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Cultural group differences in the association of neural sensitivity to social feedback and social anxiety among diverse adolescents

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ABSTRACT

Social anxiety disproportionately impacts individuals from certain cultural and developmental groups, namely those from Latinx and Asian American cultures and adolescents. Neural sensitivity to social feedback has been shown to vary across individuals and could contribute to this disparity by further exacerbating differences; thus, this could be an important phenomenon for understanding, preventing, and treating social anxiety. The goal of the present study was to examine the association of social anxiety with a neural correlate of feedback processing, the feedback-related negativity (FRN), and determine if there was a moderating effect of racial/ethnic group. A community sample of 104 Latinx (n = 41), Asian American (n = 24), and non-Latinx White (NLW; n = 39) adolescents (ages 13–17) completed a computerized peer feedback task while continuous electroencephalogram was recorded. Social anxiety and FRN measures were differentially associated as a function of race/ethnicity. NLW adolescents demonstrated greater FRN responses to acceptance feedback as social anxiety increased, whereas FRN responses to both rejection and acceptance feedback were related to greater social anxiety for Asian American adolescents. Notably, the Latinx group showed the greatest FRN responses yet endorsed the least amount of social anxiety, with no relation between social anxiety and FRN detected. Results highlight cultural variation in the relation between neural correlates of self-regulatory processes and social anxiety. This information could guide culturally-informed models of social anxiety that adopt a multiple units of analysis framework.

Conceptual frameworks addressing the intersection of culture, development, and psychopathology recognize that cultural risk, protective, and promotive factors operate on multiple levels as a normative dimension of human development to influence trajectories of behavior (Causadias, 2013; Causadias and Cicchetti, 2018). In line with these frameworks, it is possible that cultural and developmental shifts in the salience of interpersonal relationships and the perceived importance of peers could contribute to increased neural vulnerability for psychopathology during adolescence. Indeed, the perception of social context as highly salient could in part account for disparities in the burden associated with social anxiety among certain cultural (i.e., Latinx and Asian Americans) and developmental (i.e., adolescents) groups. Compared to any other racial/ethnic group, Latinx adults reported the highest level of impairment due to social anxiety (Polo et al., 2011), and on self-report measures, Latinx youth endorsed greater symptom severity (McLaughlin et al., 2007). Asian American youth similarly endorsed social anxiety to a greater degree than non-Latinx White (NLW) youth (Austin and Chorpita, 2004), and in Asian and Asian American adult samples, high rates and severity of social anxiety as well as heightened fears of negative evaluation have been reported (Okazaki

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et al., 2002). Social anxiety is also most common in adolescence relative to other developmental stages. Nearly 9% of 13–18 year-olds in the U.S. meet lifetime criteria for social anxiety disorder (SAD; Burstein et al., 2011), with approximately 90% of cases emerging before the age of 23 (Beesdo et al., 2010; Stein, 2006).

For Latinx and Asian American individuals, the perceived importance of interpersonal relationships could be in part be attributable to the cultural value of collectivism (Oyserman et al., 2002), an attitudinal orientation that emphasizes connectedness with others, places high value on harmonious interpersonal relationships, and engenders a belief that individuals should be attentive to the unexpressed thoughts and feelings of others and adjust their behavior in response (Singelis, 1994). Also characterized by greater prioritization of interpersonal relationships, adolescence is often conceptualized as a "sensitive period for social processing" (Blakemore and Mills, 2014) during which adolescents are more oriented toward peers and perceive peer interactions as highly rewarding. As such, it is possible that sensitivity to social context may contribute to psychological and neural vulnerabilities to psychopathology during adolescence, and such effects may be particularly pronounced among those from Latinx and Asian American cultural groups.

Examining social feedback processing among diverse adolescents across multiple units of analysis could improve the ability to understand and address social anxiety related disparities. There has been growing empirical support for heightened neural activation in appetitive-motivational systems and abnormalities in networks involving reward processing as risk factors for SAD (Becker et al., 2017). Indeed, neural correlates of feedback response have begun to be investigated as candidate endophenotypes for social anxiety (Harrewijn et al., 2018). The feedback-related negativity (FRN) is a negative-going event-related brain potential (ERP) component that occurs 250–300 ms following the receipt of feedback (Gehring and Willoughby, 2002). The FRN is believed to be part of a process that modifies or reinforces behavior depending on the valence of the outcome, contributing to flexible and effective decision making (Nieuwenhuis et al., 2004). A limited body of research has examined the association of FRN and social anxiety. In undergraduate samples, individuals with SAD showed an enhanced FRN following positive social feedback (Cao et al., 2015) and enhanced neural reactivity to social rejection feedback was associated with greater social anxiety symptoms (Nelson and Jarcho, 2021). Among adolescents there was a larger difference in FRN amplitude between rejection and acceptance feedback trials as social anxiety increased (i.e., greater reactivity to rejection than to acceptance) (Kessel et al., 2015; Kujawa et al., 2014), although this association has not been detected in other youth samples (Kujawa et al., 2017). Overall, there is some evidence that supports the conceptualization of FRN as a neural correlate of social processing that is relevant to an investigation of social anxiety risk (Cao et al., 2015; Harrewijn et al., 2018; Nelson and Jarcho, 2021; Voegler et al., 2019), particularly during adolescence (Kessel et al., 2015; Kujawa et al., 2014). However, given null findings in certain youth samples (e.g., Kujawa et al., 2017), additional research is needed.

The present project aimed to characterize variation in the association between neural response to social feedback and social anxiety by cultural group. It was hypothesized that race/ethnicity would moderate the following proposed relations, such that these associations would be more robust for Latinx and Asian American adolescents than for NLW adolescents: (1) greater social anxiety would be associated with enhanced neural response to peer rejection feedback (but not peer acceptance feedback) (i.e., a negative association between social anxiety and FRN_{Reject} would be observed), and (2) greater social anxiety would be associated with a larger difference score between neural response to peer acceptance and rejection feedback (i.e., greater neural reactivity to rejection feedback relative to acceptance feedback; a positive association between social anxiety and FRN_{Accept} - FRN_{Reject} would be observed).

1. Method

1.1. Participants and procedures

A community sample of 113 adolescents (ages 13–17) was recruited from throughout Los Angeles County to participate in a study approved by the Institutional Review Board at the University of California, Los Angeles and carried out in accordance with the Declaration of Helsinki. Written parental consent and youth assent were obtained before any study procedures were conducted and participants were compensated for their time. Exclusion criteria were established to ensure that youth were able to remain engaged in tasks for an extended period of time and be responsive to social stimuli. As such, exclusion criteria included clinical-level elevation of Attention-Deficit/Hyperactivity (ADHD) symptoms assessed via the Youth Self Report (Achenbach, 1991), IQ less than 80 as determined by select subtests of the Wechsler Abbreviated Scales of Intelligence (Wechsler, 1999), and a diagnosis of Autism Spectrum Disorder as reported by parent during a brief review of youth psychiatric history. Six participants were excluded following screening due to clinically elevated ADHD symptoms.

The remaining 107 participants completed three computerized tasks as part of the larger study while the electroencephalogram (EEG) was recorded. One participant opted to not complete the social feedback task. Two participants were excluded from analyses as these cases appeared to be a statistical outliers based on inspection of several indices (e.g., standardized residuals, Cook's Distance, leverage). Following these exclusions, data from 104 participants were included in subsequent analyses.

1.2. Measures

1.2.1. Demographics

Age and gender were reported by youth using a standard demographic form. Parents reported their child's race and ethnicity during screening. A free-response question ("What is your child's ethnicity?") was used to assess ethnicity, with a follow-up question specifically assessing Latinx ethnicity ("Do you consider your child to be Hispanic or Latino?"). Parents provided an estimate of annual family income by selecting from ranges of earnings per year and reported the number of individuals supported by this income. Youth reported their first language and rated perceived English proficiency on a scale from 0 ("Not at All Fluent") to 6 ("Fluent").

1.2.2. Social anxiety

The Social Anxiety Scale for Adolescents (SAS-A; La Greca and Lopez, 1998) is a 22-item scale that has been validated in diverse groups, including Latinx adolescents (La Greca et al., 2015). The total score ranges from 18 to 90, with scores above 50 indicating clinical elevation. Total score in the present sample demonstrated excellent internal consistency ($\alpha = 0.93$).

1.2.3. Collectivism

The Individualism-Collectivism Scale (Triandis and Gelfand, 1998) was used to measure collectivism. The measure is comprised of 16 items that are summed to produce collectivism (i.e., seeing the self as part of a collective; "I feel good when I cooperate with others") and individualism (i.e., seeing the self as fully autonomous; "I rely on myself most of the time; I rarely rely on others") subscale scores. In the present sample, internal consistency of the collectivism subscale was good ($\alpha = 0.81$).

1.3. Experimental task

Participants completed a computerized social feedback task adapted from the "Island Getaway" paradigm developed by Kujawa et al. (2014). At the start of the game, participants were informed that they would be voting in rounds of a draft to see who made it onto a final team of six

teenagers from a group of 12. Participants were told that those who made it through all rounds of a draft without being voted out would play a team game, otherwise the participant would play the same game but by themselves. A player profile was created for each youth which included basic demographic information (i.e., first name, age, gender, hometown, name of school, and main hobby) as well as a photograph that was taken by the experimenter at the start of the study visit. Players participated in six voting rounds in which they were presented with several different co-player profiles. The co-player profiles included five male profiles and six female profiles, with ages ranging from 13 to 17 years. Most images for the co-player profiles came from the NIMH Child Emotional Faces Picture Set (Egger et al., 2011). After casting a vote, players were presented with a fixation cross for 2000–3000 ms, followed by the co-player's profile again for 2000 ms. Prior to receiving feedback, a fixation cross was displayed for 1000 ms, followed by either a thumbs up or thumbs down image for 1500 ms, representing acceptance or rejection of the participant, respectively.

Participants completed six voting rounds, with one co-player randomly removed each round. Between rounds, the participant was asked to answer a free-response poll question (e.g., "What is your least favorite activity?") that was then added to his or her profile. The participant was also shown each co-player's response. In total, the participant completed 51 feedback trials evenly split between acceptance and rejection trials, in pseudo-random order with no more than three trials of either type in a row, with the last trial determined randomly.

1.4. Electrophysiological data recording and reduction

A BioSemi ActiveView ActiveTwo system with an elastic cap containing 64 Ag/AgCl scalp electrodes was used to obtain EEG recordings. Following a standardized data collection pipeline, the electrooculogram was recorded by placing two electrodes above and below the right eye and two electrodes near the outer canthi of both eyes. Two electrodes were placed on left and right mastoids. During recording, data were referenced to a driven right leg passive electrode and common mode sense active electrode. Offline, data were re-referenced to the average of all head electrodes, including the mastoids, which improves the validity of the average reference. Data were digitized at 1024 Hz. Impedances were maintained below 30 kΩ with filters set to pass 0.16–100 Hz.

The continuous EEG was screened for extreme artifacts and segmented into 200 ms epochs. An automated algorithm was used to conduct gross artifact inspection. All channels in an epoch were rejected if (a) the absolute difference between two adjacent sampling points exceeded 50 μV, (b) the voltage range across the epoch exceeded 300 μV, (c) amplitude exceeded 150 μV or fell below −150 μV across the epoch, and/or (d) sustained activity less than 0.5 μV within a 100 ms interval had occurred. Ocular artifacts were corrected using Independent Components Analysis (Makeig et al., 1996). Waveforms were filtered with a Butterworth zero-phase 0.1–30 Hz bandpass filter. Grand-average waveforms for acceptance and rejection trials are presented in Fig. 1.

Based on visual inspection of grand-average waveforms and previous reports in comparable youth samples, neural response to rejection and acceptance were quantified using mean amplitude measures relative to a pre-stimulus baseline of 100 ms prior to onset of feedback stimulus. The

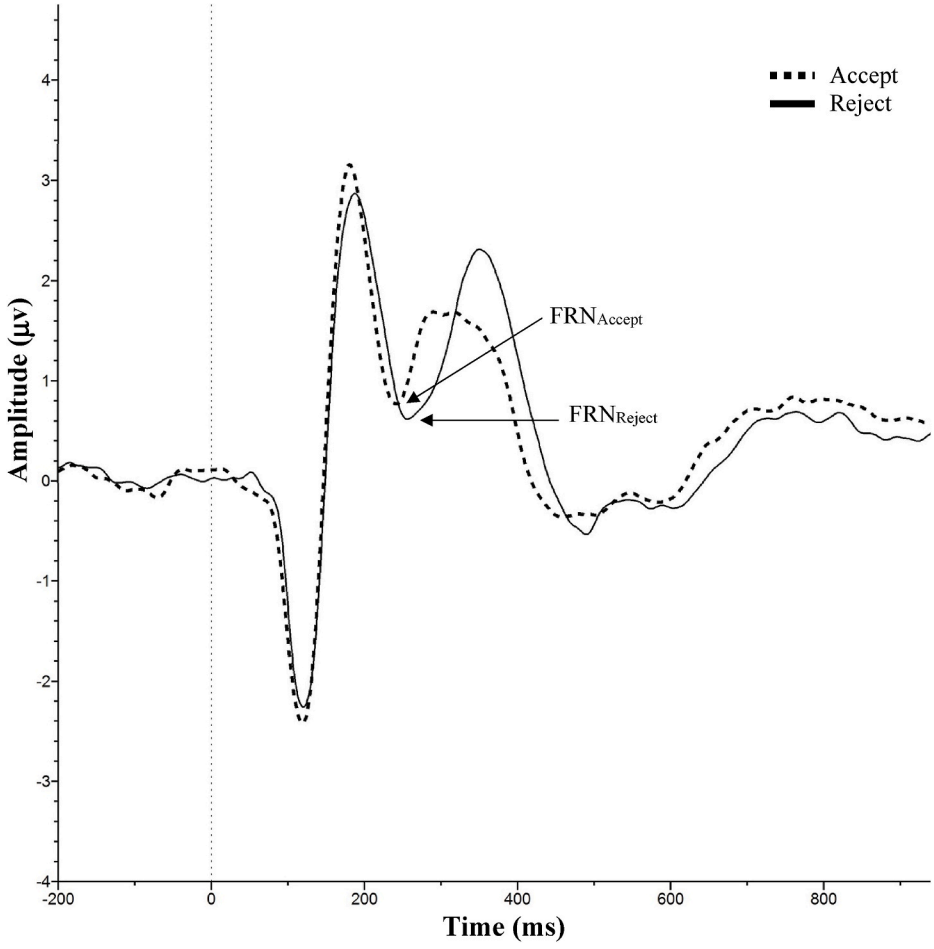

Fig. 1. Time Course of Neural Response to Acceptance and Rejection Feedback at FCz Recording Site, Relative to a 100 ms Baseline Prior to Onset of Feedback Stimuli at 0 ms, Averaged Across Participants.

mean amplitude of the FRN was computed separately for acceptance and rejection feedback in a window 200–300 ms following onset of stimuli at the FCz electrode site. Given that there are several methodological choices that can be made when quantifying the FRN, the aforementioned methodological decisions were established *a priori* consistent with recommended guidelines (Luck and Gaspelin, 2017). Quantification of FRN in the present study followed similar procedures as other research that has examined variability in the association of social anxiety with neural reactivity to social feedback (e.g., Cao et al., 2015).

1.5. Data analytic strategy

Repeated-measures ANOVAs were used to confirm the presence of the FRN. Group differences in FRN mean amplitude and difference score measures, as well as in reaction time and accuracy, were assessed using one-way ANOVAs. Post-hoc analyses of significant interactions utilized paired samples t-tests.

To test hypotheses that social anxiety was related to FRN and that this association was moderated by race/ethnicity, parallel linear regressions were conducted to produce the conditional effect of social anxiety on the ERP measure for each racial/ethnic group. To understand how preexisting group differences might contribute to FRN outcomes, variables that could be meaningful were included as independent variables in each regression model, which is a standard recommendation for addressing such potential confounds (Miller and Chapman, 2001; Verona and Miller, 2015). For all FRN outcomes, sex, low-income status, and depression were not associated with the outcome and their inclusion contributed to worse model fit. As such, these variables were not included in primary analyses. Ultimately, age was included in all primary regression models for both conceptual and statistical reasons. Regressions were conducted using the PROCESS macro (Hayes, 2017) for SPSS 26.

2. Results

2.1. Overall sample characteristics

The sample included in analyses ($n = 104$) was 52.9% male with an average age of 15.13 years ($SD = 1.38$). It was comprised of Latinx ($n = 41$; 39.4%), Asian American ($n = 24$; 23.1%), and NLW ($n = 39$; 37.5%) adolescents. Per 2018 U.S. Department of Housing and Urban Development guidelines for Los Angeles County, 34.6% of families were considered low-income based on parent-reported annual family income and number of individuals in the household (83.3% of which were Latinx). The majority of youth endorsed English as their first language (86.5%), with some reporting Spanish (8.6%) and Chinese (2.8%). Youth ratings of English proficiency indicated high English fluency (*M (SD)* = 5.81(0.73)).

Table 1 provides a summary of descriptive statistics for continuous measures for the full sample and by racial/ethnic group. There were no missing questionnaire data. Overall, the full sample endorsed a moderate amount of social anxiety, with 39.4% of adolescents demonstrating clinically elevated scores (i.e., scores ≥ 50 on the SAS-A). A one-way ANOVA showed a racial/ethnic group difference in social anxiety, $F(2,101) = 4.67$, $p = .012$, $\eta_p^2 = 0.08$. Post-hoc tests indicated that Latinx adolescents endorsed less social anxiety than NLW adolescents, $t(78) = 2.96$, $p = .004$, $d = 0.66$. No differences in social anxiety ratings were observed between Asian American adolescents and NLW or Latinx adolescents. Compared to their counterparts, female and low-income adolescents additionally endorsed less social anxiety, $t(102) = -3.48$, $p = .001$, $d = 0.69$, $t(101) = 2.96$, $p = .004$, $d = 0.60$, respectively. Younger (13–14 year old) and older (15–17 year old) adolescents did not differ in their ratings of social anxiety.

Given its frequent co-occurrence with social anxiety, depression was assessed via administration of the Short Mood and Feelings Questionnaire (Angold et al., 1995). On average, youth in this sample reported relatively low levels of depression, *M(SD)* = 4.l3(4.4), with only 5.7% of adolescents endorsing clinically elevated levels (i.e., total score > 12).

There were racial/ethnic group differences in ratings of collectivism, $F(2,101) = 5.67$, $p = .005$, $\eta_p^2 = 0.10$, such that Latinx and Asian American adolescents endorsed more collectivism than NLW adolescents, $t(78) = -3.22$, $p = .001$, $d = 0.72$, $t(61) = -2.03$, $p = .04$, $d = 0.69$, respectively. Latinx and Asian American adolescents did not differ in their collectivism ratings. Low income youth also endorsed more collectivism than counterparts, $t(85.56) = -3.49$, $p = .001$, $d = 0.70$. There were no gender or age group differences.

There were no racial/ethnic group differences in gender distribution or age. However, there was a difference between racial/ethnic groups by low-income status, $\chi^2 = 46.32$, $df = 2$, $p < .0001$, such that low-income adolescents were predominately Latinx (83.3%). Race/ethnicity and low-income status were found to be strongly related, $\varphi_c = 0.66$, $p < .0001$. Despite this correlation, these variables were not collinear, $M_{VIF} = 1.00$.

2.2. Confirming the presence of the FRN

As a manipulation check, an ANOVA involving electrode site (FCz, Cz, Pz) and feedback type (acceptance, rejection) was used to confirm the presence of a FRN based on topography and the impact of feedback type and to determine at which electrode site the component was maximal. Mauchly's Test indicated a violation of the assumption of sphericity, therefore degrees of freedom are reported using Greenhouse-Geisser estimates. Main effects of site and feedback type confirmed a negativity following receipt of feedback at frontocentral sites that was more negative on rejection than on acceptance trials, $F(1.45,150.29) = 6.96$, $p = .001$, $\eta_p^2 = 0.063$, $F(1,103) = 6.89$, $p = .01$, $\eta_p^2 = 0.063$, respectively. Post-hoc tests determined that FRN to acceptance and rejection was more negative at FCz than at Cz, acceptance: $t(103) = -5.63$, $p < .0001$, $d = 0.31$, rejection: $t(103) = -4.20$, $p < .0001$, $d = 0.30$. As such, FRN was quantified using mean amplitude measures at the FCz electrode site. Results indicated that the social feedback task was successful in eliciting a FRN that varied as a function of feedback type (Fig. 1).

Mean amplitude FRN measures are summarized by racial/ethnic group in Table 2. The majority of FRN trials were retained during data processing, $M(SD)_{\text{Accept}} = 24.5(0.97)$, $M(SD)_{\text{Reject}} = 25.5(1.2)$. One-way ANOVAs revealed group differences by race/ethnicity in neural response to both acceptance and rejection feedback, $F(2,101) = 3.47$, $p = .03$, $\eta_p^2 = 0.06$, $F(2,101) = 3.68$, $p = .02$, $\eta_p^2 = 0.07$, respectively. Latinx

Table 1
Descriptive Statistics for Continuous Measures in the Full Sample and by Racial/Ethnic Group.

	Full Sample	NLW	Latinx	Asian American
	M(SD)	M(SD)	M(SD)	M(SD)
Social Anxiety	44.60 (12.80)	48.76 (11.99)	40.34 (13.38)	45.12(11.06)
Collectivism	55.75(9.40)	52.00(9.98)	58.61(8.33)	56.95(8.36)

Note: M = Mean; SD = Standard deviation; NLW = Non-Latinx White.

Table 2
Descriptive Statistics for FRN Mean Amplitude Measures (μV).

	NLW	Latinx	Asian American
	M(SD)	M(SD)	M(SD)
FRN_{Accept}	1.31(2.70)	.65(2.48)	2.54(3.34)
FRN_{Reject}	1.41(2.22)	.41(2.58)	2.06(2.70)
$\Delta FRN_{Accept\text{-}Reject}$	-.10(2.10)	.25(1.80)	.47(2.18)

Note: FRN = Feedback-related negativity; NLW = Non-Latinx White; M = Mean; SD = Standard deviation.

adolescents demonstrated a more negative FRN to acceptance and rejection feedback than did Asian American adolescents, acceptance: $t(63) = -2.59$, $p = .01$, d=.63, rejection: $t(63) = -2.45$, $p = .02$, $d = 0.62$. FRN to rejection was marginally more negative for Latinx adolescents than for NLW adolescents, $t(78) = -2.26$, $p = .06$, $d = 0.41$. NLW and Asian American adolescents did not differ on any FRN measures.

2.3. Social anxiety and neural response to social feedback

Three regression models were conducted to test the hypotheses that greater social anxiety would be associated with enhanced FRN following peer rejection (but not peer acceptance) (Hypothesis 1) and greater differentiation between acceptance and rejection feedback (Hypothesis 2). In line with the hypothesis that the association between FRN and social anxiety would be more pronounced for Latinx and Asian American adolescents, race/ethnicity was tested as a moderator in all models. Age was included in all models, although results did not vary based on inclusion of this variable (Miller and Chapman, 2001). Bivariate correlations between main study variables (i.e., social anxiety, FRN_{Accept}, FRN_{Reject}, and $\Delta FRN_{Accept\text{-}Reject}$) are provided in Table 3.

Model 1 predicting FRN_{Reject} accounted for approximately 18% of the variance, $F(6,97) = 3.44$, $p = .004$, $\eta_p^2 = 0.17$. Age was not associated with FRN_{Reject}, $\beta = -0.42$, $p = .40$. Social anxiety and race/ethnicity interacted to predict FRN_{Reject}, $F(2,97) = 5.01$ $p = .008$, $\eta_p^2 = 0.09$. Probing of this interaction revealed conditional effects illustrated in Fig. 2 such that for Asian American adolescents, FRN to rejection feedback was more negative as social anxiety increased, $\beta = -0.15$, $p = .001$. These findings provided partial support for hypotheses that social anxiety would be related to neural response to peer rejection and that peer rejection would be more salient for Asian American adolescents.

Model 2 predicting FRN_{Accept} accounted for approximately 24% of the variance, $F(6,97) = 5.04$, $p = .0002$, $\eta_p^2 = 0.24$. Age was associated with FRN_{Accept}, $\beta = -1.35$, $p = .01$. Race/ethnicity interacted with social anxiety in predicting FRN_{Accept}, $F(2,97) = 5.34$, $p = .006$, $\eta_p^2 = 0.10$. Probing of this interaction revealed conditional effects represented in Fig. 3 such that for NLW and Asian American adolescents, FRN to acceptance feedback was more negative as social anxiety increased, NLW: $\beta = -0.08$, $p = .03$, Asian American: $\beta = -0.16$, $p = .001$. This finding was unexpected, as neural response to peer acceptance was not predicted to be related to social anxiety.

Model 3 predicting $\Delta FRN_{Accept\text{-}Reject}$ accounted for approximately 12% of the variance, $F(6,97) = 2.27$, $p = .04$, $\eta_p^2 = 0.12$. Age was associated with $\Delta FRN_{Accept\text{-}Reject}$, $\beta = -0.92$, $p = .02$. Race/ethnicity interacted with social anxiety in predicting the outcome, $F(2,97) = 2.96$, $p = .04$, $\eta_p^2 = 0.06$. Probing of this interaction revealed conditional effects illustrated in Fig. 4, such that for NLW adolescents there was greater differentiation between acceptance and rejection feedback as social anxiety increased, $\beta = -0.08$, $p = .002$. Although findings were partially in line with the hypothesis that there would be greater differentiation between acceptance and rejection feedback as social anxiety increased, the direction of the observed association was contrary to what was anticipated.

3. Discussion

The present study sought to extend research examining the relation between neural response to social feedback and social anxiety by identifying differential patterns of association by cultural group in a diverse sample of adolescents. In line with hypotheses, variability by racial/ethnic group in the association of exaggerated neural response to peer feedback and social anxiety was confirmed. Neural response to negatively valanced peer feedback (i.e., rejection) was expected to be associated with greater social anxiety among adolescents from cultural groups that prioritize interpersonal relationships (i.e., Latinx and Asian American adolescents). Instead, the relation between social anxiety and neural response to both acceptance and rejection feedback was of a similar magnitude for Asian American adolescents, and NLW adolescents with higher endorsement of social anxiety showed exaggerated response only to acceptance feedback. Surprisingly, Latinx adolescents demonstrated the greatest neural reactivity to both valences of feedback, but this did not vary with social anxiety. Differential patterns of association require further unpacking.

First, among Asian American adolescents there was a link between heightened sensitivity to social feedback and social anxiety. Although Asian culture is generally characterized by a high degree of collectivism, as also seen in Latinx culture, it is possible that variability in how social cues are processed would explain why heightened neural response to feedback was associated with social anxiety for Asian American but not Latinx adolescents. Some research has hypothesized that among Asian and Asian American individuals, socialization practices in line with interdependent self-construal lead to a heightened attention to the feelings and emotions of others (Hong and Woody, 2007). These practices are thought to result in a high degree of social awareness but can also engender increased worries about competence in anticipating, recognizing, and evaluating the affective reactions of others. In part, this priority on attunement to social cues, together with culturally-influenced social display rules that discourage unrestrained expression of emotion, can result in distress in social contexts. Experimental data support this explanation, with research demonstrating that concerns about and competence in detecting emotions were related to social anxiety in Asian American undergraduates (Lau et al., 2008). This research is in line with present findings that, as social anxiety increased, Asian American adolescents showed heightened neural response to both acceptance and rejection feedback but not enhanced differentiation between neural response to acceptance and rejection feedback.

Findings in the NLW subsample were consistent with research that has used the Island Getaway task (Cao et al., 2015), namely that social anxiety was associated with enhanced neural reactivity to acceptance feedback (i.e., negative association between social anxiety and FRN_{Accept}) that was greater than neural reactivity to rejection feedback (i.e., negative association between social anxiety and $\Delta FRN_{Accept\text{-}Reject}$). In line with findings from Kujawa et al. (2014), there was also an association between social anxiety and greater differentiation between neural response to acceptance and rejection feedback. Given research that has shown social rejection to be interpreted as threatening (Voegler et al., 2019), it was somewhat surprising that social anxiety was associated with FRN following acceptance feedback but not following rejection for NLW youth. However, this pattern of responding may be attributable to biased expectancies regarding feedback seen among youth with social anxiety. Youth with social anxiety have been shown to make negatively biased social predictions (e.g., appraising peers' social desirability to be higher than their own; Smith et al., 2018) that correspond with symptom severity (Caouette et al., 2014; Guyer et al., 2008). Among both socially-anxious (Gu et al., 2020) and non-clinical samples (Ferdinand et al., 2012; Hajcak et al., 2007; for review, Walsh and Anderson, 2012), unexpected feedback has been consistently associated with enhanced FRN. As such, youth with social anxiety may find acceptance feedback to be unexpected, which is reflected in exaggerated neural response.

Finally, a notable finding was that Latinx adolescents demonstrated greater neural response to social feedback overall and higher levels of collectivism, which was anticipated to result in greater social anxiety. However, this group was characterized by less social anxiety than other

Table 3
Correlations Between Main Study Variables.

	FRN_{Accept}		FRN_{Reject}		$\Delta FRN_{Accept\text{-}Reject}$	
	r	p	r	p	r	p
Social Anxiety	−.14	.15	−.02	.87	−.18	.07
FRN_{Accept}			.73	<.001	.49	<.001
FRN_{Reject}					−.23	.02

Note: FRN = Feedback-related negativity.

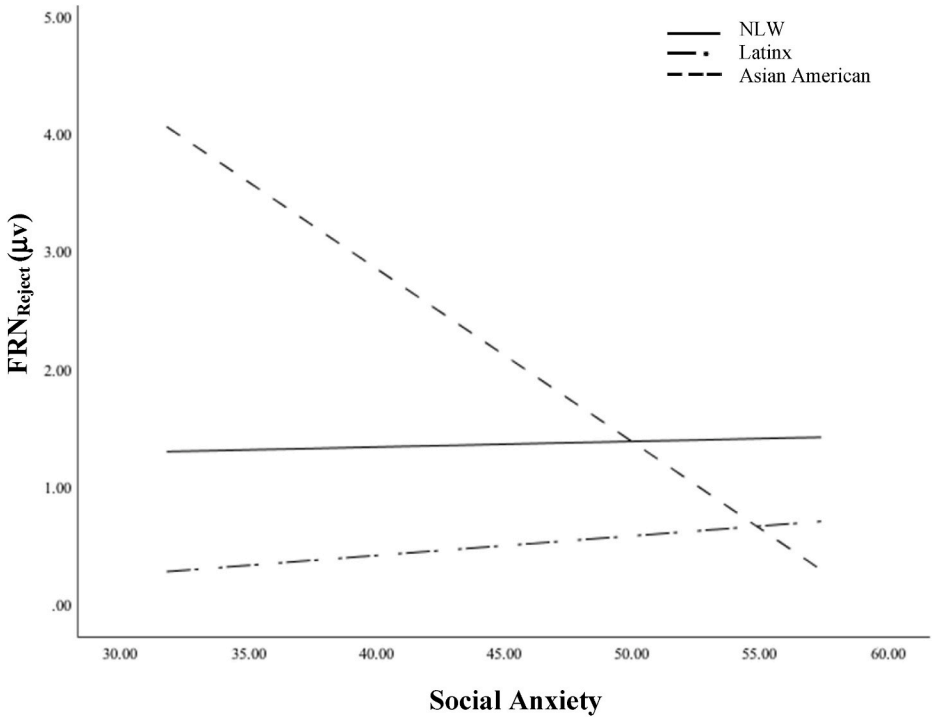

Fig. 2. Association of Social Anxiety with FRN_{Reject} for NLW, Latinx, and Asian American Adolescents.

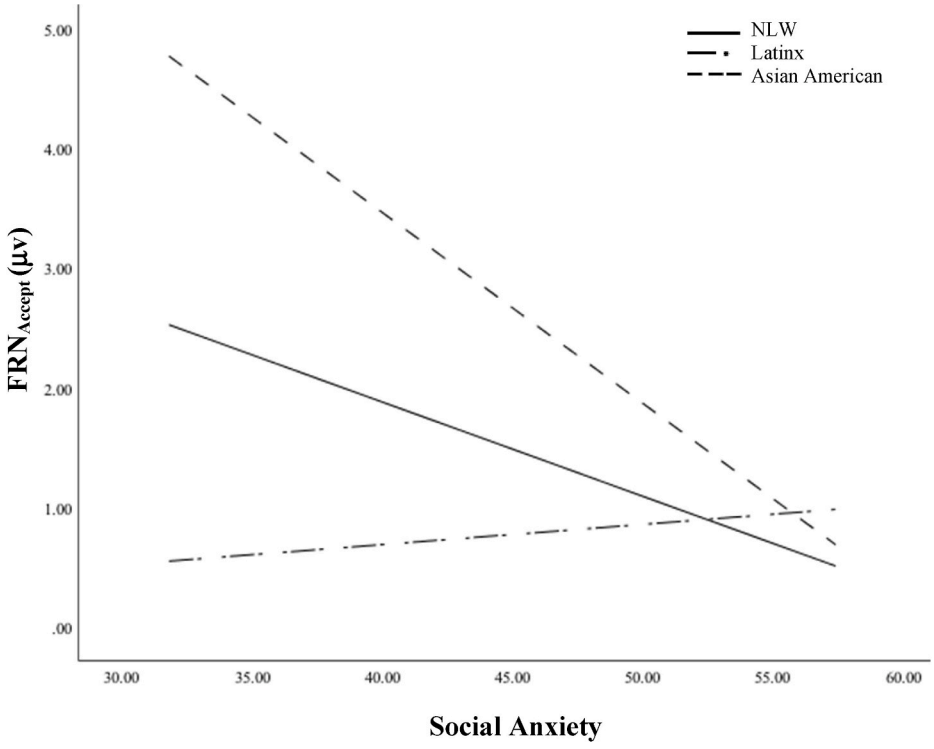

Fig. 3. Association of Social Anxiety with FRN_{Accept} for NLW, Latinx, and Asian American Adolescents.

racial/ethnic groups and showed no association between FRN and social anxiety. In cultural groups that are predominantly collectivistic, attunement to social feedback is viewed as critical for maintaining desirable behaviors that benefit the group (Heine et al., 2008). Emotional sensitivity has been shown to promote adaptive and flexible social behavior (Rosen et al., 2017), which may be particularly advantageous during adolescence (Crone and Dahl, 2012; Pfeifer and Allen, 2012). For example, neural and behavioral sensitivity to reward in adolescence was shown to lead to greater response inhibition, which behaviorally is associated with lower risk-seeking and susceptibility to peer pressure (Pfeifer et al., 2011; Telzer et al., 2015). In the present sample, it may be that Latinx adolescents were sensitive to social feedback but that this neural response was not necessarily linked with a maladaptive outcome. A similar pattern has been found in fMRI research

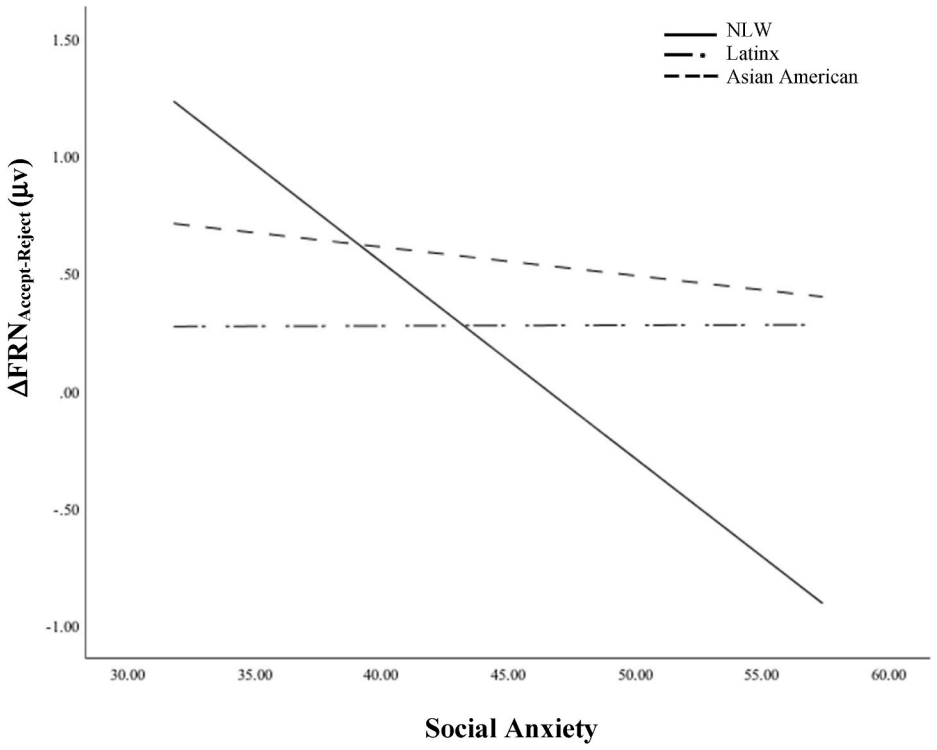

Fig. 4. Association of Social Anxiety with $\Delta FRN_{Accept\text{-}Reject}$ for NLW, Latinx, and Asian American Adolescents.

involving low-socioeconomic status youth, a finding relevant to the present sample given that the majority of low-income adolescents were Latinx. In previous research, adolescents exposed to childhood stressors completing a cognitive flexibility task were shown to recruit a broader neural network than adolescents who had not experienced childhood stress, despite both groups demonstrating comparable task performance (Mueller et al., 2010). These findings suggest that when there are group differences in neural activation that do not translate to behavioral differences, it is possible that adaptive compensation strategies have emerged that account for this outcome. Alternatively, there could be a protective factor at play for Latinx adolescents that buffered the association between heightened neural response to feedback and social anxiety.

Despite the strengths of the present study, particularly the inclusion of participants from sociodemographic groups that are highly underrepresented in psychological science (i.e., Latinx and low-income youth) and use of a multiple units of analysis approach, some limitations should be discussed. First, racial/ethnic groups varied significantly in terms of family income, with the majority of low-income youth being Latinx. Because low-income status and race/ethnicity were highly related, it was difficult to parse socioeconomic effects. Next, although attempts were made to select a heterogeneous group of images for the co-player profiles, racial/ethnic information of the youth photographed for the stimuli set was not available. As such, there may have been neural reactivity to in-group/out-group images that was not accounted for. Additionally, although the task did elicit the FRN in a manner that was consistent with previous studies, six adolescents endorsed skepticism about the veracity of the social feedback task during the debriefing process, which could have influenced neural response. However, analyses were conducted with and without these participants, and results were consistent. Finally, race/ethnicity is likely a proxy for a range of societal- and individual-level processes that constitute culture. Future research would benefit from precise and multifaceted measurement of socially transmitted cultural processes that are associated with critical changes across multiple domains of development (Fiske, 2002; Rogoff, 2003) and internalizing psychopathology (e.g., socioeconomic status; Merz et al., 2018).

The present study advances the identification of neurophysiological profiles that characterize culturally-influenced trajectories of social anxiety. This type of information can be leveraged, especially during periods of relative neural plasticity such as adolescence, to identify youth at risk for psychopathology and inform intervention approaches (Suleiman and Dahl, 2017). It is particularly critical to consider the joint influences of culture and development on social anxiety risk, given that social anxiety typically arises as youth experience normative changes in social environment, sensitivity to social information, and affective responding. Given that culture plays a crucial role in shaping how an adolescent navigates and experiences these processes, exploring the mechanisms by which cultural factors relate to the emergence of psychopathology can inform the etiological understanding of social anxiety. Although the present study included a community sample of adolescents, there was considerable variability in social anxiety symptoms, with a significant portion of adolescents endorsing clinically-elevated social anxiety. However, given the limited body of work that has examined neural correlates of feedback processing in individuals diagnosed with SAD (e.g., Becker et al., 2017; Cao et al., 2015; Voegler et al., 2019), additional research in diverse clinical samples is critical for improving outcomes. Future research could build on present findings to clarify the mechanisms by which neural response to social feedback is linked with psychopathology outcomes in youth with SAD, in order to identify more precise prevention opportunities and treatment targets, particularly for those belonging to cultural and developmental groups experiencing mental health disparities.

Author statement

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