.073

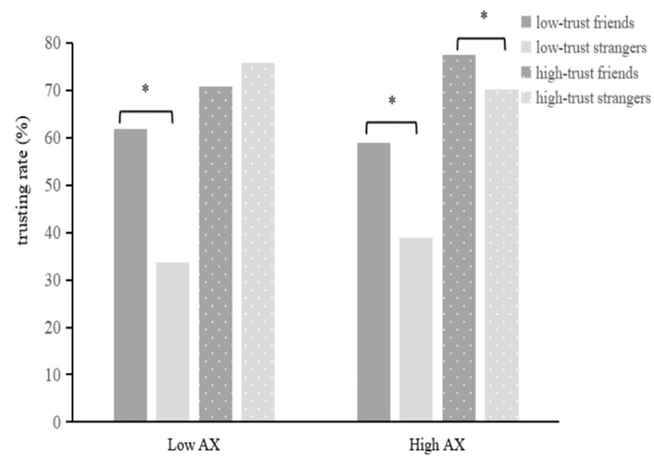

Fig. 2. Trusting rates and reaction time in the coin-toss task. * p < 0.05.

N2

For mean amplitude of N2, ANOVA revealed that the main effects of RC ($F_{(1, 58)}$ = 11.65, p = 0.001, η_p^2 = 0.167) and the three-way interaction ($F_{(1, 58)} = 3.813, p < 0.05, \eta_p^2 = 0.07$) were significant in the channel of FC1/2 (Fig. 4). The N2 amplitude evoked by strangers (−1.712 ± 0.54 μV) was greater (more negative) than that evoked by friends (−0.908 ± 0.52 μV) ($p = 0.001$). For low-AX individuals, the N2 amplitude did not differ between high-trust friends and strangers, whereas the N2 amplitude evoked by low-trust strangers (−1.75 ± 0.75 μV) was greater (more negative) than that evoked by low-trust friends (−0.94 ± 0.81 μV) (p = 0.003). For high-AX individuals, there was no difference in the amplitude of the N2 evoked by low-trust friends and strangers, while the amplitude of the N2 evoked by high-trust strangers (−1.24 ± 0.78 μV) was more negative than that evoked by high-trust friends (−1.12 ± 0.77 μV) (p = 0.045).

P3

For mean amplitude of P3, ANOVA revealed the main effects of RC ($F_{(1, 58)} = 27, p < 0.001, \eta_p^2 = 0.318$), PT ($F_{(1, 58)} = 4.04, p < 0.05, \eta_p^2$ = 0.065), and the interaction between PT and AX ($F_{(1, 58)} = 4.13, p < 0.05$, η_p^2 = 0.067) on the channel of Fz. The amplitudes of the P3 evoked by friends (0.22 ± 0.55 μV) and low-trust partners (−0.35 ± 0.49 μV) were greater than those evoked by strangers (−1.33 ± 0.47 μV) and high-trust people (−0.76 ± 0.51 μV). Simple effect analysis revealed that the effect of PT only occurred in low-AX individuals, with low-trust partners (−0.41 ± 0.7 μV) eliciting a higher P3 than high-trust partners (−1.18 ± 0.72 μV), see Fig. 5.

Discussion

This study was the first to utilize the ERPs method to examine the influences of PT and RC on IT in individuals with AX. The behavioral results indicated that high-AX individuals exhibited a trust pattern in

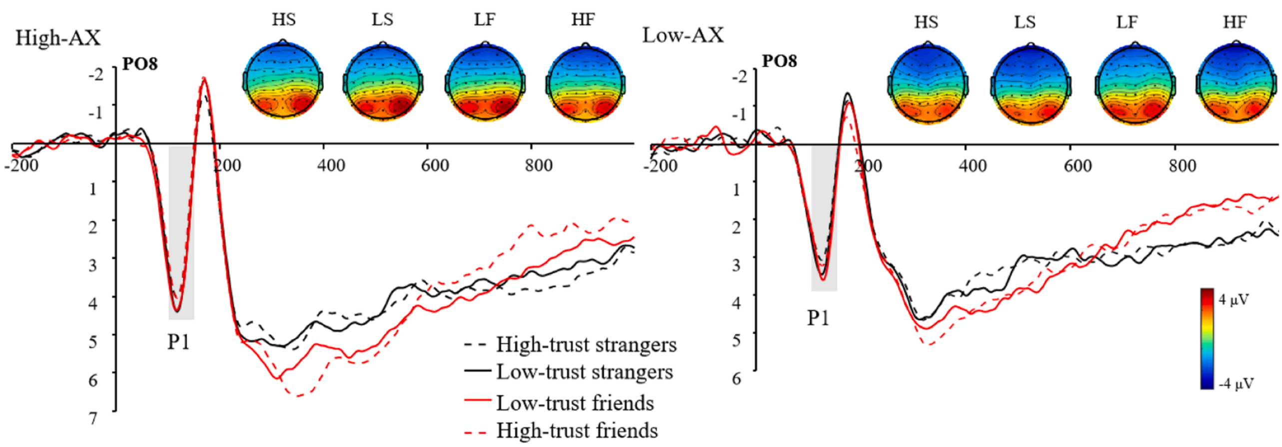

Fig. 3. ERP results (waveforms and scalp maps) of P1 component for high- and low-AX individuals. HS: high-trust strangers; LS: low-trust strangers; LF: low-trust friends; HF: high-trust friends.

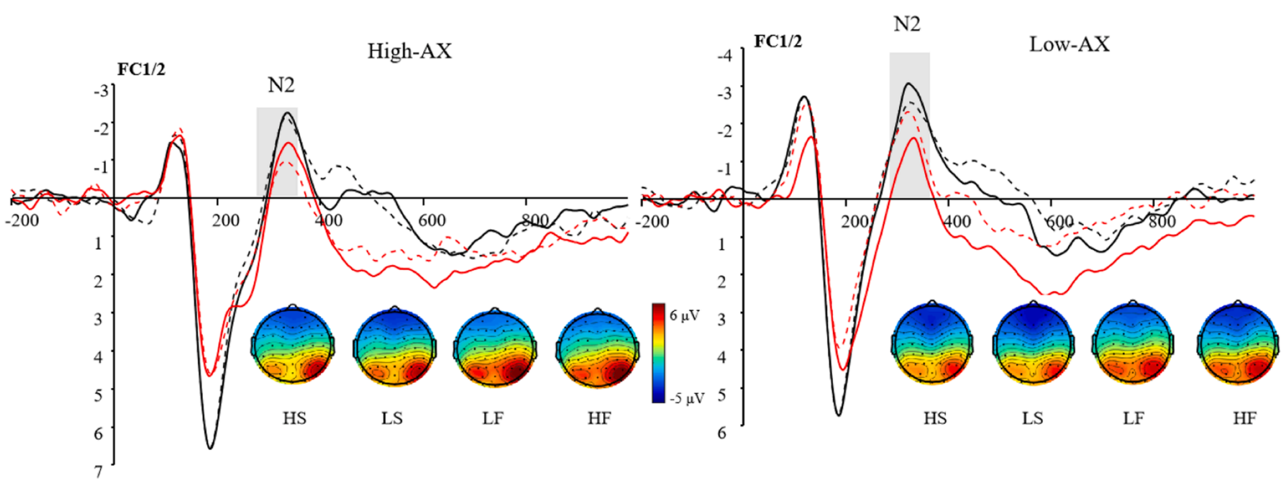

Fig. 4. ERP results (waveforms and scalp maps) of N2 component for high- and low-AX individuals.

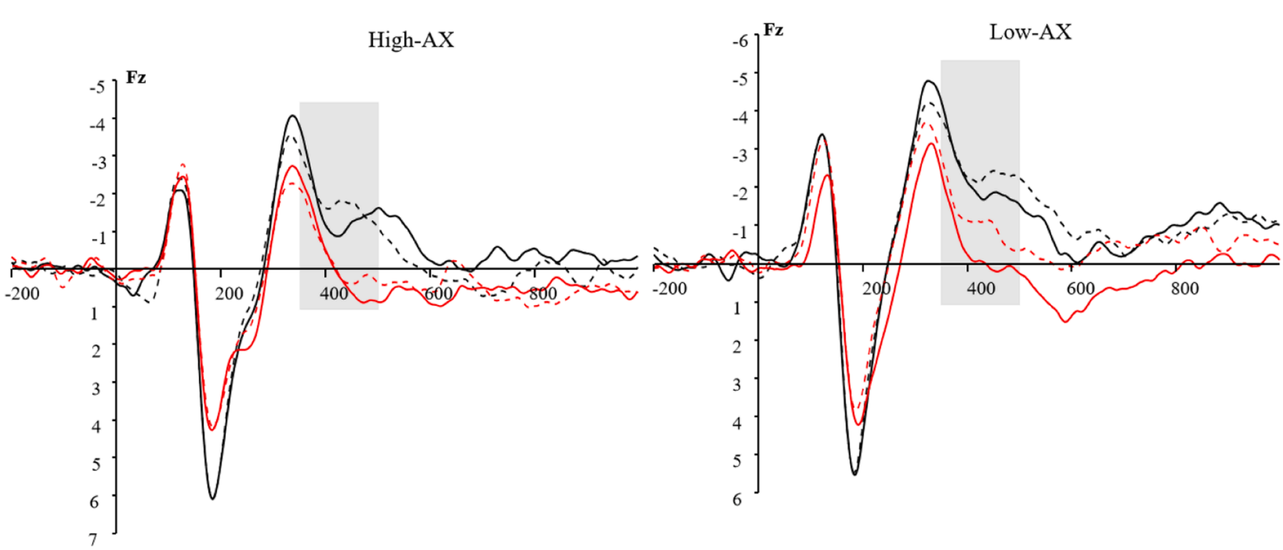

Fig. 5. ERP results of P3 component for high- and low-AX individuals.

which they trusted high-closeness partners regardless of their trustworthiness. In contrast, low-AX individuals considered both the two characteristics before trust decision-making; they only trusted high-closeness partners under low-trustworthiness conditions, and there was no difference in trust based on RC under high-trustworthiness conditions. The ERP results revealed that low-trust partners elicited higher threat perception (larger P1) in high-AX individuals, making it difficult for them to discern the intimacy of partners under this condition (similar N2), exhibiting compromised conflict detection abilities; the behavior and neural activity of low-AX individuals exhibited higher consistency, with trust in others stemming from weaker conflict perception (smaller N2) and heightened motivation enhancement (larger P3). The collective findings illustrated that the weaker cognitive control abilities of high-AX individuals led to a higher reliance on RC in their trust decisions, which is maladaptive, while trust decisions of low-AX individuals were influenced by PT and RC, demonstrating greater flexibility and their higher ability to balance affection and cognition. This study not only elucidated the characteristics and neural mechanisms underlying trust decisions among individuals with AX to guide and intervene their interpersonal behaviors, but also offering evidence for the NAMA model.

The impact of attachment anxiety on the regulation of partner trustworthiness and relationship intimacy on trust behavior

Behavioral outcomes showed that PT moderated the impact of RC on trust behavior, with this moderation effect absent in high-AX individuals. Specifically, when facing high-trustworthy partners, there was no difference in the trust rate between friends and strangers; when facing untrustworthy partners, individuals exhibited higher trust rates towards friends compared to strangers. However, for high-AX individuals, regardless of the PT, they trusted their friends more. This finding aligned with previous research (Corriveau et al., 2009), indicating that high-AX individuals tend to trust their mother over strangers regardless of cues. This suggested that their trust decisions primarily rely on RC rather than PT. The characteristic of trust decision-making in high-AX individuals not only validates the claims in the NAMA model that their information processing is primarily dependent on affective evaluation systems, but also reflects the influence of negative internal working models on their interpersonal interactions. Due to negative self-schemas, they believe they are undeserving of love and are suspicious of others' intentions (Griffin & Bartholomew, 1994; Shaver et al., 2019). Therefore, regardless of the trustworthiness of their partners, they have lower expectations of others' behaviors (Harms et al., 2016), leading to their trust decisions being unaffected by the trustworthiness of the individuals involved.

On the other hand, the dependence on RC reflected the impact of high interpersonal needs for closeness on their interpersonal behaviors. They attached great importance to building and sustaining intimate relationships (Karantzas et al., 2014; Ren et al., 2017). Trust, as the cornerstone for establishing and maintaining interpersonal relationships (Krueger & Meyer-Lindenberg, 2018; Simpson, 2007), prompted them to form emotional and behavioral responses in order to repair relationship connections (Mikulincer et al., 2010). Previous studies have demonstrated that they maintain relationships through behaviors such as relationship disclosure (Tan et al., 2012), a willingness to apologize (Schumann & Orehek, 2019), and a high tolerance for others' low investment (Almakias & Weiss, 2012). These results indicate that although the negative interaction experiences of high-AX individuals mainly stem from intimate partners, they exhibit higher levels of trust in them in order to satisfy their own needs for closeness. In contrast, low-AX individuals demonstrated trust behaviors that were the result of a balanced consideration of both the cognitive and emotional aspects of the partner's characteristics (Mikulincer & Shaver, 2007b). Their positive internal working models and secure base strategies led to high expectations of others and effective coping with threats (Mikulincer et al., 2003; Shaver et al., 2019), allowing them to make trust decisions based on the perceived trustworthiness of different levels of closeness (Corriveau et al., 2009). Moreover, in information processing, individuals' excessive reliance on emotional information is considered a maladaptive strategy (Dunbar, 1998). These behavioral outcomes highlighted that trust decisions among low-AX individuals were more socially adaptive, whereas high-AX individuals' reliance on RC for trust decisions lacked flexibility. Friends hold strong emotional bonds with individuals, and trusting friends in the absence of trustworthy conditions helps mitigate risks and losses from trust betrayal (Binzel & Fehr, 2013). However, trust decisions in real life do not only occur between acquaintances. When cues indicate higher partner trustworthiness, trusting strangers contributes to individuals' interpersonal interactions and even fosters societal harmony and development.

Partner trustworthiness moderates cognitive resource allocation in the automatized processing stage of trust behavior among high- and low-AX individuals

ERP results revealed that in the early stages of information processing, low-trustworthy partners elicited a more positive P1 in high-AX individuals. P1, as an index of early perceptual processing, reflects an individual's allocation of attention to stimuli or decision tasks (Carretié et al., 2004; Martin & Potts, 2004; Potts, 2004), indicating individual attention vigilance (Dan & Raz, 2012). The greater the significance or importance of a stimulus or decision task to an individual, the more attention resources they invest in it, and the greater the P1 wave amplitude it induces (Dan & Raz, 2012). Low-trustworthy represents increased potential for trust betrayal, leading individuals to experience higher perceived threat levels (Jessen & Grossmann, 2019; Marzi et al., 2014). High-AX individuals exhibit excessive vigilance towards threats under the influence of hyper-activation strategies (Fraleyet et al., 2006; Mikulincer et al., 2000, 2003), Therefore, the P1 of them induced by low -trustworthy partners was greater than that of high-trustworthy partners. The P1 amplitudes in high-AX individuals supported the NAMA model's claim of heightened vigilance and reliance on affective evaluation.

Partner trustworthiness diminishes cognitive conflict in trust behavior among high-AX individuals

ERP results indicated that compared to friends, strangers elicited more negative N2 in individuals; regardless of whether facing high-trustworthy or low-trustworthy partners, the performance of low-AX individuals on this neural activity component reflected that their trust behavior towards a certain partner originated from the partner inducing their smaller N2; however, this feature did not exist in the game between high-AX individuals and low-trustworthy partners, as low-trustworthy friends and strangers induced their indistinguishable N2. N2 reflects conflict monitoring and cognitive control in the decision-making process. The more negative the N2 induced by decision-making, the stronger the cognitive conflict experienced by individuals in decision-making (Gajewski & Falkenstein, 2013; van Veen & Carter, 2002). Trusting others means taking risks, especially when facing strangers (Thielmann & Hilbig, 2015; Wang et al., 2017). Therefore, under the condition of strangers, smaller rewards and potential risks lead individuals to experience stronger cognitive conflicts when making trust behaviors, thereby inducing more negative N2. However, low-trustworthy strangers and friends did not differ in eliciting cognitive conflict in high-AX individuals. This may be due to heightened attention vigilance towards low-trustworthy partners among high-AX individuals, stemming from their potential threat in early attention processing (reflected in enhanced P1). Under the influence of hyper-activation strategies, they tend to exaggerate the threat, requiring the use of cognitive resources to deal with the threat, resulting in insufficient cognitive resources in subsequent information processing. This suggested their diminished cognitive-control ability when processing threatening stimuli (DeWall et al., 2012; Vrticka et al., 2008),which had been revealed in the study of Gillath et al. (2005). This finding validates the NAMA model's proposition that heightened arousal in the affective evaluation system of high-AX individuals compromises the cognitive control system. The neural activity and behavioral consistency observed in low-AX individuals suggested that their trust decisions integrated considerations of PT and RC, demonstrating their ability to effectively manage cognitive and affective conflicts in complex situations. This result supported the NAMA model's suggestion that low-AX individuals maintain a balance between cognitive control and affective evaluation system, approaching perceived information with openness and emotional equilibrium (Mikulincer & Shaver, 2007b). This indicated that low-AX individuals possess stronger cognitive control abilities compared to high-AX individuals, who exhibited weaker cognitive control capabilities.

Partner trustworthiness modulates the late cognitive processing of trust behavior in high- and low-AX individuals

Trust decisions are risky behavioral decisions based on positive expectations of others (Evans & Revelle, 2008; Mayer et al., 1995; Rousseau et al., 1998), linked with processes of motivational enhancement (Boudreau et al., 2009). P3 not only reflects the allocation of late attention resources and emotional enhancement but also relates to higher prosocial and trust motives (Boudreau et al., 2009; Li et al., 2022). Low-trustworthy partners elicited low-AX individuals more positive P3, consistent with the findings of Yang et al. (2011), indicating that low-AX individuals with positive other models had positive expectations and invested more attention towards them, leading to increased motivational enhancement. Lischke et al. (2018) proposed that there is a negative correlation between late components and individuals' predictions of trustworthiness. The larger the P3 or LPP, the lower the individual's score for the trustworthiness of others. According to this view, low-trustworthy individuals induced a more positive P3 response in low-AX individuals, indicating that they can effectively discern the trustworthiness of partners and showed increased attention towards low-trustworthy individuals. This further illustrated their higher cognitive control abilities, as they can effectively mobilized cognitive resources in the later stages of information processing to perceive others' trustworthiness. It should be noted that although high-AX individuals trusted more high and low trustworthy friends, no motivational investment was found towards either type of them. This implied that their trust in their friends was not based on positive expectations of them. Vrticka et al. (2008) found no activation in the ventral striatum and tegmental area of the reward-related brain regions in high-AX individuals after receiving positive feedback. Vrticka and Vuilleumier (2012) suggested that the relationship between AX and social approach was uncertain. Given their higher tolerance for low allocations to others in ultimatum games (Almakias & Weiss, 2012), we speculated that their trusting behavior toward friends was primarily driven by the motivation to maintain a positive impression and foster close relationships with others. In other words, their trust behaviors toward close individuals were aimed at fulfilling their own need for closeness rather than having positive expectations of the person.

There are several aspects that require further investigation in future research. First, it is necessary to delve deeper into the reasons why high-AX individuals trust high-intimacy partners more. Previous studies have observed a dissociation between individuals' trust attitudes and trust behaviors (Burns et al., 2006; Gazdag et al., 2019). Considering the high interpersonal needs of them, it is important to explore whether they exhibit trusting behaviors toward partners that are likely to fulfill their needs. Revealing this underlying reason would contribute to further elucidating whether their trusting pattern is instrumental. Second, an excessive reliance on the affective-evaluation system in social-information processing is a maladaptive behavioral strategy (Dunbar, 1998). However, this study only revealed that high-AX individuals' trust-decision had poor flexibility, manifested as an excessive reliance on RC, while low-AX individuals exhibited a more flexible trust-decision pattern. Whether this pattern leads to negative outcomes such as susceptibility to deception remains to be explored in future research. Additionally, despite the efforts made in this study to create vivid interpersonal interactions, such as inviting participants' friends to accompany them to the laboratory and making participants believe that they completed the experiment together with their friends, future research could employ virtual procedures (Hale et al., 2018) to capture participants' behavior with more ecological validity.

Conclusion

This study revealed high- and low-AX individuals' IT decision-making patterns under the influences of both PT and RC from the temporal dynamics of ERP, which offers direct evidence for NAMA that individual differences in attachment anxiety can be seen as possible determinants of "switch point" shifts in the dynamic balance of affection evaluation and cognitive control. High- and low-AX individuals' trust was influenced differently by PT and RC, and these influences were reflected in multiple cognitive processes such as early attention engagement, conflict detection, and motivation enhancement. Specifically, the heightened sensitivity to the affective content of information and impaired cognitive control in high-AX individuals led to a rigid decision-making pattern that heavily relied on RC and was unaffected by trustworthiness. Meanwhile, the higher cognitive-affective balance ability of low-AX individuals enabled them to make trust decisions that considered both factors, exhibiting higher flexibility.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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