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Original Article

Neural responses to shared positive and negative experiences: unveiling the social feedback processing dynamics

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This study examined the impacts of shared experience valence on the dynamic processing of social feedback. Electroencephalography (EEG) was recorded when participants performed an adapted social judgment paradigm with three stages: social feedback expectation, social feedback evaluation, and expectation updating. Behavioral analysis revealed higher acceptance expectation and lower rejection expectation in the shared positive experience (SPE) condition than in the shared negative experience (SNE) condition; receiving acceptance feedback increased acceptance expectation in the subsequent trial. EEG results revealed that at the social feedback expectation stage, rejection evoked a larger stimulus-preceding negativity magnitude than acceptance in the SNE but not SPE condition. At the social feedback evaluation stage, rejection feedback evoked a smaller early frontal theta than acceptance feedback in the SNE but not SPE condition; unexpected acceptance evoked a larger P300 than unexpected rejection in the SPE but not SNE condition. At the expectation updating stage, unexpected acceptance elicited larger late posterior theta than expected acceptance in the SNE but not SPE condition. These results suggest that shared positive experiences reduce vigilance toward impending rejection and increase sensitivity to pleasantness, whereas shared negative experiences blunt reactivity to rejection feedback and foster social learning from unexpected acceptance to enhance positive expectation.

Keywords: EEG; expectation; shared experience; social judgment paradigm; valence.

Introduction

Shared experiences refer to instances where individuals undergo the same or similar events or situations, such as receiving a reward or encountering a hardship (Bastian et al. 2014; Boothby et al. 2014). A key finding in the literature on shared experiences is that they can foster positive social interactions and fulfill the fundamental need to belong, laying foundations for societal organization (Aron et al. 2000; Bastian et al. 2014; Baumeister and Leary 2017; Wolf and Tomasello 2025). Recent research has begun to differentiate between the valence of shared experiences (i.e. whether shared experiences are positive or negative). However, findings regarding the effects of shared experience valence on social outcomes remain inconclusive. Additionally, existing studies on shared experiences and their valence have primarily focused on examining the mediating mechanisms through affective processes (e.g. emotional synchrony; Páez et al. 2015) and categorization processes (e.g. perceived similarity and identification; Gao et al. 2021), leaving the underlying neurocognitive processes less well understood. Furthermore, few studies on shared experiences have taken a dynamic perspective to examine social interactions, such as investigating individuals' reactions before and after receiving social feedback (e.g. acceptance or rejection from interaction partners).

In this study, we aimed to address the above gaps in the literature by examining the impacts of shared experience valence on the dynamic processing of social feedback using behavioral and neural data collected with an adapted social judgment paradigm (Somerville et al. 2006; Xie et al. 2022). This research extends the existing literature in three ways. First, to our knowledge, this study is among the first to examine individuals' dynamic neural responses associated with shared experiences during social interactions. In a pioneering study, using fMRI, Wagner et al. (2015) found that shared experiences activated the reward circuitry (e.g. ventral striatum and medial orbitofrontal cortex). Our study contributes to the literature by using EEG, which offers higher temporal resolution, to examine the role of shared experience valence in the dynamic social interaction process. Second, we bring in a neurocognitive approach to compare the impacts of shared positive and negative experiences. This complements previous research on shared experience valence that primarily focused on examining affective and categorization processes using self-reported data (Bastian et al. 2014; Gao et al. 2021). Compared with self-reported data, neural data provide more sensitive means of capturing complex mental processes, including processes that are less overt or less accessible through introspection (Amodio et al. 2014; van der Molen et al. 2017; Gu et al. 2020). Third, this study

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investigates the full cycle of social feedback processing: social feedback expectation, social feedback evaluation, and expectation updating. This enables us to understand not only how individuals perceive social feedback, but also how their expectation about social feedback changes as a result of learning and adaptation. Together, these contribute to a more comprehensive and nuanced understanding of how shared experience valence affects social feedback processing.

Expectation of social feedback plays a central role in social interactions (Sommer and Rubin 2013). Expectation can affect social outcomes through the self-fulfilling prophecy (Merton 1948; Downey et al. 1998; Sommer and Rubin 2013). Also, according to the goal-expectation theory, expecting interaction partners to behave favorably is a necessary condition for collaboration (Pruitt and Kimmel 1977; Ng and Au 2016). Moreover, negative social expectancies (i.e. the expectation of being socially rejected) are potent stressors detrimental to self-esteem and well-being (Sjåstad et al. 2021; Kirchner et al. 2022), which further hinder social outcomes. Despite the burgeoning interest in studying shared experiences, surprisingly, no prior study has examined how shared experiences affect individuals' expectation of social feedback. Existing research has suggested that when individuals go through a positive (or negative) experience alone, they are more likely to expect to be accepted (or rejected) by an interaction partner (McGee et al. 1984; Lorion and Saltzman 1993; Dubow et al. 2001). However, whether the same pattern emerges for shared positive and negative experiences remains an open question.

Although no existing studies have examined how shared experiences valence affects the neurocognitive processes or the expectation of social feedback, several lines of research and theoretical perspectives provide valuable insights to inform our predictions. Shared positive experiences may increase the expectation of receiving acceptance rather than rejection for at least two reasons. First, consistent with the similarity-attraction hypothesis (Byrne 1971), studies showed that shared positive experiences enhance perceived similarity and identification with the interaction partner (Motyl et al. 2011; Gao et al. 2021; Zabala et al. 2024), which can increase individuals' expectation of being accepted by the interaction partner (hereafter, acceptance expectation). Second, according to the positivity resonance theory (Fredrickson 2016), shared positive experiences can lead to enriched emotional synchrony and resonance of positivity, which foster acceptance expectation (Fredrickson 2016; Brown et al. 2022; Datu and Tang 2024).

Compared to shared positive experiences, it is less clear whether individuals expect to be socially accepted or rejected by those who share negative experiences. On the one hand, the similarity-attraction hypothesis (Byrne 1971; Montoya and Horton 2013) might as well apply when the shared experiences are negative. Also, individuals who share negative experiences, such as adversities and pain, are better able to empathize with each other (Bastian et al. 2014; Brown et al. 2022) and develop fused identities (Segal et al. 2018), which can increase their expectation of mutual acceptance. On the other hand, individuals tend to affiliate with positive attributes or entities while distancing themselves from negative attributes or entities (Turner et al. 1979; Steele 1988), which reduces mutual acceptance. Additionally, negative experiences can be amplified when shared, which leads to greater negative affect and lower acceptance expectation (Nahleen et al. 2019). Furthermore, negative experiences can threaten individuals' self-concept (Tajfel and Turner 1986; Sedikides and Spencer 2007), which reduces their expectation of developing positive social relationships (Sherman and Cohen 2006).

Only a few studies have directly compared the effects of shared positive experiences and shared negative experiences, with mixed findings on social outcomes. Some studies found that shared positive experiences enhanced social bonding, reduced stress, and contributed more positively to marital quality than shared negative experience (Gao et al. 2021; Brown et al. 2022; Goldring et al. 2022). In contrast, other studies showed that shared negative experiences fostered more supportive interactions and cooperation than shared positive experiences, as individuals sought reconnections to satisfy their belongingness needs threatened by shared negative experiences (Maner et al. 2007; Bastian et al. 2018; Miao et al. 2021). Still, other studies suggested no significant differences between shared positive and negative experiences in terms of activity enjoyment, emotions, arousal, or activation in reward-related brain areas (Wagner et al. 2015; Jolly et al. 2019). None of the aforementioned studies explicitly examined social expectation or the processing of social feedback.

When individuals undergo multiple rounds of social feedback, their expectations of social feedback are often not isolated, but evolve based on past experiences that confirm or violate past expectations. Individuals constantly attempt to reduce the discrepancy between their expectation and reality, or prediction error, by modifying their expectation (Friston 2005, 2010; Clark 2013). The temporal dynamic process through which the current expectation is influenced by prior feedback is known as expectation updating (Kube et al. 2022; Ding et al. 2025). Existing research found that expectation updating is often asymmetric, with positive feedback or "good news" leading to greater updates than negative feedback or "bad news" (Sharot and Garrett 2016; Kube and Rozenkrantz 2021; García Alanis et al. 2023). Such asymmetric updating is caused by individuals' differential encoding of positive and negative feedback (Sharot et al. 2011), which plays a central role in maintaining a positive view of self and reducing risks of mental disorders (Rief et al. 2015; Kube and Rozenkrantz 2021; Elder et al. 2022). For instance, individuals who previously received unexpected acceptance are more likely to expect acceptance feedback in the future. This finding has implications for mitigating depressive symptoms (Kirchner et al. 2022; Kirchner et al. 2023). Furthermore, such asymmetric updating is more likely when outcomes are open to interpretation (Sharot and Garrett 2016).

In this study, we manipulated shared experience valence with personal ranking in a time estimation task (Hu et al. 2014; Hu et al. 2016), and used an adapted social judgment paradigm (Somerville et al. 2006) to investigate participants' processing of social feedback. Our adapted social judgment paradigm effectively separates three stages of social feedback processing: social feedback expectation stage (i.e. participants predicted whether peers who shared positive or negative experiences with them would accept them as partners for a subsequent dyadic task), social feedback evaluation stage (i.e. participants' reactions after receiving feedback on the peer's decision), and expectation updating stage (i.e. whether the social feedback in the current trial affected participants' expectation in a subsequent trial).

Based on the ERP literature on social feedback processing (van der Molen et al. 2017; Gu et al. 2020; Ha and Hampton 2022; Zhang et al. 2023), we examined the following behavioral and neural responses. At the social feedback expectation stage, we examined participants' behavioral keyboard reactions as well as the stimulus-preceding negativity (SPN). The SPN component is a slow, negative-going wave that peaks around 200 ms before the onset of feedback stimuli, which could be sourced to various brain areas. The SPN has been used to capture (emotion- or motivation-laden) anticipatory attention to social feedback (Damen and Brunia 1987; Brunia et al. 2011), with its magnitude being larger when anticipating acceptance than rejection (Pornpattananangkul and Nusslock 2015; Zhang et al. 2022; Peters et al. 2024). In our literature review, we have identified theoretical arguments regarding how shared positive experiences may affect acceptance expectation and how shared negative experiences may affect acceptance expectation; we have also noted the scarcity of past studies that directly compared the effects of shared experience valence on social expectation. Despite this, we hypothesize that shared positive experiences lead to higher acceptance expectation and larger SPN magnitudes in response to acceptance feedback than shared negative experiences. This hypothesis aligns with a simple idea that has been repeatedly supported in studies on individuals in solo situations: positive experience increases positive expectation (Dubow et al. 2001). Moreover, for shared positive experiences, all lines of theoretical arguments converge on the prediction that shared positive experiences are conducive to acceptance expectation, whereas for shared negative experiences, different theoretical perspectives lean toward competing predictions.

At the social feedback evaluation stage, we examined the feedback-related negativity (FRN) and P300 components, as well as early theta power. The FRN is a negative-going wave that reaches its maximum around 250 ms following feedback presentation in the fronto-central cortex (Bellebaum et al. 2010; Warren et al. 2015). It is modulated by dopaminergic activity in the anterior cingulate cortex (ACC), which reflects processes such as prediction error monitoring, reward evaluation and monitoring, controlled adjustment or change in strategy, and motor control filtering (San Martin 2012; Sambrook and Goslin 2015; Heilbronner and Hayden 2016). Past studies showed that the FRN magnitude was larger for unexpected feedback than for expected feedback, with mixed evidence regarding whether expectancy congruence interacted with social feedback type (e.g. acceptance and rejection) in predicting FRN (van der Molen et al. 2017; Harrewijn et al. 2018). We hypothesized that unexpected rejection is particularly salient under shared positive experiences, leading to a larger FRN magnitude. We also explored how shared experience valence affects the FRN in reaction to the other possible social feedback-expectancy congruence combinations: expected acceptance, unexpected acceptance, and expected rejection.

The P300 component peaks around 250–600 ms after feedback stimulus presentation, with its latency influenced by stimulus evaluation timing, task demands, and individual differences (Polich 2007; van der Molen et al. 2014). There are at least two subcomponents of the P300: P3a, an earlier component typically observed in the frontal area and linked to dopaminergic activity in ACC; and P3b, a later component that is typically found in the parietal area and associated with both ACC and the locus coeruleus-norepinephrine system (Nieuwenhuis et al. 2005; Polich 2007; Peters et al. 2024). Previous studies on social judgments tended to focus on P3a (P300 hereafter), which reflects stimulus-driven attentional processes elicited by emotionally and motivationally salient feedback (Nieuwenhuis et al. 2005; Severo et al. 2020). These studies showed that the P300 amplitude was larger for acceptance than rejection feedback (van der Veen et al. 2014; Kortink et al. 2018), likely due to the rewarding nature of social acceptance (Wu and Zhou 2009; van der Veen et al. 2014), and larger for expected than unexpected feedback (Harrewijn et al. 2018; Kortink et al. 2018), as P300 is larger for hits than for misses (Aston-Jones et al. 2005; Hajcak et al. 2007). More importantly, existing studies have yielded mixed findings regarding the interaction between social feedback and congruence. Some found that expected acceptance elicited larger P300 than the other social feedback-expectancy congruence combinations (van der Veen et al. 2014; van der Veen et al. 2016; Kortink et al. 2018; van der Molen et al. 2018; Hoffman et al. 2021), whereas others suggested that unexpected acceptance could elicit the largest P300 (Gutz et al. 2011; Schindler et al. 2021). Still others found no significant interaction between social feedback and congruence (Dekkers et al. 2015; Harrewijn et al. 2018). These inconsistencies may be contingent on the actual or perceived probability, or novelty, of the stimuli and the reward value of the feedback in the specific setting (Aston-Jones et al. 2005; Polich 2007). Shared experience valence provides a novel context to further examine this interaction between social feedback and congruence.

In this study, we explored whether and how shared experience valence affects the P300 responses to various social feedback-expectancy congruence combinations. One possibility is that expected acceptance elicits larger P300 than the other combinations, particularly under shared positive experiences, which may be considered more rewarding than shared negative experiences. A second possibility is that unexpected acceptance elicits larger P300 under shared negative experiences than under shared positive experiences. This is because unexpected acceptance following shared negative experiences may be perceived as more rewarding, as it conveys the precious positivity (i.e. acceptance and social connection) that grows out of negativity (i.e. the negative experiences that both the participant and the interaction partner have been through). Other patterns are also plausible, and we approach this research question as an open inquiry.

In addition to the ERP components above, we examined early theta band power (4–8 Hz) (De Pascalis et al. 2012; Crowley et al. 2014; Cristofori et al. 2015) in the social feedback evaluation stage. Previous studies suggested that early theta band power (200–400 ms after feedback onset) in the fronto-central region is associated with social-evaluative threat monitoring (Kortink et al. 2018; Zhang, van der Molen et al. 2022). It has been found to be larger following expectation violation (Cavanagh et al. 2013) and social rejection feedback (Cristofori et al. 2013; van Noordt et al. 2015), and highest in the unexpected rejection condition (van der Veen et al. 2016; van der Molen et al. 2017; Harrewijn et al. 2018; Kortink et al. 2018; van der Molen et al. 2018). We proposed two competing hypotheses regarding early-theta power. Past studies showed that unexpected rejection triggers larger early theta power than other social feedback-expectancy congruence combinations (van der Molen et al. 2017; van der Molen et al. 2018). This pattern may be weaker under shared positive experiences, which provide individuals with ample psychological resources to buffer the potential threats caused by unexpected rejection (Fredrickson 2016; Datu et al. 2024). However, it is also possible that this pattern would be weaker under shared negative experiences, which can amplify negative affect (Boothby et al. 2014) and activate a self-protection mode. The self-protection mode may direct individuals' attention away from potential external threats, leading them to be insensitive to rejection feedback (van der Molen et al. 2018).

At the expectation updating stage, we examined both behavioral responses and late theta power. Specifically, we examined theta power that occurred 600–700 ms after feedback onset in the posterior region. Late theta power in this region has been associated with the memory encoding process, with larger late theta power indicating greater intensity of episodic memory encoding and predicting higher memory performance (Klimesch 1999;

Itthipuripat et al. 2013). We therefore suspected that this late theta power may serve as an indicator of expectation updating, where current social feedback is encoded into episodic memory and influences future expectation. Because of the asymmetric updating effect (Sharot et al. 2011), expectation updating is more likely to occur when individuals receive unexpected acceptance feedback, compared to receiving unexpected rejection feedback. Considering the effect of shared experience valence, and given that asymmetric updating is more likely when outcomes are uncertain and open to interpretation (Sharot and Garrett 2016), we expected the asymmetric updating due to unexpected acceptance to be greater under shared negative experiences than under shared positive experiences.

Method

Power analysis, transparency, and ethics

Before launching the study, we conducted a power analysis to determine the sample size using G∗Power 3.1.9.7 (Faul et al. 2007). Based on previous ERP research that used a similar experimental paradigm (Rösler et al. 2023), we estimated that a minimum sample size of 26 (10 × 30 useful trials per participant) was required for testing a small-to-medium effect size ($\alpha = 0.05$, power = 0.80, $\eta_p^2 = 0.25$) for the three-way interaction of shared experience valence (shared positive experiences [SPE] vs. shared negative experiences [SNE]) × expectancy congruence (expected vs. unexpected) × social feedback (acceptance vs. rejection) using repeated-measures analysis of variance (ANOVA). We deposited the data and analysis code on the Open Science Framework (OSF; https://osf.io/wtujs/?view_only=e9eb3d0052344a0ebcfdc0cf0f3adfc3). A transparency report is available in supplementary materials. Each participant provided written informed consent before the experiment. This experiment was carried out in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the School of Psychological and Cognitive Sciences, Peking University (Approval of IRB Protocol #2021–03-03e).

Participants

We recruited 50 participants from a large public research university in China. Two participants were excluded due to artifact rejection, resulting in a final sample of 48 participants (21 men and 27 women) with an average age of 20.88 years old (*SD* = 2.33). All participants were right-handed and had normal or corrected-to-normal vision. None of the participants reported any history of psychiatric, neurological, or cognitive disorders.

Procedure

Upon arrival at the laboratory, participants provided consent for the experimenter to take their photos, which would later be used in the study. Participants then read a cover story adapted from previous studies (Somerville et al. 2006; van der Molen et al. 2017; see supplementary materials for details). The cover story explained that, over a month ago, a group of 1000 students from the same university had completed an online study. In that study, participants performed a time estimation task, and then were asked whether they would be willing to pair with an unknown peer who shared the same performance on the time estimation task for a subsequent study scheduled ∼1 month later.

Participants were then informed that they would perform the same time estimation task. Following this, participants were asked to assess whether the peers in the previous online study, described in the cover story above, were willing to collaborate with them (i.e. the adapted social judgment paradigm, SJP). Each participant completed 12 blocks, which included five SPE blocks, five SNE blocks, and two filler blocks. The order of the blocks was randomized for each participant. Each block consisted of six trials of the time estimation task, followed by 30 trials of the adapted SJP.

In the time estimation task (see Fig. 1, Panel A), participants first read an instruction about a time duration that they needed to estimate on a computer screen. The time duration was randomly generated, ranging from 1 to 12 seconds. Once the instruction disappeared, a red dot cue appeared. Participants were instructed to press the spacebar for the estimated duration once the red dot turned green. After completing six trials of the time estimation task, participants received fake feedback regarding their rank on this task for the block. The rank was displayed as three stars (high rank), two stars (medium rank), or one star (low rank) beneath a photo of the participant's face. This rank served to manipulate positive versus negative experiences. In the manipulation check, all participants recalled their ranks for all blocks correctly.

In each adapted SJP trial (see Fig. 1, Panel B), participants first viewed a grayscale photo of the face of an anonymous peer, purportedly from the previous online study, who shared the same rank in the time estimation task as the participant. The rank of the peer was indicated by three, two, or one stars under the face of the peer. In the SPE blocks, both the participant and the peer had a high rank. In the SNE blocks, both the participant and the peer had a low rank. In the filler blocks, both the participant and the peer had a medium rank. The filler blocks served to reduce participants' suspicion about the manipulation of rank. Participants then judged whether the peer accepted or rejected them as a partner in the previous online study. This was done by pressing the F or J button (counterbalanced across participants) within 3 seconds. If the participant did not press either button within the response window, the message "too slow" appeared on the screen, and the trial advanced. Immediately following the participant's response, their expectation ("Willing" [Accept] or "Not Willing" [Reject]) of the peer's decision appeared to the left of the peer's face. After 3 seconds, the peer's feedback ("Willing" [Accept] or "Not Willing" [Reject]) appeared to the right of the peer's face and lasted for 2 seconds. Across all 360 adapted SJP trials (12 blocks × 30 trials per block), half of the peers were males and half were females. Photos of the peers, sourced from CAS-PEAL-R1 (Gao et al. 2008), were unique to each trial (i.e. 360 distinct photos in total). The probabilities of acceptance and rejection feedback from the peers were evenly distributed at 50% each.

The experiment ended with participants filling out self-report questionnaires and writing down their thoughts about the study. They were then debriefed. No participant guessed the purpose of the study correctly.

Self-reported measures

As a manipulation check, after completing all 12 blocks, participants rated their perceived rank (1 = *very low*, 7 = *very high*), as well as their state positive and negative affects (measured using the Positive and Negative Affect Scale; Watson et al. 1988) upon seeing low, medium, and high ranks in the time estimation task. The measures of state positive affect and state negative affect demonstrated high reliabilities, with Cronbach's α reliabilities ranging from 0.89 to 0.92 across different rank conditions.

Behavioral responses

Participants' expectation was assessed with the acceptance expectancy rate. This rate was calculated by dividing the number

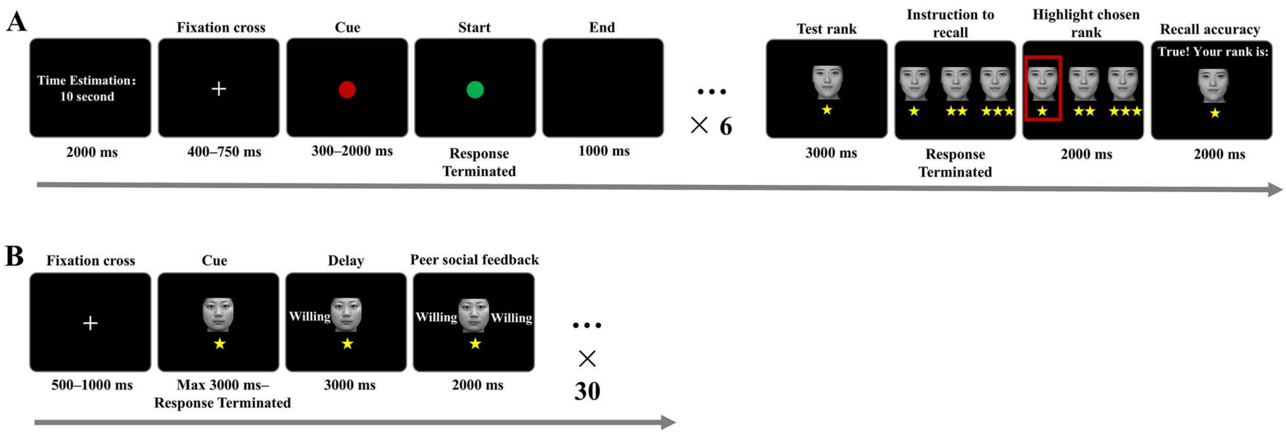

Fig. 1. Experimental procedure. (A) Time estimation task (six trials per block; Hu et al. 2014). Rank was shown with a star system: One star-low rank (SNE condition), two stars-medium rank (filler condition), and three stars-high rank (SPE condition). The photo in Panel A depicted the participant's own face. (B) Adapted social judgment paradigm (30 trials per block; Somerville et al. 2006). The photo in Panel B depicted an anonymous peer's face. Participants were required to judge whether the peer accepted or rejected them as a partner for a subsequent task. Participants' expectation of the social feedback appeared to the left of the peer's face, while the peer's social feedback appeared to the right. Photos of the peers were obtained from CAS-PEAL-R1 (Gao et al. 2008), with permission for reproduction granted by the lCT-ISVISlON Joint Research & Development Laboratory.

of trials in which participants expected acceptance feedback by the total number of valid trials within each block, then averaging across blocks in the SPE and SNE conditions separately. The rejection expectancy rate was calculated as one minus the acceptance expectancy rate.

EEG recording and processing

EEG data were recorded with the Brain Products system at a 500 Hz sampling rate (with an online band-pass filter of 0.01–100 Hz) using 64 Ag/AgCl ring electrodes mounted according to the 10–20 system (Sharbrough et al. 1991). Electrode impedance was kept below 5 kΩ. The ground electrode was AFz, and the reference electrode for online recording was FCz. Eye movement-related artifacts were monitored via an additional electrode placed below the right eye. The acquired data were preprocessed using EEGLAB v2022.1 (Delorme and Makeig 2004). The offline data were re-referenced to the average of the bilateral mastoid electrodes and then filtered with a 0.05–40 Hz (6 dB/oct) band-pass filter. Artifacts such as blinking, horizontal eye movement, and muscle activity were detected and discarded through an extended Info-Max independent component analysis (Bell and Sejnowski 1995). We relied on both automatic identification through ICLabel and visual inspection to identify and remove independent component analysis components (Chaumon et al. 2015; Pion-Tonachini et al. 2019), which resulted in the exclusion of an average of 6.31 components per participant ($SD = 6.44$; range: 0–17; see supplementary materials for details). The average number of valid trials retained per condition was 44.32 ($SD = 21.91$, $Median = 40$, range: 4 to 136). In all conditions, the average number of valid trials surpassed 30, which met the recommendations by past studies (Boudewyn et al. 2018; Cohen and Polich 1997; Duncan et al. 2009). Three participants had fewer than 10 valid trials in at least one condition. Excluding data from these three participants yielded results comparable to those obtained with the full sample (see supplementary materials for details).

Time series were epoched surrounding the onset of social feedback: −1200 to 200 ms for SPN, −200 to 1000 ms for FRN and P300, and − 4000 to 4000 ms for time-frequency analysis (van der Molen et al. 2017; Zhang et al. 2022). The offline data were baseline-corrected against the pre-feedback period: 1200 to 1000 ms for SPN (Zhang et al. 2022) and 200 to 0 ms for FRN and P300 (van der Veen et al. 2016). Epochs contaminated with significant artifacts (exceeding ±100 μV) were excluded from further analyses (Gu et al. 2020; Zhang et al. 2022). Artifact-free segments were then averaged condition-wise. See supplementary materials for more details.

We determined the time windows and electrodes of ERP components based on previous studies using similar paradigms, the grand average waveforms (available on OSF), and topographic maps (Luck 2014; Kappenman and Luck 2016; Luck and Gaspelin 2017; see supplementary materials for details). The SPN segments were extracted from −200 to 0 ms relative to feedback onset at the Fpz and Pz electrodes (van der Molen et al. 2014; Topel et al. 2021; Zhang et al. 2022). The FRN was analyzed using a peak-to-peak detection method, subtracting the peak amplitude of P2 from the most negative peak following P2 at the Fz electrode site (van der Veen et al. 2016; van der Molen et al. 2018). In our data, P2 peaked around 200–300 ms, which was consistent with previous studies (van der Molen et al. 2014; van der Molen et al. 2017). The most negative peak after P2 occurred around 250–375 ms, which also overlapped with the time windows chosen in prior studies (van der Molen et al. 2014; van der Molen et al. 2017; Harrewijn et al. 2018). The mean amplitude of P300 was averaged between 350 and 450 ms post-feedback onset at the fronto-central electrodes (FC1/2/3/4/5/6, FCz) (Kortink et al. 2018; van der Molen et al. 2018; Gu et al. 2020).

The time-frequency analysis was conducted using convolution of single trials with complex Morlet wavelets, after which power was averaged within each condition for each participant. The Morlet parameter was set to 5 for a trade-off between time and frequency power precision (van der Molen et al. 2018). Power was normalized using a ratio-change from the −500 to −200 ms relative to feedback onset (van der Molen et al. 2017). Considering previous literature and data characteristics, we extracted the average theta power (4–8 Hz) at fronto-central and central electrodes (FC3/4/5/6, C3/4) around 250–350 ms (van der Veen et al. 2016; van der Molen et al. 2017; van der Molen et al. 2018) and parietal and centro-parietal electrodes (P5/6, CP5/6) around 600–700 ms (Klimesch et al. 1996; Cohen et al. 1997; Klimesch et al. 2006).

Statistical analyses

To test our hypotheses for the social feedback expectation stage with behavioral data, we conducted a paired samples t-test comparing the acceptance expectation rates of the SPE condition and the SNE condition. We also performed a trial-level binomial logistic regression with shared experience valence as the independent variable and probability of acceptance expectation as the dependent variable. For the expectation updating stage, we performed two sets of trial-level binomial logistic regressions for the SPE and SNE conditions, respectively. The dependent variable was acceptance expectation in the subsequent trial, and the independent variables were expectancy congruence and social feedback in the current trial, with trial order, block, and participant as random effects.

For the EEG measures, we took the average for each condition and conducted the repeated measures ANOVA using the bruceR package in R (version 4.0.5; Bao 2022). For the social feedback expectation stage, we examined whether shared experience valence (SPE vs. SNE) interacted with social feedback expectation (acceptance expectation vs. rejection expectation) in predicting SPN. For the social feedback evaluation stage, we entered FRN, P300, and early theta power into a shared experience valence (SPE vs. SNE) × expectancy congruence (expected vs. unexpected) × social feedback (acceptance vs. rejection) repeated-measures ANOVA. For the expectation updating stage, we entered late theta power into the same shared experience valence × expectancy congruence × social feedback repeated-measures ANOVA. Moreover, we calculated the Pearson correlation coefficients between late theta power and the behavioral measures. We adjusted the p values of the post-hoc analyses for multiple comparisons using the Bonferroni method (Levin et al. 1994).

Results

Manipulation check

We performed paired samples t-tests to examine whether participants felt distinct emotions in the SPE and SNE conditions. The results showed that participants perceived greater positive affect in the SPE condition (30.58 ± 8.96) than in the SNE condition (20.35 ± 7.35), $t(47) = 7.83$, $P < 0.001$, Cohen's $d = 1.13$; also, participants perceived greater negative affect in the SNE condition (19.58 ± 7.34) than in the SPE condition (12.60 ± 4.16), $t(47) = 7.73$, $P < 0.001$, Cohen's $d = 1.12$. These manipulation checks suggested successful manipulation of shared experience valence (see supplementary materials for more details).

Behavioral analysis

Social feedback expectation

Table 1 summarizes the repeated-measures ANOVA results for all behavioral and EEG measures at all stages.

Consistent with previous studies (Gunther Moor et al. 2010; Dekkers et al. 2015), a one-sample t-test revealed that participants' likelihood of expecting acceptance feedback (0.58 ± 0.15) was higher than chance level (0.50) in the SPE condition, $t(47) = 3.78$, $P < 0.001$, Cohen's $d = 0.54$, indicating an optimistic bias. However, this optimistic bias was not found in the SNE condition, $t(47) = 1.78$, $P = 0.081$ (acceptance expectation: 0.55 ± 0.18). Moreover, a paired samples t-test showed that participants' acceptance expectation was significantly higher in the SPE condition than in the SNE condition, $t(47) = 2.03$, $P = 0.048$, Cohen's $d = 0.29$. This test result also meant that rejection expectation was significantly higher in the SNE condition than in the SPE condition (rejection expectation = 1−acceptance expectation). A trial-level binomial logistic regression revealed that shared experience valence significantly predicted behavioral expectation, with the probability of acceptance expectation in the SPE condition being 1.17 times that of the SNE condition ($B = 0.15$, $SE = 0.04$,

Table 1. Summary of repeated-measures ANOVA results for behavioral and EEG measures.

	Social feedback expectation stage						Social feedback evaluation stage									Expectation updating stage		
	Acceptance expectancy rate			SPN			FRN			P300			Early theta			Late theta		
	t	p	d	F	p	η_p^2	F	p	η_p^2	F	p	η_p^2	F	p	η_p^2	F	p	η_p^2
Shared experience valence (S)	2.03	0.048	0.29	1.33	0.254	0.028	0.03	0.862	0.001	0.24	0.626	0.005	0.92	0.341	0.019	0.44	0.51	0.009
Social feedback expectation (FE)				0.21	0.653	0.004												
S × FE				4.14	0.047	0.081												
Expectancy congruence (C)							7.83	0.007	0.143	1.82	0.184	0.037	4.46	0.040	0.087	0.004	0.952	<0.001
Social feedback (F)							4.58	0.038	0.089	2.06	0.158	0.042	5.65	0.022	0.107	3.06	0.087	0.061
S × C							0.06	0.816	0.001	1.58	0.215	0.033	1.20	0.279	0.025	4.61	0.037	0.089
S × F							0.78	0.381	0.016	0.82	0.371	0.017	4.90	0.032	0.094	0.07	0.796	0.001
C × F							0.11	0.740	0.002	4.08	0.049	0.080	1.44	0.236	0.030	0.05	0.820	0.001
S × C × F							0.17	0.682	0.004	5.11	0.029	0.098	1.88	0.177	0.038	4.58	0.038	0.089

Note. $n = 48$. Each participant provided data for five blocks in the SPE condition, and five in the SNE condition.

$z = 4.23$, $P < 0.001$). These findings supported the hypothesis that acceptance expectation was higher in the SPE condition than in the SNE condition at the behavioral level.

Expectation updating

We conducted two sets of trial-level binomial logistic regression analyses to examine expectation updating under the SPE and SNE conditions, respectively. In both conditions, we found significant and positive main effects of social feedback (acceptance = 1, rejection = 0; SNE: $B = 0.30$, $SE = 0.08$, $z = 4.00$, $P < 0.001$; SPE: $B = 0.30$, $SE = 0.08$, $z = 3.94$, $P < 0.001$) and expectancy congruence (expected = 1, unexpected = 0; SNE: $B = 0.15$, $SE = 0.08$, $z = 2.02$, $P = 0.043$; SPE: $B = 0.16$, $SE = 0.08$, $z = 2.06$, $P = 0.040$). These results indicate that receiving acceptance feedback or expected feedback in the current trial significantly increased the probability of expecting acceptance feedback in the subsequent trial. Additionally, we found a significant interaction between social feedback and expectancy congruence in both conditions (SNE: $B = -0.32$, $SE = 0.11$, $z = -2.89$, $P = 0.004$; SPE: $B = -0.38$, $SE = 0.11$, $z = -3.43$, $P < 0.001$). Simple effects analyses showed that compared to receiving expected acceptance or unexpected rejection, participants were more likely to expect acceptance in the subsequent trial after receiving unexpected acceptance feedback in the current trial. These results suggested that the asymmetric updating effect due to unexpected acceptance held for both SPE and SNE conditions at the behavioral level, contradicting our hypothesis.

Event-related brain potential analyses

Social feedback expectation

We examined participants' expectation of social feedback through the negative-going SPN in the fronto-parietal areas. There was no significant main effect of shared experience valence or social feedback expectation, nor an interaction between them ($Ps > 0.05$). Exploratory analysis of the SPN signals at the F7/8, T7/8, and TP7/8 electrodes—areas associated with the ventral attention system (Corbetta and Shulman 2002; Brunia et al. 2011)—revealed no main effect of shared experience valence or social feedback expectation ($Ps > 0.05$). However, there was a significant two-way interaction effect between shared experience valence and social feedback expectation, $F(1, 47) = 4.14$, $P = 0.047$, $\eta_p^2 = 0.081$ (see Fig. 2). Simple effects analyses indicated that under the SNE condition, rejection expectation (-1.04 ± 1.17 μV) evoked a larger (i.e. more negative-going) ventral frontal and temporo-parietal SPN magnitude than acceptance expectation (-0.66 ± 1.22 μV), $t(47) = 2.24$, $P = 0.030$, Cohen's $d = 0.22$. In contrast, no significant difference was observed in the SPE condition, $t(47) = -0.79$, $P = 0.436$, Cohen's $d = -0.13$.

Social feedback evaluation

A repeated measures three-way ANOVA was conducted to examine the interaction of shared experience valence (SPE vs. SNE) × expectancy congruence (expected vs. unexpected) × social feedback (acceptance vs. rejection) on two neural indicators at the social feedback evaluation stage: FRN and P300. Regarding FRN, the results yielded a significant main effect of expectancy congruence, $F(1, 47) = 7.83$, $P = 0.007$, $\eta_p^2 = 0.143$ (see Fig. 3), with a larger FRN magnitude for unexpected feedback (-4.77 ± 2.79 μV) than for expected feedback (-4.18 ± 2.87 μV). A significant main effect of social feedback was also found, $F(1, 47) = 4.58$, $P = 0.038$, $\eta_p^2 = 0.089$, with a larger FRN magnitude for rejection feedback (-4.69 ± 2.88 μV) than for acceptance feedback (-4.26 ± 2.80 μV). The main effect of shared experience valence, as well as the other two-way and three-way interaction effects, were non-significant ($Ps > 0.05$).

Regarding P300, no significant main effects were found ($Ps > 0.05$). However, a significant two-way interaction between expectancy congruence and social feedback emerged, $F(1, 47) = 4.08$, $P = 0.049$, $\eta_p^2 = 0.080$. Simple effects analyses indicated that P300 evoked by unexpected acceptance (3.38 ± 5.11 μV) was larger than that evoked by unexpected rejection (2.62 ± 4.61 μV), $t(47) = 2.33$, $P = 0.024$, Cohen's $d = 0.28$; no significant difference was found between expected acceptance (3.09 ± 4.64 μV) and expected rejection (3.42 ± 4.67 μV), $t(47) = -1.11$, $P = 0.273$; also, P300 evoked by expected rejection was larger than that evoked by unexpected rejection, $t(47) = 2.51$, $P = 0.015$, Cohen's $d = 0.29$; no significant difference was found between expected acceptance and unexpected acceptance, $t(47) = -0.83$, $P = 0.409$. In addition, the three-way interaction of shared experience valence, expectancy congruence, and social feedback was significant, $F(1, 47) = 5.11$, $P = 0.029$, $\eta_p^2 = 0.098$(see Fig. 4). To further explore this three-way interaction, we tested the simple interaction effects of expectancy congruence and social feedback in the SNE and SPE conditions, respectively. In the SPE condition, this simple two-way interaction was significant, $F(1, 47) = 9.10$, $P = 0.004$, $\eta_p^2 = 0.162$: P300 evoked by unexpected acceptance (3.68 ± 4.78 μV) was larger than that evoked by unexpected rejection (2.43 ± 4.42 μV), $t(47) = 3.37$, $P = 0.002$, Cohen's $d = 0.46$; no significant difference was found between expected acceptance (2.82 ± 4.08 μV) and expected rejection (3.34 ± 4.82 μV), $t(47) = -1.53$, $P = 0.133$; also, P300 evoked by expected rejection was larger than that for unexpected rejection, $t(47) = 2.21$, $P = 0.032$, Cohen's $d = 0.33$. Conversely, in the SNE condition, the simple two-way interaction between expectancy congruence and social feedback was non-significant, $F(1, 47) = 0.47$, $P = 0.496$.

Theta oscillations

Social feedback evaluation

A repeated measures three-way ANOVA was conducted to examine the interaction of shared experience valence × expectancy congruence × social feedback on the fronto-central theta power in the early phase of the feedback process (250–350 ms). The results revealed a significant main effect of expectancy congruence, $F(1, 47) = 4.46$, $P = 0.040$, $\eta_p^2 = 0.087$. Early theta power was larger for unexpected feedback (0.48 ± 0.49) than for expected feedback (0.42 ± 0.33). The main effect of social feedback was also significant, $F(1, 47) = 5.65$, $P = 0.022$, $\eta_p^2 = 0.107$. Early theta power was smaller for rejection feedback (0.41 ± 0.31) than for acceptance feedback (0.48 ± 0.51). Furthermore, the interaction effect between shared experience valence and social feedback was significant, $F(1, 47) = 4.90$, $P = 0.032$, $\eta_p^2 = 0.094$ (see Fig. 5). Simple effects analyses showed that in the SNE condition, early theta power was smaller for rejection feedback (0.36 ± 0.29) than for acceptance feedback (0.51 ± 0.64), $t(47) = 2.92$, $P = 0.005$, Cohen's $d = 0.29$; this effect was non-significant in the SPE condition, $t(47) = -0.13$, $P = 0.894$. In addition, early theta power for rejection feedback was larger in the SPE condition (0.47 ± 0.32) than in the SNE condition (0.36 ± 0.29), $t(47) = 3.68$, $P < 0.001$, Cohen's $d = 0.22$.

Expectation updating

A repeated measures three-way ANOVA was conducted to examine the interaction of shared experience valence × expectancy congruence × social feedback on the centro-parietal theta power in the late phase of the feedback process (600–700 ms). We found a significant two-way interaction between shared experience

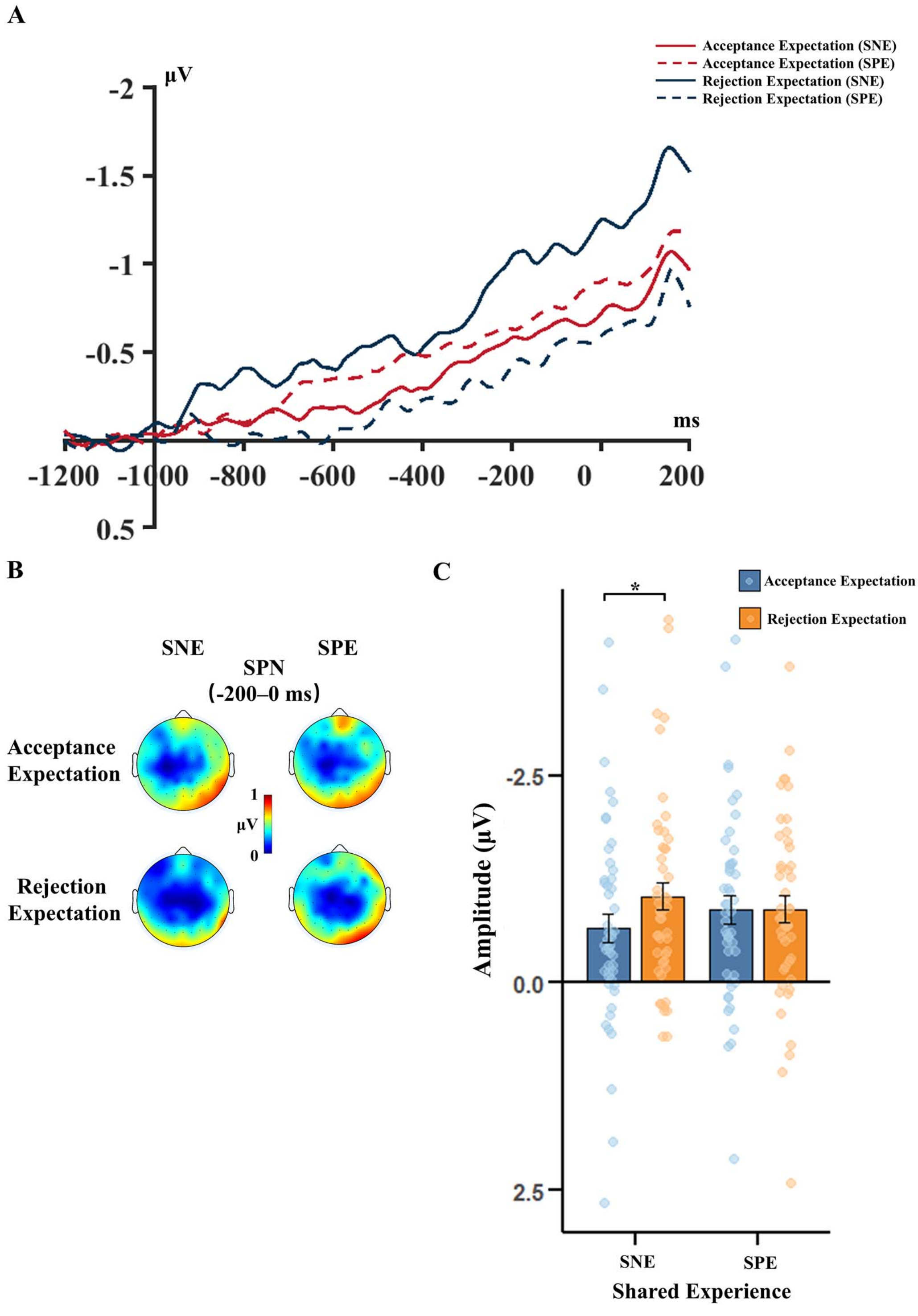

Fig. 2. Stimulus-preceding negativity (SPN) elicited at the social feedback expectation stage at the ventral frontal and temporo-parietal electrodes (F7/8, T7/8, TP7/8). (A) Grand-mean SPN waveforms during acceptance and rejection anticipation. (B) Scalp topography of SPN at −200–0 ms. (C) Average amplitude of SPN. Error bars indicate standard errors. $^*P < 0.05$.

valence and expectancy congruence, $F(1, 47) = 4.61$, $P = 0.037$, $\eta_p^2 = 0.089$ (see Fig. 6). Simple effects analyses showed a marginally significant difference between late theta power elicited by expected feedback in the SPE (0.15 ± 0.30) and SNE (0.08 ± 0.19) conditions, $t(47) = 1.92$, $P = 0.060$, Cohen's $d = 0.21$; no significant difference was found between late theta power elicited by unexpected feedback in the SPE (0.09 ± 0.23) and SNE (0.13 ± 0.27) conditions, $t(47) = -1.03$, $P = 0.309$, Cohen's $d = -0.11$. More importantly, the three-way interaction of shared experience valence, expectancy congruence, and social feedback was significant, $F(1, 47) = 4.58$, $P = 0.038$, $\eta_p^2 = 0.089$ (see Fig. 6). Simple interaction analyses showed that in the SNE condition, the simple two-way interaction of expectancy congruence and social feedback was marginally significant, $F(1, 47) = 3.66$, $P = 0.062$. Specifically, in the SNE condition, late theta power evoked by unexpected acceptance (0.17 ± 0.34) was larger than that evoked by expected acceptance (0.07 ± 0.20),

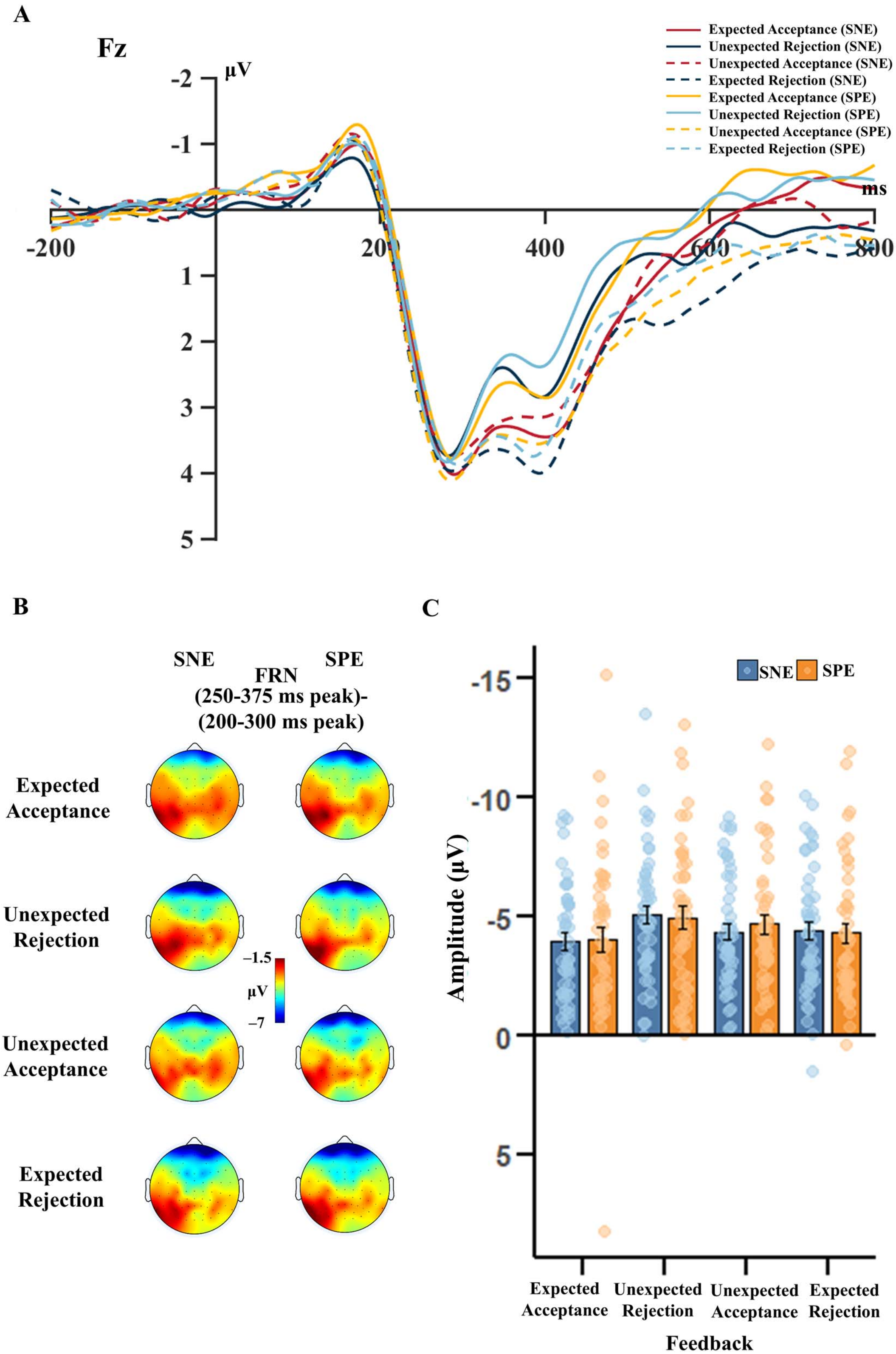

Fig. 3. Event-related brain potentials elicited at the social feedback evaluation stage: FRN at the Fz electrode. (A) Grand-mean FRN waveforms elicited by social feedback. (B) Scalp topography of FRN. (C) Average amplitude of FRN. Error bars indicate standard errors.

$t(47) = 2.11$, $P = 0.040$, Cohen's $d = 0.33$; no significant difference between late theta power evoked by unexpected rejection (0.08 ± 0.18) and by expected rejection (0.09 ± 0.18), $t(47) = 0.25$, $P = 0.803$, Cohen's $d = 0.03$. In the SPE condition, this simple two-way interaction was non-significant, $F(1, 47) = 1.79$, $P = 0.187$. These results supported our hypothesis that the asymmetric updating effect due to unexpected acceptance was stronger in the SNE condition than in the SPE condition in neural responses. Additionally, late theta power elicited by expected acceptance was larger in the SPE condition (0.19 ± 0.36) than in the SNE condition (0.07 ± 0.20),

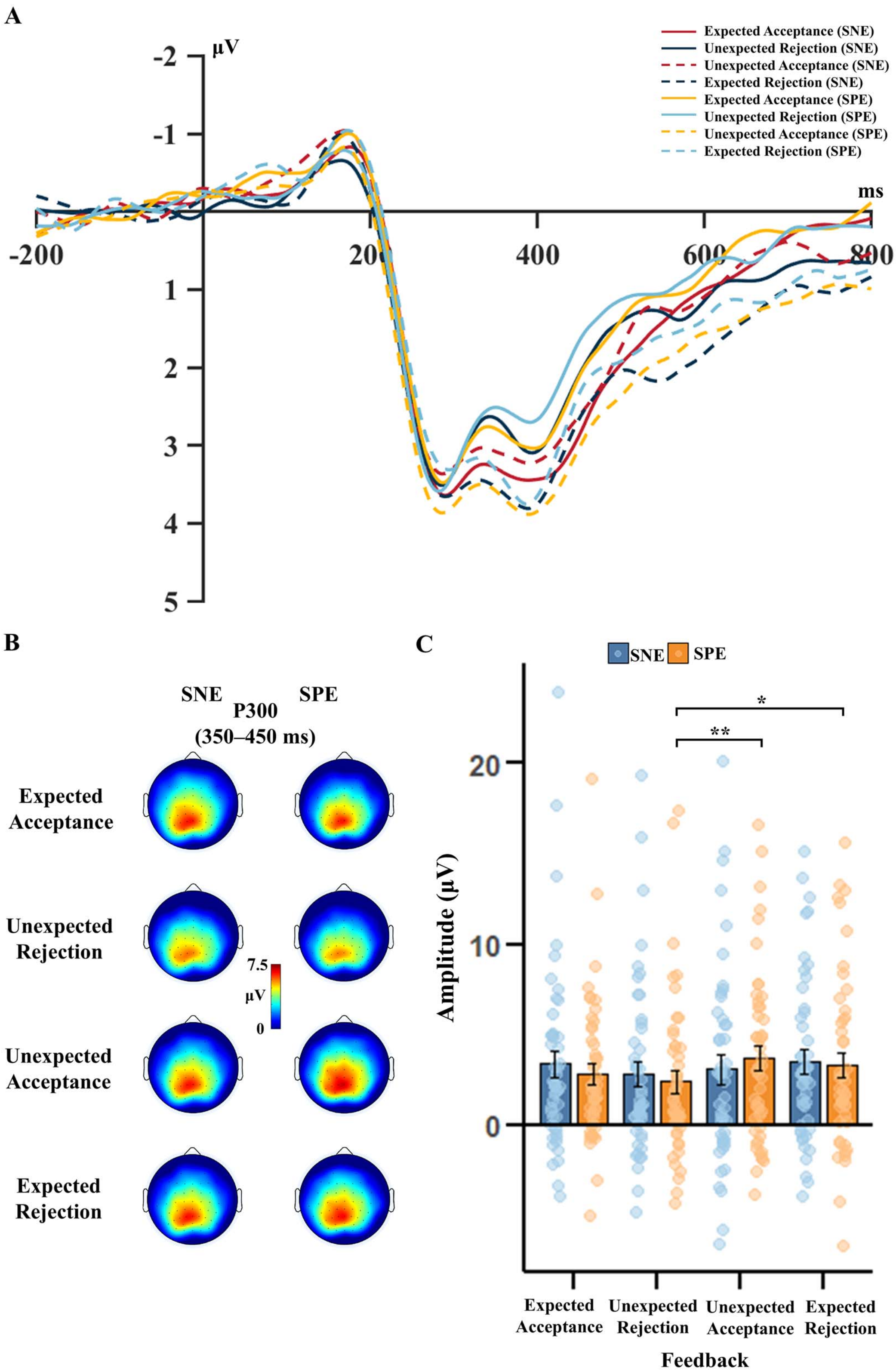

Fig. 4. Event-related brain potentials elicited at the social feedback evaluation stage: P300 at the fronto-central electrodes (FC1/2/3/4/5/6, FCz). (A) Grand-mean P300 waveforms elicited by social feedback. (B) Scalp topography of P300. (C) Average amplitude of P300. Error bars indicate standard errors. *$P < 0.05$. **$P < 0.01$.

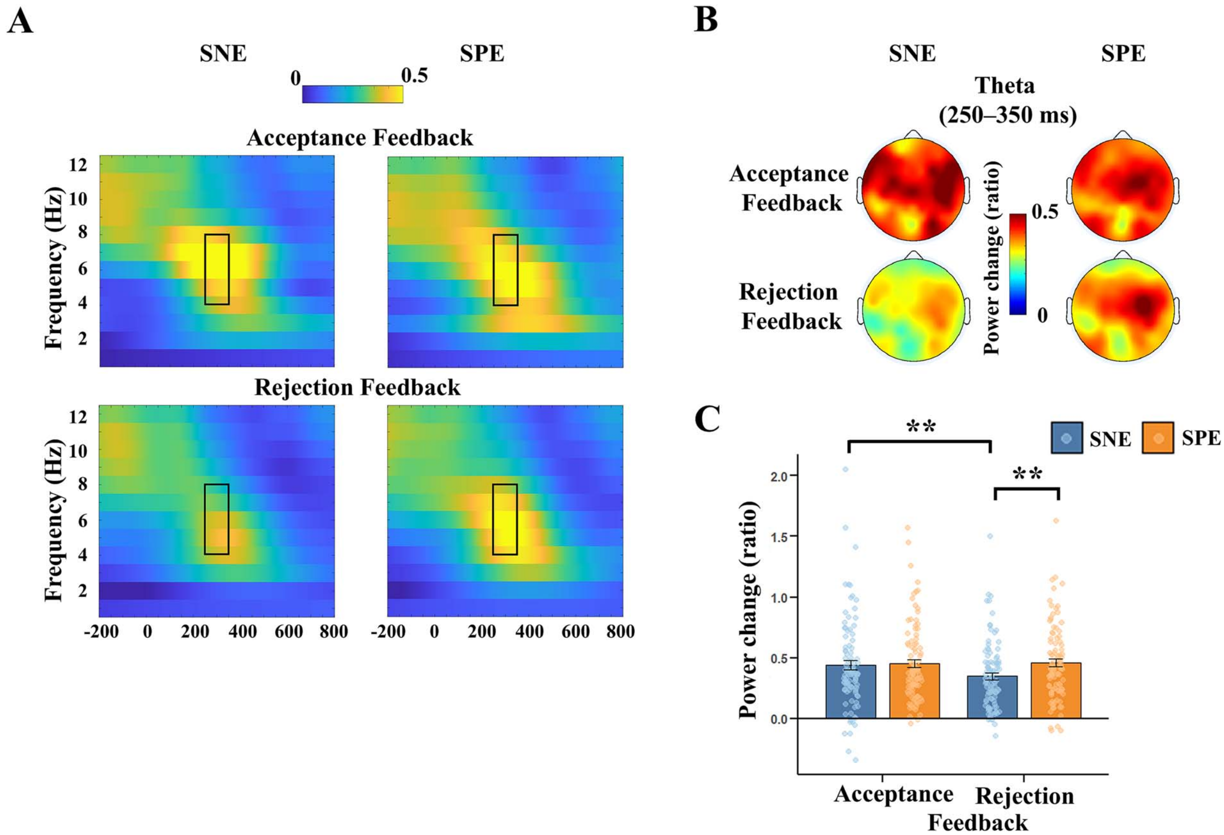

Fig. 5. Time-frequency power at fronto-central and central electrodes (FC3/4/5/6, C3/4) during the 250–350 ms post-feedback interval. (A) Time frequency spectrograms about spectral power over time. (B) Scalp topography of early theta power. (C) Averaged feedback-related early theta power. Error bars indicate standard errors. $^*P < 0.05$. $^{**}P < 0.01$.

$t(47) = 2.05$, $P = 0.046$, Cohen's $d = 0.39$. All other tests of main effects or two-way interaction effects were non-significant ($Ps > 0.05$).

Pearson correlation analysis showed that in the SNE condition, late theta power elicited by unexpected acceptance was positively correlated with the coefficient representing the probability of acceptance expectation in the subsequent trial following unexpected acceptance in the current trial in the binomial logistic regression ($r = 0.49$, $P < 0.001$).

Discussion

The current study investigated the neurocognitive processes underlying how shared positive and negative experiences influence social feedback processing. Using an adapted social judgment paradigm with EEG recording, we examined participants' behavioral and neural responses across three stages: (1) social feedback expectation (behavioral data and SPN), (2) social feedback evaluation (FRN, P300, and early theta power), and (3) expectation updating (behavioral data and late theta power).

At the social feedback expectation stage, using behavioral measures, we found that participants were more likely to expect acceptance and less likely to expect rejection in the SPE condition than in the SNE condition. Regarding neural responses, we did not find any main effects or interaction effect of shared experience valence and social feedback expectation on the frontal–parietal SPN. However, exploratory analyses of the SPN in the ventral frontal and temporo-parietal regions revealed interesting and important findings. Specifically, there was a significant interaction between shared experience valence and social feedback expectation on the SPN in this area. In the SNE condition, rejection expectation evoked a larger SPN magnitude than acceptance expectation, whereas no significant difference was observed in the SPE condition. Previous studies adopting the social judgment paradigm have mainly focused on the frontal–parietal SPN and considered it as a signal of reward anticipation (van der Molen et al. 2014; Pornpattananangkul and Nusslock 2015; Zhang et al. 2022; Peters et al. 2024). However, SPN can be generated by two distinct attention systems (Brunia et al. 2011). The fronto-parietal SPN is associated with the dorsal attention system in the frontal eye fields and the intraparietal region, which is responsible for top-down, goal-directed control processes. The other system, the ventral attention system, consists of the inferior frontal and temporo-parietal cortices. It mediates involuntary attention to salient, motivationally relevant, and intense stimuli (Corbetta and Shulman 2002; Brunia et al. 2011). In healthy individuals, the ventral attention system is often activated first, which then provides inputs to the dorsal attention system if stimuli are considered relevant. Our findings regarding SPN in the ventral attention system suggested that participants in the SNE condition perceived rejection as more salient and potentially more uncertain and threatening than acceptance (Tanovic et al. 2018; Tanovic and Joormann 2019). In comparison, the SPE condition was non-alerting and did not trigger this ventral attention system. These findings revealed converging evidence that, compared with shared positive experiences, shared negative experiences increased rejection expectation and made individuals more vigilant toward impending rejection.

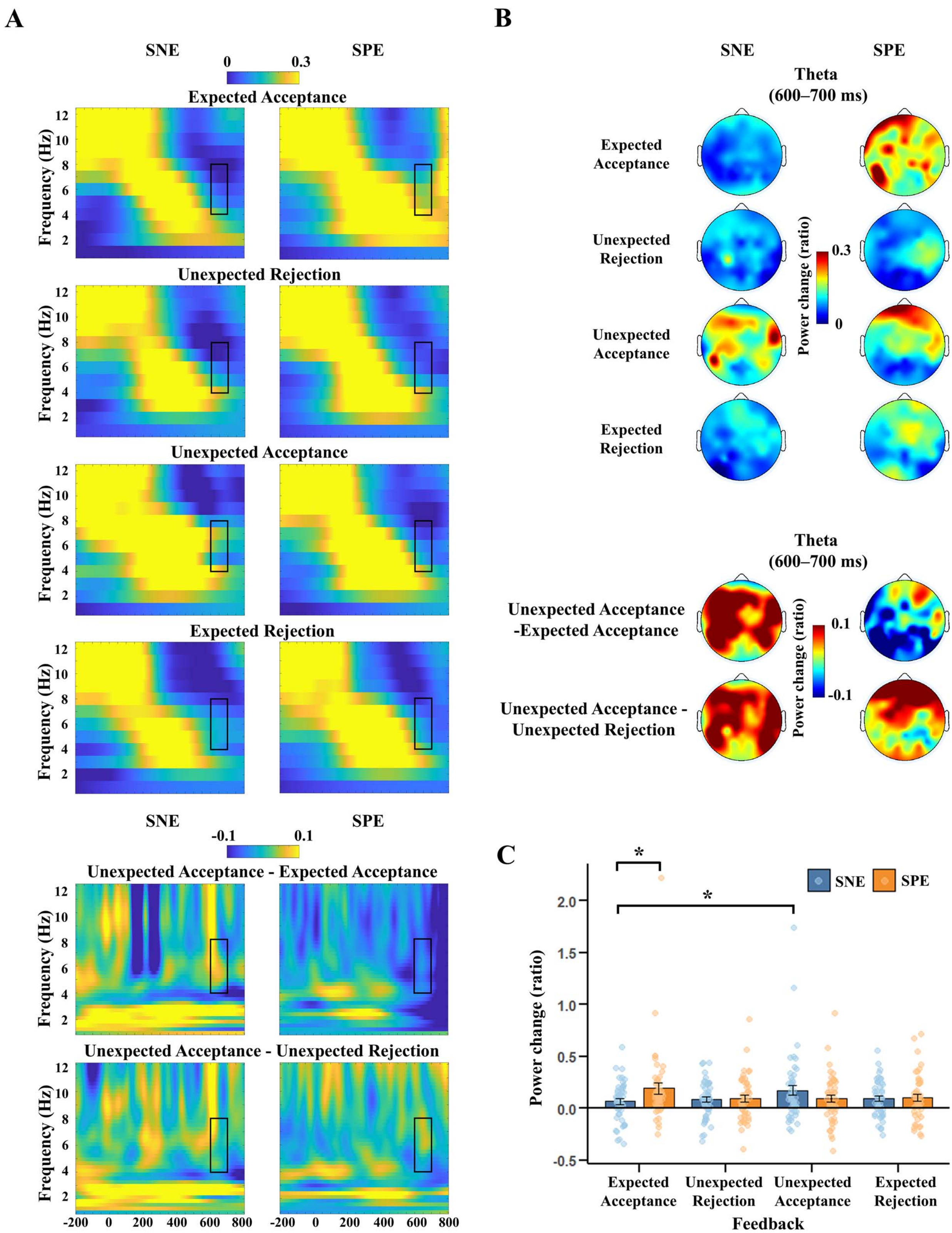

Fig. 6. Time-frequency power at parietal and centro-parietal electrodes (P5/6, CP5/6) during 600–700 ms post-feedback interval. (A) Time frequency spectrograms about spectral power over time. (B) Scalp topography of late theta power. (C) Averaged feedback-related late theta power. Error bars indicate standard errors. *$P < 0.05$.

At the social feedback evaluation stage, our analyses of participants' neural responses revealed several findings consistent with previous studies: unexpected feedback evoked a larger FRN magnitude than expected feedback (Dekkers et al. 2015; van der Molen et al. 2017; Kortink et al. 2018); rejection feedback evoked a larger FRN magnitude than acceptance feedback (Sun and Yu 2014); there was no significant two-way interaction between expectancy congruence and social feedback (Dekkers et al. 2015; van der Molen et al. 2017; Kortink et al. 2018). Also, no significant interaction effects involving shared experience valence were observed. These results can be interpreted against the role of ACC in theories of reinforcement learning (Holroyd and Coles 2002). The ACC, a brain area where the FRN is generated, is long considered a control filter in reinforcement learning (Holroyd and Coles 2002; Hauser et al. 2014). The ACC is involved in at least two cognitive processes: error monitoring and reward monitoring (Swick and Turken 2002; Apps et al. 2016). It is possible that these two processes are distinctive from each other, yet both serve a common underlying function of modulating control signals to adjust or change strategy (San Martin 2012; Heilbronner and Hayden 2016). In our study, it is likely that unexpected feedback triggered the error monitoring process (Alexander and Brown 2011), which signaled the need for a change through one strategy (e.g. re-evaluate one's expectation); whereas rejection feedback activated the reward monitoring process (Hajcak et al. 2005), which signaled the need for a change through another strategy (e.g. adjust behaviors to increase the chance of being accepted). These two processes operate relatively independently (i.e. additively but not multiplicatively). In addition, both processes were so powerful that they manifested regardless of shared experience valence, such that the effects of unexpected and rejection feedback on FRN held in both the SPE and SNE conditions.

Regarding P300, which reflects attention to emotional or motivational processes associated with positivity or rewards (San Martin 2012; van der Veen et al. 2016; van der Molen et al. 2018), we found no significant main effects, but a significant two-way interaction between expectancy congruence and social feedback. Specifically, P300 evoked by unexpected acceptance was larger than that evoked by unexpected rejection. This finding partially aligned with past studies (e.g. Gu et al. 2020), which also found a significant interaction between expectancy congruence and social feedback on P300. However, unlike our study, these past studies mostly reported that the P300 evoked by expected acceptance was larger than that evoked by other social feedback (van der Veen et al. 2014; Kortink et al. 2018; Hofman et al. 2021). Meanwhile, the pattern found in our study aligned with some other indirect evidence from past studies. For instance, acceptance feedback increased self-reported pleasure, especially when the feedback was unexpected (Yao et al. 2020). Also, in social evaluations, receiving feedback that was more positive than one's self-evaluation was associated with larger P300 than receiving feedback that was consistent (either negative or positive) with one's self-evaluation (Schindler et al. 2021). Thus, our findings challenged the impression that P300 was always higher for expected acceptance and suggested an alternative pattern where unexpected acceptance led to larger P300. Furthermore, this interaction between expectancy congruence and social feedback was conditioned by shared experience valence—it was significant only in the SPE condition but not in the SNE condition. The generation of P300 is sensitive to the amount of attentional resources engaged. In other words, the effect of affective-motivational factors on P300 is contingent on the amount of attentional resources allocated to the stimulus (Nieuwenhuis et al. 2005; Polich 2007). It is possible that shared negative experiences created an ambiguous and cognitively taxing situation for information processing and sensemaking, making P300 a less sensitive neural marker of positivity and rewards in the SNE condition. This finding also aligned with previous research indicating that individuals enjoyed the shared activities more under SPE than SNE conditions (Boothby et al. 2014; Wu et al. 2021), and that P300 is a more sensitive indicator of positivity and rewards among individuals with low but not high levels of anxiety (Gu et al. 2020).

Additionally, we found that compared with the SPE condition, individuals in the SNE condition exhibited smaller early frontal theta power in response to rejection feedback, which was inconsistent with our hypotheses. These findings also contradicted previous research showing that social rejection elicited larger early frontal theta (van der Molen et al. 2017; Zhang et al. 2023). However, they aligned with past studies linking early frontal theta power to expectation violation and conflict monitoring (Cavanagh et al. 2013; Cavanagh and Frank 2014). Our behavioral and SPN analyses suggested that participants had higher rejection expectation in the SNE condition than in the SPE condition, and that acceptance expectation was higher than rejection expectation in the SPE condition but not significantly different from rejection expectation in the SNE condition. Therefore, participants might experience reduced cognitive conflict after receiving rejection feedback in the SNE but not SPE condition. Additionally, shared negative experiences may activate defensive responses, leading individuals to reduce attention to rejection feedback to mitigate potential feelings of threat or negative emotions (Bar-Haim et al. 2010; Kungl et al. 2023). These explanations were consistent with the finding that socially anxious individuals were less responsive to rejection feedback (van der Molen et al. 2018). Our findings also shed light on potential differences between FRN and early frontal theta. Although both are associated with ACC and reflect prediction errors, FRN may indicate a rapid response to salient negative stimuli, whereas early frontal theta may indicate goal-relevant cognitive control for adaptation (Cavanagh and Frank 2014; Paul et al. 2020).

At the expectation updating stage, analysis of the behavioral data showed that receiving acceptance feedback in the current trial increased the probability of acceptance expectation in the subsequent trial. This effect was further modulated by expectancy congruence, such that receiving unexpected acceptance feedback (compared to expected acceptance and unexpected rejection) in the current trial increased the probability of acceptance expectation in the subsequent trial. This finding was consistent with the asymmetric updating effect that more positive feedback leads to greater expectation updating (Sharot and Garrett 2016; Kube and Rozenkrantz 2021; García Alanis et al. 2023). The above expectation updating effects held similarly for both SNE and SPE conditions, which was inconsistent with our hypothesis for a stronger expectation updating effect in the SNE condition than in the SPE condition.

Additionally, we found a significant three-way interaction of shared experience valence, expectancy congruence, and social feedback on late theta power in the posterior area. Specifically, late posterior theta power elicited by unexpected acceptance was larger than that elicited by expected acceptance in the SNE condition, whereas there were no significant differences among any social feedback-expectancy congruence combinations in the SPE condition. Late posterior theta power has been associated with memory encoding, learning, expectation updating, and behavioral adjustment (Cohen et al. 1997; Itthipuripat et al. 2013; Billeke et al. 2014). The above findings regarding late posterior theta power aligned with previous research on the asymmetric updating effect: late posterior theta power was largest for unexpected acceptance (i.e. most positive outcome) when participants had shared negative experiences (i.e. in a highly uncertain situation), but not when they shared positive experiences. These findings were also consistent with the observation that individuals made fewer memory errors under negative emotions than under positive emotions, as negative emotions can serve as informational inputs to trigger controlled processing and facilitate environmental scanning (Storbeck and Clore 2005; Clore and Huntsinger 2007).

We also found additional interesting results regarding late posterior theta power that we did not hypothesize. There was a significant two-way interaction between shared experience valence and expectancy congruence, such that late posterior theta power elicited by expected feedback tended to be larger in the SPE condition than in the SNE condition. This effect was further modulated by the type of social feedback, such that it was significant for acceptance feedback but not for rejection feedback. Further post-hoc analyses showed that late posterior theta power elicited by expected acceptance was larger in the SPE condition than in the SNE condition. These findings suggested more nuances in expectation updating: for unexpected feedback that likely required reinterpretation, asymmetric expectation updating favoring acceptance feedback seemed stronger in the SNE condition, which was characterized by high uncertainty that allowed for increased possibilities for open interpretation; however, for expected feedback that required minimal reinterpretation, asymmetric expectation updating favoring acceptance feedback seemed stronger in the SPE condition, which featured positive experience under low uncertainty.

Comparing the behavioral and neural responses at the expectation updating stage, the results supported the asymmetric updating effect in both SPE and SNE conditions in behavioral responses, but only in the SNE condition in neural responses. This could be due to the behavioral responses being more explicit and hence more susceptible to social desirability (Crowne and Marlowe 1964) than late posterior theta, which reflected episodic memory encoding processes not observed by others. Alternatively, behavioral responses, which were based on immediate and fast forced-choice keyboard reactions, might contain more noises due to guessing than late posterior theta.

Overall, our results suggest that at the social feedback expectation stage, shared negative experiences increased rejection expectation (behavioral data) and heightened vigilance to upcoming rejection (SPN), compared with shared positive experiences. At the feedback evaluation stage, under shared positive experiences but not shared negative experiences, individuals perceived unexpected acceptance as more rewarding than expected rejection and unexpected rejection (P300). Thus, shared positive experiences prepared individuals for enjoyment. In addition, under shared negative experiences but not shared positive experiences, rejection feedback elicited lower cognitive conflict and expectation violation than acceptance feedback (early frontal theta). Thus, shared negative experiences desensitized individuals to rejection feedback. At the expectation updating stage, shared negative experiences but not shared positive experiences facilitated the asymmetric updating of expectation, such that unexpected acceptance (vs. expected acceptance) was more likely to be encoded into episodic memory to foster positive social expectation (late posterior theta). Thus, individuals can selectively remember unexpected positive aspects in shared negative experiences, which is beneficial for psychological well-being.

The current study is the first to uncover the neurocognitive mechanisms underlying social feedback processing when interacting with partners who share positive or negative experiences. That said, several limitations of this study merit consideration. First, our manipulation of shared experience valence was based on participants' performance ranks in the time estimation task (Hu et al. 2014). While this manipulation was simple and effective in influencing participants' positive and negative affects, we recognize that there are alternative ways to manipulate shared experiences (e.g. eating the same food, experiencing the same pain, staying in the same space; Bastian et al. 2014; Cheong et al. 2023; Zabala et al. 2024). These manipulations of shared experiences vary on two key dimensions that differentially affect individuals' psychological processes: warmth and competence (Fiske et al. 2007; Holoien and Fiske 2013; Roussos and Dunham 2016). Future research may compare the effects of shared experience valence manipulations with different levels of competence and warmth. Second, because this study focused on shared experience valence, we did not include conditions where participants experienced positive or negative events alone, or where participants experienced events with different valences. Future research may examine those situations by introducing additional control groups. Third, although EEG is well-suited for studying rapid dynamics in cognitive processes such as attention and expectation during social interactions, it has limited spatial resolution. Future research could examine the neural mechanisms underlying various influences of shared experiences and their valence using other brain imaging techniques that offer higher spatial resolution, such as functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG). Fourth, our investigation of shared experience valence was based on the processing of social feedback provided by strangers. However, the effects of shared experience valence may differ for friends and romantic partners, or vary depending on the stage of relationship development. Shared positive experiences may be more conducive to initiating positive expectation between strangers, whereas shared negative experiences may be more effective in strengthening connections in subsequent interactions.

Conclusion

This study used an adapted social judgment paradigm and EEG recordings to investigate the neurocognitive processes of how shared experience valence affects social feedback processing. Our findings illustrate a picture where individuals in the SPE condition are more optimistic regarding social expectation and more likely to gain pleasure and a sense of reward from positive social feedback; meanwhile, individuals in the SNE condition are more vigilant to impending rejection, yet less surprised by rejection feedback; they are also more likely to encode unexpected acceptance episodes in their memory to enhance future positive social expectation. In summary, shared experiences with different valences exert unique influences on various stages of social feedback processing.

Our findings have important implications for strengthening social bonding, growing trust and collaboration, enhancing well-being, and fostering social learning through shared experiences. In cultivating social bonding through shared experiences, people should focus on creating shared positive experiences to garner the benefits of increased optimism, pleasantness, and calmness. When going through shared negative experiences, people may benefit from focusing on memorizing unexpected positivity (e.g. unexpected acceptance) in those experiences, and using such memories to reinforce positive social expectation, which can facilitate trust building, collaboration, and positive self-concepts.

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Author contributions

Wenxian Ruan (Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing—original draft, Writing—review & editing), Jieying Chen (Formal analysis, Methodology, Validation, Writing—original draft, Writing—review & editing), and Yanhong Wu (Conceptualization, Data curation, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Writing—original draft, Writing—review & editing).

Supplementary material

Supplementary material is available at *Cerebral Cortex* online.

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Conflict of interest statement: There is no conflict of interest.

Data availability

The data and code that support the findings of this study are available at: https://osf.io/wtujs/?view_only=e9eb3d0052344a0ebcfdc0cf0f3adfc3.

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