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RESEARCH

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Longing for belonging: Feeling loved (or not) and why it matters

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Abstract

Objective: This study tested the hypothesis that adults who report having been unloved/rejected in childhood are likely to show greater activation in specific brain regions than adults who report a history of parental love/acceptance.

Background: Interpersonal acceptance-rejection theory (IPARTheory) argues that a specific set of effects of perceived parental acceptance and rejection appear with such near invariance across populations worldwide that it is likely that they are related to humankind's common biocultural evolution. If this is true, specific brain mechanisms are likely to differentially characterize responses to parental acceptance versus rejection.

Method: Using fMRI, the study experimentally manipulated rejection during a computer-based ball-toss game among 40 young adults. One group reported having been loved/accepted by both parents in childhood and self-reported being psychologically well-adjusted (AcceptedAdjusted, $n = 20$). The other group reported having been unloved/rejected by both parents in childhood and self-reported being psychologically maladjusted (RejectedMaladjusted, $n = 20$).

Results: Members of the RejectedMaladjusted group—as compared to members of the AcceptedAdjusted group—had increased activation in the posterior cingulate cortex and anterior cingulate cortex, dorsolateral prefrontal cortex, medial prefrontal cortex, insula, cuneus, precuneus, and amygdala. These brain regions critically support emotion processing.

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Conclusion: This study provides a foundation for understanding neural mechanisms underlying emotion processing, as influenced by adults' memories of parental love or lack of love (acceptance-rejection) in childhood.
Implications: Findings may help clinicians and practitioners design therapeutic interventions that can lead to structural and functional changes in brain areas associated with emotion regulation, possibly counteracting some of the negative effects of early emotional trauma.

KEYWORDS
Cyberball, IPARTheory, neuroimaging, parental love/acceptance, parental rejection

Six decades of interpersonal acceptance-rejection theory (IPARTheory) research with several hundred thousand children and adults around the world have shown that children and adults everywhere—regardless of differences in race, culture, gender, and other such defining characteristics—tend to understand themselves to be cared about (loved) or not cared about (unloved/rejected) in the same four ways. Specifically, interpersonal love/acceptance may be expressed physically, verbally, or symbolically by acts of emotional support and caring, nurturance, or simply love. Interpersonal rejection—in contrast—is manifested in physical, verbal, and symbolically hurtful behaviors including (1) coldness and lack of affection (i.e., the significant other is emotionally cold and fails to express either warmth or affection), (2) hostility and aggression (e.g., insulting, yelling, hitting, rude behaviors and gestures), (3) indifference and neglect (i.e., being physically or psychologically unavailable or not interested in supporting the emotional needs of the individual), and (4) undifferentiated rejection (i.e., the perception that the significant other does not care about, appreciate, want, or love the individual, although there may be no behavioral manifestation of any of the prior three forms of rejection; Rohner, 1986, 2004, 2021).

IPARTheory research has found that about 90%–93% of the individuals in any given American population report having experienced at least moderate love/acceptance from significant others, especially parents in childhood (Khaleque & Ali, 2017; Rohner, 1986, 2021). Additionally, cross-cultural survey research has shown that parents in about 75% of the world's societies tend to be predominantly warm, loving, and accepting whereas parents in about 25% of the world's societies tend to be mild to seriously rejecting (Rohner, 1986, 2021).

Psychological consequences and correlates of interpersonal acceptance-rejection

IPARTheory is an evidence-based theory of socialization and life span development that attempts to predict and explain major consequences, causes, and other correlates of interpersonal—especially parental—love (acceptance) and rejection worldwide (Rohner, 1986, 2021). Love/acceptance or lack of love/rejection from attachment figures is postulated in the theory to have a major influence on children's and adults' personality and psychological (mal) adjustment (Khaleque & Ali, 2017; Rohner, 2021; Rohner & Lansford, 2017). Perceiving oneself as unloved/rejected is associated with becoming anxious and insecure; having problems with anger and the management of hostility and aggression; becoming emotionally unresponsive; developing an impaired sense of self-esteem and self-adequacy; becoming emotionally unstable; becoming dependent or defensively independent depending on the form, frequency, duration, and severity of rejection experienced; developing a negative worldview; and other cognitive

distortions (Khaleque & Ali, 2017; Rohner, 2021). Cognitive distortions and other mental representations of rejected individuals are implicit conceptions of existence that shape the way individuals perceive, construe, and react to social situations and interpersonal relationships (Rohner, 2023). Because of these distorted or negative mental representations, rejected individuals often come to regard interpersonal relationships as being untrustworthy and hurtful—making it difficult to trust new relationships (Phillips et al., 2013; Rohner, 2021).

These effects of perceived rejection appear with such near invariance across genders, cultures, and racial–ethnic populations worldwide that it appears likely that they are related to humankind's common biocultural evolution (Khaleque & Ali, 2017; Rohner, 2021). Insofar as this is true, then IPARTheorists hypothesize that specific brain mechanisms are likely to differentially characterize responses to interpersonal rejection among adults who remember having been loved/accepted in childhood by their parents versus those who remember having been unloved/rejected.

Neurobiological consequences and correlates of interpersonal acceptance-rejection

A modest amount of neurobiological research partially supports this hypothesis. Brain imaging studies have found, for example, an increased activation in brain structures such as dorsal anterior cingulate cortex (dACC; Eisenberger et al., 2003), ventrolateral prefrontal cortex (vlPFC; Eisenberger et al., 2003), and insula (Domsalla et al., 2014) in the context of subjective experiences of social rejection manipulated by the study design (Bolling et al., 2011; Mwilambwe-Tshilobo & Spreng, 2021). Furthermore, looking at romantic relationships, Domsalla et al. (2014) found individuals with anxious attachment with their romantic partners displayed heightened activations in the dACC and anterior insula during the exclusion phase in Cyberball game. These regions are associated with emotional distress. In comparison, individuals with an avoidant attachment style showed less activation in these brain regions. A study by Landa et al. (2020) found adults' memories of parental care and overprotection/control during childhood modulate the intensity of painful hot/cold pain stimuli. More specifically, they found participants *who felt rejected by caregivers* reported more physical pain than participants who felt accepted by caregivers. These behavioral responses correlated with increased neural activity in pain processing systems in the brain including in the pons, limbic system, ventral striatum, dACC, precuneus, and somatosensory cortex. This brain circuit regulates the processing of physical pain and emotional distress (Kross et al., 2011). A recent study by van Houtum et al. (2022) investigated adolescents' neural responses to *one* parent's social feedback (criticism versus praise) about their offspring's personality characteristics (e.g., "lazy" versus "respectful"). The authors found parents' criticism was associated with increased activity in the brain regions, including the anterior insula, anterior cingulate cortex (ACC), and dorsomedial prefrontal cortex (dPFC). These regions are also associated with social pain processing (see Kross et al., 2011). Parents' compliments, however, were associated with increased activity in brain regions supporting social cognition, including the temporoparietal junction, posterior superior temporal sulcus, and precuneus. Activation in these regions is known to be associated with the mental representation of the self (Northoff et al., 2011).

Furthermore, Schulz et al. (2022) investigated brain activity among adolescents with and without childhood maltreatment histories (i.e., moral-legal/educational neglect, sexual abuse, physical abuse, emotional maltreatment, and witnessing domestic violence). The authors found during the exclusion episode in the Cyberball paradigm that participants who had experienced childhood maltreatment showed heightened activation in the dPFC, dACC, medial prefrontal gyrus, and precuneus/posterior cingulate cortex. These brain areas form a network of brain regions supporting cognitive control, mentalizing, and emotion regulation.

Neural substrates of emotional instability

As already noted, emotional instability is a key psychological disposition included in the form of maladjustment associated worldwide with parental rejection. As construed in IPARTheory, emotional instability is an intense emotion that shifts quickly from baseline mood to depression, irritability, and anxiety, among other forms of negative affect (Rohner, 2021). Neurobiological research suggests that social brain regions such as the amygdala, ACC, and prefrontal cortex (PFC) are typically activated by paradigms used to investigate emotional stability and social rejection (Helion et al., 2019). These brain regions remain plastic through childhood but are vulnerable to structural modification by childhood experiences (Bolling et al., 2011). Child maltreatment, for example, is often associated with signs of dysfunction in the limbic system, with frontal and frontotemporal electrophysiologic abnormalities and lateral asymmetries later in life (Miller et al., 2022). Thus, neurobiological measures offer novel clues about cognitive and social-affective processes underlying interpersonal acceptance-rejection. These neurobiological measures may also provide insight into psychological maladjustment associated worldwide with perceived interpersonal rejection.

Koenigsberg (2010) suggested affective instability assumes that psychologically maladjusted individuals are likely to exhibit hyperactivity in limbic structures such as the amygdala and insula—in combination with reduced activation of prefrontal brain regions. These alterations are assumed to result in impairments of emotion processing that are clinically observable as pronounced emotional instability, and magnified sensitivity and reactivity to emotional information. Thus, amplified activation in the limbic region becomes linked to affective experiences of interpersonal rejection (Bolling et al., 2011). Both neurobiological and social psychological systems contribute to emotional (in)stability. That is, emotions can be stabilized by better interpersonal relationships, such as loving, caring, and accepting behaviors from significant others, as well as by cognitive-based therapeutic interventions.

Rationale and hypotheses for the present study

Most research investigating neural correlates of social rejection focuses on the current experience of rejection as induced in the study itself (Mwilambwe-Tshilobo & Spreng, 2021). None of that research, however, investigated the neural correlates of current social rejection as influenced by experiences with having been loved/accepted or unloved/rejected by *both* parents during childhood (see Ali & Britner, 2019; Schulz et al., 2022; Vijayakumar et al., 2017). Thus, drawing from limited prior evidence and especially from IPARTheory, we expected that adults' memories of parental love/acceptance or lack of love/rejection in childhood to be differentially associated with adults' neural responses to experimentally induced interpersonal rejection. Further, we expected psychological maladjustment to be one of the generative mechanisms that link childhood memories of parental love/acceptance and lack of love/rejection to neural responses to experimentally induced rejection. These expectations led to the following hypotheses:

> **Hypotheses 1.** Adults who report having been unloved/rejected in childhood are likely to show greater activation in the dACC, ventral anterior cingulate cortex (vACC), insula, precuneus, and medial prefrontal cortex (mPFC), as well as in the vlPFC, and possibly dorsolateral prefrontal cortex (dlPFC) than do adults who report a childhood history of parental love/acceptance (see Figures 1 and 2).

> **Hypothesis 2.** Brain activation in these regions is likely to be associated with regions involved in impaired emotional processing and reactivity to emotional information, such as exclusion episode in the fMRI paradigm.

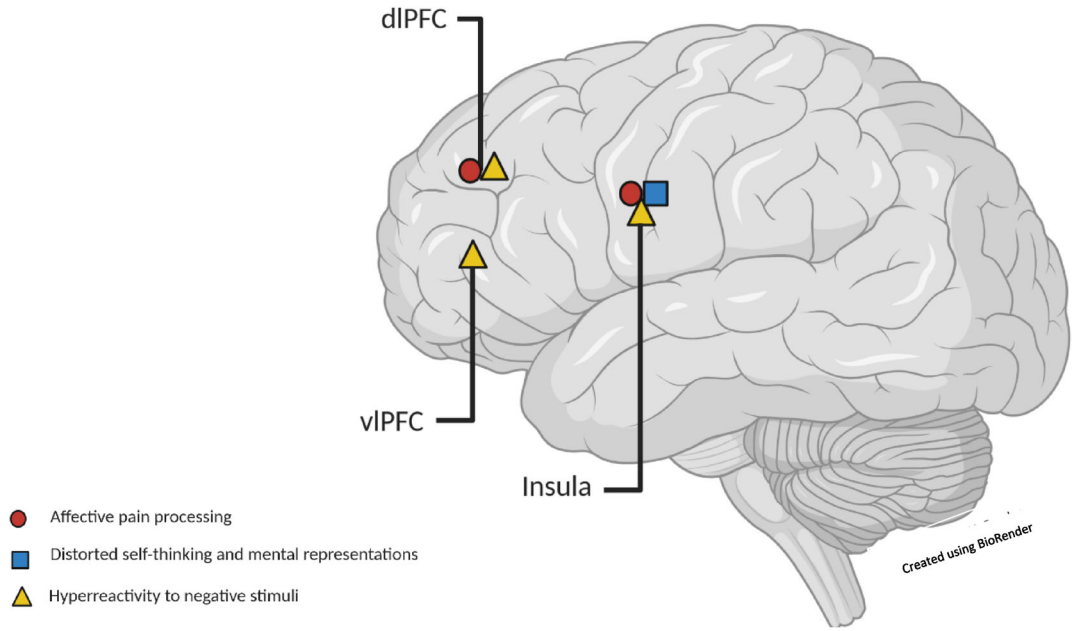


FIGURE 1 Lateral view of brain regions involved in social rejection.
Note. dlPFC = dorsolateral prefrontal cortex; vlPFC = ventrolateral prefrontal cortex. Copyright 2024 Rohner Research Publications. [Color figure can be viewed at wileyonlinelibrary.com]

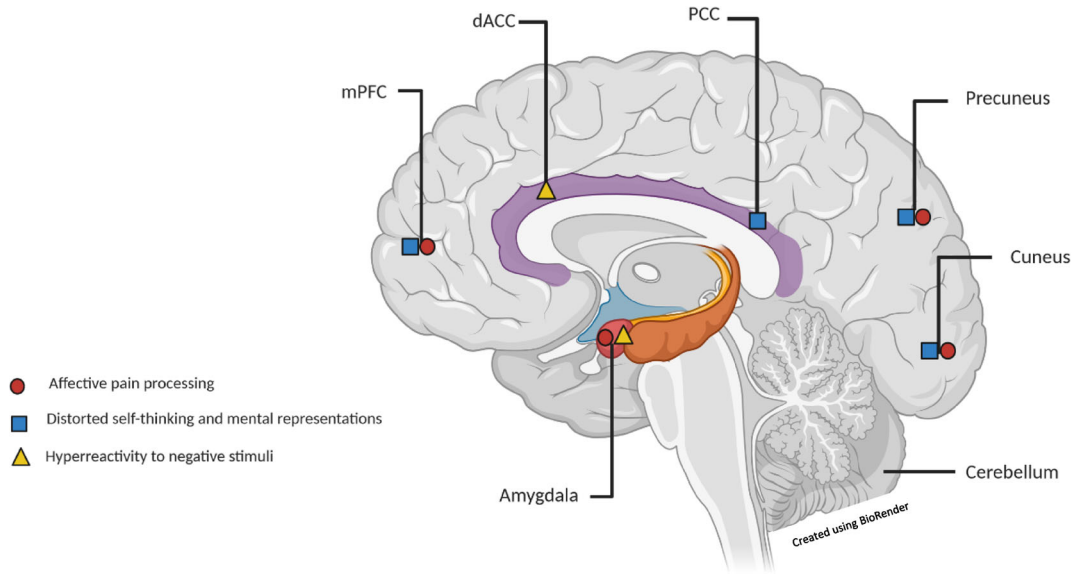


FIGURE 2 Medial view of brain regions involved in social rejection.
Note. dACC = dorsal anterior cingulate cortex; mPFC = medial prefrontal cortex; PCC = posterior cingulate cortex. Copyright 2024 Rohner Research Publications. [Color figure can be viewed at wileyonlinelibrary.com]

METHOD

Study design

We categorized participants as having been loved/accepted or unloved/rejected during childhood by administering the Mother and Father forms of the Parental Acceptance-Rejection Questionnaire (PARQ; Rohner, 2005a). Additionally, because adults' overall psychological adjustment tends to be so well predicted by their perceptions of parental acceptance and rejection in childhood, we also screened prospective participants into two categories of being psychologically well adjusted versus maladjusted using the Personality Assessment Questionnaire (PAQ; Rohner, 2005b). Those who met the criteria on both measures were categorized into the AcceptedAdjusted group and RejectedMaladjusted group. Those individuals were then invited to participate in an fMRI laboratory session during which they played an online Cyberball game (explained more fully below).

Participants

Overall, the participants included 40 (20 AcceptedAdjusted and 20 RejectedMaladjusted) right-handed students at the University of Connecticut. Their ages ranged from 18 to 25 years ($M_{age} = 19$ years, $SD = 1.39$). The sample comprised 70% females. Thirty percent ($n = 12$) were Asian American, 20% ($n = 8$) were European American, 10% ($n = 4$) were Hispanic American (e.g., Puerto Rican, Mexican American), and 10% ($n = 4$) were African American. The remaining 30% ($n = 12$) comprised a diverse group coded as "Other" (biracial or multiracial). The sample size was identified as being adequate using power estimates from prior studies with similar research designs (e.g., Cacioppo et al., 2013; Mwilambwe-Tshilobo & Spreng, 2021).

Procedure

The study protocol was approved by the University of Connecticut's Institutional Review Board (IRB #H19-023). Students were invited to participate in the study via the psychology department's research participant pool, by posting flyers around the university, and by announcements in the campus daily newspaper. Participant selection was based on a two-step process. In the first step, prospective participants responded to the Mother and Father versions of the Adult PARQ, the Adult PAQ, and an fMRI safety form. Students who responded to these questionnaires were eligible to enter a gift card raffle. Five gift cards worth $100 each were paid after the survey closed. In the second step, eligible students were invited to participate in the brain imaging study. Participants were paid $30 for time spent in the fMRI scanner. As was true in prior studies (Mwilambwe-Tshilobo & Spreng, 2021), participants were told that the study investigates relationships among team players and the social dynamics of play. Participants became acquainted with the Cyberball game in a practice session. They then played the game during the fMRI scan. Immediately after completing the game, participants responded to a Need Threat Scale (van Beest & Williams, 2006). Written informed consent was obtained from each participant before participating in the fMRI study. A debriefing session was conducted following the completion of the study.

Inclusion and exclusion criteria

The initial online assessment had no inclusion criteria beyond requiring participants to be 18 to 25 years of age. However, potential participants were excluded from fMRI scanning if they

reported any contraindications such as unremovable metal on their bodies (e.g., a pacemaker or an aneurysm clip). Only right-handed participants were recruited to ensure that observed effects were not confounded by individual differences related to brain lateralization. Potential participants were also excluded if they had more than 3% missing data on the self-report measures ($n = 28$), if they felt nervous about being in the MRI scanner (e.g., claustrophobia; $n = 25$), or if they had a physical disability (e.g., back problems) that made lying straight in the scanner difficult ($n = 18$). Individuals who self-reported a prior history of neurological or psychiatric illness ($n = 20$), current or prior psychoactive medications ($n = 25$), or who were left-handed ($n = 20$) were also excluded.

Pairing the PARQ and the PAQ yielded clear-cut cases of parental acceptance/adjustment (AcceptedAdjusted) and rejection/maladjustment (RejectedMaladjusted). Participants were placed in the AcceptedAdjusted category if their self-reported scores on both Mother and Father versions of the PARQ were between 29 and 47, and if their scores were between 42 and 104 on the PAQ. Both measures were conceptually designed so that these point ranges would clearly reveal self-reported parental acceptance and psychological adjustment. Participants were categorized in the RejectedMaladjusted category if their scores on the two PARQs fell between 56 and 96, and if their scores on the PAQ fell between 105 and 186. These measures were also conceptually designed so that scores in these point ranges would clearly reveal self-reported parental rejection and psychological maladjustment (Rohner, 2005a, 2005c, 2021).

Measures

Personal Information Form

The Personal Information Form (PIF; Rohner, 2005c), including an MRI safety screening, was used to gather demographic data (e.g., age, gender, race) and to prescreen eligibility for the fMRI scan (i.e., exclusions for metal implants, pregnancy, claustrophobia, or left-handedness of the participant).

Adult Parental Acceptance-Rejection Questionnaire (PARQ–Short Form Adult version; Mother and Father versions)

Both the Mother and Father versions of the Adult PARQ–Short Form (Rohner, 2005a) were administered. The Adult PARQ–Short Form consists of 24 items. The measure asks respondents to reflect on their memories of their mothers' or fathers' behavior toward them when they were children growing up at home. The two versions are identical except for the reference to mothers' behavior versus fathers' behavior. Items on the measure are scored on a 4-point Likert scale ranging from (4) *almost always true* through (1) *almost never true*. Both measures consist of four summed scales: (a) a six-item "hostility/aggression" scale (e.g., "My mother [father] nagged or scolded me when I was bad"), (b) a four-item "undifferentiated rejection" scale (e.g., "My mother [father] did not really love me"), (c) a six-item "indifference/neglect" scale (e.g., "My mother [father] paid no attention to me"), and (d) an eight-item "warmth/affection" scale (e.g., "My mother [father] said nice things about me). The latter scale is reverse-scored to indicate coldness/lack of affection.

The sum of the four scales provides a total acceptance-rejection score, which ranges from a minimum of 24 to a maximum of 96. Higher scores reveal the experience of greater rejection than lower scores. A meta-analysis of the reliability of the PARQ in 51 studies representing 6,898 respondents worldwide revealed that the mean weighted size of coefficient alpha aggregated across all PARQ versions was .89 (Rohner & Khaleque, 2005). In this study, Cronbach's alpha for PARQ Father and Mother versions were .79 and .80, respectively.

Adult Personality Assessment Questionnaire (PAQ–Short Form)

The PAQ (Rohner, 2005b) is a self-report measure assessing the form of psychological (mal) adjustment known to be associated worldwide with the experience of parental acceptance-rejection. The measure consists of 42 items divided into seven scales with six items in each scale: (1) "hostility and aggression" (e.g., "I think about fighting or being mean"), (2) "dependence" (e.g., "I like my friends to make a fuss over me when I am hurt or sick"), (3) "positive self-esteem" (e.g., "I like myself"), (4) "positive self-adequacy" (e.g., "I can compete successfully for the things I want"), (5) "emotional responsiveness" (e.g., "It is easy for me to be affectionate with people I care about"), (6) "emotional instability" (e.g., "I am cheerful and happy one minute and gloomy or unhappy the next"), and (7) "positive worldview" (e.g., "I think the world is a good, happy place").

Individuals respond to items such as these on a 4-point Likert scale ranging from (4) *almost always true of me* through (1) *almost never true of me*. Total test scores on the PAQ–Short Form spread from a low of 42, revealing excellent psychological adjustment, through a high of 168, revealing serious psychological maladjustment. The transcultural reliability for the PAQ is .86 (Rohner & Khaleque, 2005). Cronbach's alpha for the scale in this study was .79.

Need Threat Scale

Immediately after completing of the Cyberball game, participants completed the 20-item Need Threat Scale (NTS; van Beest & Williams, 2006). This measures distress during the Cyberball game and helps researchers understand the extent to which the participants felt threatened during the exclusion condition of the ball-toss game. The scale assesses how participants felt on four dimensions while playing Cyberball. These dimensions include "belonging" (e.g., "I felt poorly accepted by the other participants"), "self-esteem" (e.g., "I felt good about myself"), "meaningful existence" (e.g., "I felt nonexistent"), and "control" (e.g., "I felt that I was able to throw the ball as often as I wanted during the game"). Each of these constructs is measured on a 5-point Likert scale ranging from (1) *not at all* through (5) *extremely*. Higher scores indicate greater distress. Mean item rating across the 20 items was the primary index of ostracism distress for this research. Possible scores range from a low of 20 (i.e., no self-reported feelings of distress) through a high of 100 (i.e., maximum possible self-reported distress). The reliability of the NTS was reported by van Beest and Williams (2006) to be .92. In this study, Cronbach's alpha was .86.

Cyberball paradigm

After categorizing participants into the AcceptedAdjusted versus RejectedMaladjusted categories, individuals who met the inclusion criteria were invited to participate in the fMRI session. This involved playing Cyberball inside the MRI scanner. The game is a well-researched paradigm for experimentally inducing feelings of interpersonal rejection (see Mwilambwe-Tshilobo & Spreng, 2021; Williams et al., 2000). The game began with a mock Google search-engine screen followed by a "loading" screen where participants were told that they were being logged into the game by the experimenter. As the game loaded, the experimenter informed participants that they are being connected through the internet so they could play online with other participants. Participants in the MRI scanner were given two button boxes, one for each hand. This allowed them to throw the virtual ball to either the player on their right or their left.

Before starting the game, visual and auditory instructions were given, and the participant was allowed to practice with the other two players for 16 throws inside the scanner. The real game began after participants understood clearly how to play the game. Participants saw pictures of the other players and a gloved image of their own hand. To avoid introducing social bias into the research design, the fictional players' pictures were matched with the participant's age, gender, and ethnicity. This was done because prior neuroimaging and behavioral studies have found that a mismatch between gender and ethnicity group membership may become associated with depression and a decrease in self-esteem (Bolling et al., 2012).

Participants played Cyberball for 5 minutes in 10 continuous alternating blocks of Inclusion and Exclusion. Prior studies have found that an inclusion session followed by an exclusion session reduces noise due to order effect and scanner drift, and it reduces disengagement from the task in a prolonged period of exclusion (Bolling et al., 2011). Every block consisted of 12 throws lasting 30 seconds each. During the Inclusion session, participants received the ball for one third of the throws in counterbalanced order. In the Exclusion block, participants never received the ball. After the fMRI session, the experimenter asked participants if they had doubted whether they were playing with real players, but no one reported having any doubts.

The fMRI data acquisition and preprocessing

Brain imaging data were collected with a 3 T Siemens Prisma MRI Scanner in the Brain Imaging Research Center at the University of Connecticut. Whole-brain T1-weighted anatomical images were acquired using an MPRAGE sequence (TR = 1900 ms; TE = 2.52 ms; flip angle = 9°; FOV = 250 mm; image matrix 256 mm1; voxel size = 1 × 1 × 1 mm; 176 slices). Whole-brain functional images were acquired using a single-shot, gradient-recalled echo-planar pulse sequence (TR = 1070 ms; TE = 30.20 ms; flip angle = 57°; FOV = 210 mm; image matrix = 84 mm2.5; voxel size = 2.5 × 2.5 × 2.5 mm; 60 slices), sensitive to blood-oxygen-level-dependent (BOLD) magnetic susceptibility.

Imaging data were preprocessed and analyzed using FSL (FMRIB center, University of Oxford) software (Version 6.0; www.fmrib.ox.ac.uk/fsl). The data preprocessing included all transformations needed to prepare the data for further task-related analyses. The preprocessing pipeline consisted of first removing non–brain tissue using the optiBET brain extraction (Lutkenhoff et al., 2014). The preprocessing pipeline corrected for motion artifacts by aligning the volumes within a run to the middle volume of the run using FMRIB's Linear Image Registration Tool (MCFLIRT; Jenkinson et al., 2012). Slice-timing differences were adjusted by temporal interpolation, and low frequencies were removed via a high-pass filter of 100 s. Functional imaging was registered to the Montreal Neurological Institute (MNI) template space using FLIRT (Jenkinson et al., 2012). Finally, the normalized functional images were smoothed with an 8-mm full width at half-minimum (FWHM) Gaussian smoothing kernel, and grand-mean intensity normalized to facilitate intersubject registration in group analysis (i.e., combining effect estimates and their variances from the data from each subject). All registrations were checked manually for good alignment of the boundaries of the brain as well as internal structures such as the ventricles.

As in previous studies, each round of Cyberball was modeled as a run with blocks of Exclusion and Inclusion. Functional data sets were coregistered to within-session (whether Inclusion or Exclusion) anatomical images (structural versus functional), which were in turn normalized to Talairach space and convolved with a double-gamma hemodynamic response function (HRF). Estimated motion plots and sine loops were examined for each participant to identify movement and eliminate runs with head motion greater than 2.5 mm between consecutive volumes in any direction. No subjects exceeded these motion thresholds.

The fMRI statistical analysis

Second-level analysis was carried out with a flexible factorial model that included the first-level contrasts for two ball-tossing conditions (i.e., Inclusion versus Exclusion) for both sample groups. The conditions and the subjects included in the study resulted in a 2×2 factorial design: Group (AcceptedAdjusted, RejectedMaladjusted) × Condition (Inclusion, Exclusion). Finally, we included the six standard head-movement-related estimates from realignment (x, y, and z; i.e., roll, pitch, and yaw), as well as their derivatives, squares, and squared derivatives (24 movement-related regressors total) to minimize the likelihood that results would be related to artifactual sources of variance.

Group analyses were then performed to identify brain regions that showed significant differences between groups and conditions. Group-level random-effects generalized linear model analyses were conducted with functional data from each participant and for each group separately. To perform a whole-brain voxel-wise analysis we created four planned linear contrasts for each participant of Inclusion, Exclusion, Inclusion minus Exclusion, and Exclusion minus Inclusion. Linear contrasts comparing observed Exclusion to observed Inclusion were calculated for each participant. These individual contrast images were then used in group-level and whole-brain analyses. A mixed-effects analysis was performed, and brain activation in the contrast Exclusion > Inclusion and Inclusion > Exclusion were assessed at an uncorrected statistical threshold of $p < .05$.

A voxel-wise threshold of $Z = 3.1$ (corresponding to $p = .001$) was calculated to correspond to a corrected threshold of $\alpha < .05$ using FSL's FLAME1. A two-sample t test was used to compare brain activation between groups independent of the ball-tossing condition (McLaren et al., 2012). Following the whole-brain analysis, a spherical region-of-interest (ROI) analysis was performed to explore the effects of social exclusion between the two groups (i.e., participants who had been rejected in childhood by their parents versus those who had been accepted). An ROI analysis is a common approach to analyze fMRI data that involves the extraction of signal from specified regions of interest (or ROIs). This approach effectively limits the search space to one or more a priori specified regions of interest to perform confirmatory analyses. The ROIs identified in this study were based on prior literature indicating their role in processing social exclusion (e.g., Domsalla et al., 2014; Wrege et al., 2019). Brain masks (6 mm sphere with peak x, y, z activations) were created by using anatomical templates Harvard-Oxford Cortical Atlas in FSL. Each ROI's alpha level ($p < .001$) was corrected for the total number of ROI analyses carried out on brain regions found active during exclusion versus inclusion conditions from the past literature. These regions included vlPFC and anterior insula (Eisenberger et al., 2003; Masten et al., 2009), vACC (Masten et al., 2009; Onoda et al., 2009), dACC (Eisenberger et al., 2003), and posterior cingulate cortex (PCC; Onoda et al., 2009).

Peak voxels are reported as MNI coordinates [x y z] (see Tables A1 and A2 in Appendix A in the supplemental materials). For every structurally defined ROI, beta values were extracted for each participant for the contrasts (Inclusion, Exclusion, Inclusion minus Exclusion, and Exclusion minus Inclusion). An independent samples t test was conducted to compare Inclusion versus Exclusion conditions to investigate regions that were differentially activated among the AcceptedAdjusted and RejectedMaladjusted groups (see Appendix A in the supplemental materials, Figures A1 through A8 for activation patterns).

RESULTS

Behavioral results

Table 1 displays descriptive statistics for the major study variables. There one can see that participants in the AcceptedAdjusted and RejectedMaladjusted groups showed significant differences in their memories of both maternal and paternal acceptance-rejection, as well as in the

TABLE 1 Distribution of study variables, with results of *t* tests (independent, two-tailed).

	AcceptedAdjusted (AA) ($n = 20$)			RejectedMaladjusted (RM) ($n = 20$)			AA vs. RM
Measure	**Range**	***M***	***SD***	**Range**	***M***	***SD***	***t***
Maternal acceptance-rejection	29–40	33.05	3.39	57–95	67.0	7.86	17.62*
Paternal acceptance-rejection	29–41	33.75	4.25	57–95	69.50	11.53	13.0*
Psychological adjustment	66–89	76.89	5.99	105–126	113	6.76	17.94*
Distress	37–89	73.25	5.96	54–100	78.0	14.51	1.19

*$p < .001$.

level of their current psychological adjustment. There were, however, no significant differences between groups in their feelings of distress as a result of being rejected in the Exclusion conditions of the Cyberball game. Both groups were distressed by it.

Memories of maternal and paternal acceptance and rejection in childhood, controlling for psychological (mal)adjustment, were each found to have significant direct effects on the level of distress reported by participants following exclusion in the Cyberball paradigm. Specifically, in the RejectedMaladjusted group, both maternal rejection ($\beta = .89$, $SE = .42$, $p < .05$) and paternal rejection ($\beta = .67$, $SE = .06$, $p < .05$) were directly associated with the level of self-reported distress. Additionally, in the AcceptedAdjusted group, both maternal acceptance ($\beta = -.48$, $SE = .35$, $p < .01$) and paternal acceptance ($\beta = -.52$, $SE = .31$, $p < .05$) were directly but negatively associated with the level of self-reported distress. These analyses were conducted with IBM SPSS Statistics for Windows (Version 25.0).

The fMRI results

Testing for interaction, the whole-brain analysis with flexible factorial design revealed an interaction trend in several brain clusters (see Appendix B in the supplemental materials, Table B1). However, the majority of the contrasts did not survive the interaction effect but trended toward significance.

ROI analysis

The beta values extracted from the whole-brain analysis and ROI analysis with the factorial design contrast revealed a significant Group × Condition interaction in several brain clusters. Brain activation in the Inclusion and Exclusion conditions was assessed at a cluster-corrected statistical threshold of $p < .001$. No statistically significant differences were found in the inclusion condition. However, the exclusion condition analyses revealed higher peak-voxel activations in the RejectedMaladjusted group in comparison to the AcceptedAdjusted group in several clusters, including in the insula, middle frontal gyrus, pregenual anterior cingulate cortex, precuneus, posterior cingulate cortex, ACC, amygdala, and subgenual anterior cingulate cortex (see Table 2 and Appendix C in the supplemental materials, Figure C1).

DISCUSSION

Cross-cultural comparative research has consistently shown over the course of 6 decades with several hundred thousand children and adults on every continent except Antarctica that

TABLE 2 Region of interest analysis.

Brain region	x	y	z	Cluster size (voxels)	*t*-test difference between AcceptedAdjusted and RejectedMaladjusted groups
Amygdala	22	−2	−15	5378	4.90*
Insula	36	20	22	6862	6.34*
Middle frontal gyrus	48	32	19	5391	11.15*
Pregenual anterior cingulate cortex	5	47	11	5522	4.02*
Precuneus	0	−61	40	4217	3.34*
Posterior cingulate cortex	−9	−55	13	5508	6.23*
Anterior cingulate cortex	21	29	22	7848	5.26*
Subgenual anterior cingulate cortex	5	25	−10	5818	3.25*

*$p < .001$.

individuals everywhere tend to understand themselves to be loved/accepted or unloved/rejected in the same four ways. This body of research has also shown that when individuals feel unloved, not appreciated, not cared about, or rejected by people most important to them, they tend to respond psychologically and behaviorally in similar ways. These behaviors occur with such near invariance across cultures, genders, races, time, and other such defining conditions that IPARTheory researchers have come to believe they are probably embedded in a common bio-cultural evolution among humans everywhere (Rohner, 1986, 2004, 2021).

If this is true, then IPARTheorists hypothesize that specific brain mechanisms are likely to differentially characterize individuals' responses to interpersonal rejection among adults who remember having been loved/accepted by their parents in childhood versus those adults who remember having been unloved/rejected in childhood. Research reported in this article supports that hypothesis. Overall, findings show that during social rejection (Exclusion condition) in the Cyberball game, members of the RejectedMaladjusted group—as compared to members of the AcceptedAdjusted group—displayed increased activation of brain regions that critically support emotion processing and social pain. Results also reveal, however, that both groups self-reported feeling rejected by their partner players during the Exclusion condition of the Cyberball game. This is because social exclusion is typically perceived to be so threatening that even psychologically well-adjusted individuals are likely to react negatively to the experience (Landa et al., 2020).

From an IPARTheory perspective, being loved/accepted might be unexpected by most RejectedMaladjusted individuals because their self-perception tends to be characterized by low self-esteem, negative worldview, a heightened disposition toward hostility and aggression, dependency or defensive independence, negative self-adequacy, emotional unresponsiveness, and emotional instability (Rohner, 1986, 2004, 2021). Thus, during the Inclusion condition of Cyberball, participants in the RejectedMaladjusted group may have experienced cognitive dissonance, which happens when people experience a mismatch between their expectations and actual experiences (Festinger, 1954).

Participants in the RejectedMaladjusted group—in comparison with the AcceptedAdjusted group—show increased activity in several cerebral structures such as the cuneus, precentral gyrus, precuneus, amygdala, and insula (see Figure 1C in Appendix C of the supplemental materials). Earlier research showed that these brain regions are associated with experiences of social rejection, affective instability, and feelings of distress (Ochsner et al., 2004; Schulz

et al., 2022; Vijayakumar et al., 2017). Overall, this study supports the hypothesis that social exclusion is associated with significant activation in brain regions associated with emotion processing and emotion regulation such as the dACC and mPFC (Bolling et al., 2011; Schulz et al., 2022). These findings extend the literature by showing that differences in memories of parental acceptance and rejection during childhood tend to become associated with differential neural processing of Exclusion versus Inclusion in young adults.

Significance and implications for family science policy and practice

The findings from this study have the potential to inform psychotherapeutic interventions targeting executive dysfunction and rejection issues. Our results also have the potential for helping to formulate culture-fair and practicable programs, policies, and interventions affecting families and children everywhere. Repetti and Robles (2016) argued that parents are crucial in determining and shaping children's levels and responses to life stressors. Ha and Granger (2016) proposed that early family intervention programs designed to provide biomarker feedback to parents about their and their children's emotion regulation patterns might help them change their parental behavior early. Repetti and Robles (2016) proposed that by observing family interaction via home visitation, practitioners can identify family protective factors, including parenting strategies that foster tolerable responses to moderate stressors. Additionally, research has found that there are number of approaches that could help individuals cope with emotion dysregulation such as sociocognitive training and neurofeedback training (for details, see Barrasso-Catanzaro & Eslinger, 2016). With information such as this, clinicians, researchers, and policymakers can be confident about developing workable and culturally fair policies and intervention programs to assist people who struggle with the effects of rejection. Research has shown that therapeutic interventions can lead to structural and functional changes in brain areas associated with emotion regulation (Davidson & McEwen, 2012), possibly counteracting some of the negative effects of early emotional trauma.

Beyond this, family scientists have long adopted a multilevel systemic view in their research, utilizing longitudinal and dyadic research models that highlight not only family dynamics but also larger contextual issues. The present study adds a deeper layer to our understanding of interpersonal relationships by integrating information about body, brain, and interpersonal relationships. It also explores physiological, self, and social processes that are embedded in the larger societal context (Siegel, 2012). With access to the fMRI technique, family scientists can better understand the cognitive and social processes underlying the experience of interpersonal acceptance-rejection.

Limitations

This study has several limitations that must be acknowledged. For example, it is a cross-sectional study providing a snapshot at a single point in time. Prospective longitudinal studies are best positioned to provide conclusive answers to big questions relating to causal developmental pathways. Ha and Granger (2016) argued that stress physiology between parent and child are interconnected and coregulated because of shared environments and experiences. Thus, future research could collect ecological momentary assessments and investigate significant dyadic coregulation and inform therapeutic interventions.

Additionally, we acknowledge that the sample size is small; therefore, possible gender and racial differences could not be investigated. Finally, participants were college students, making it difficult to generalize to more diverse populations. Despite these limitations, the study does help researchers understand fundamental questions about significant differences in cerebral

functioning among adults who experienced substantial parental love/acceptance in childhood compared to those who experienced a lack of parental love in childhood.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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