Psychiatry Research 268 (2018) 263–271

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Neural processing of social exclusion in individuals with psychopathic traits: Links to anger and aggression☆

Grace M. Brennan[a,*], Michael J. Crowley[b], Jia Wu[b], Linda C. Mayes[b], Arielle R. Baskin-Sommers[a,b]

[a] Department of Psychology, Yale University, P.O. Box 208205, New Haven, CT 06520, USA
[b] Yale Child Study Center, Yale University School of Medicine, P.O. Box 207900, 230 South Frontage Road, New Haven, CT 06520, USA

A R T I C L E I N F O

Keywords:
Psychopathic traits
Event-related potential (ERP)
Social exclusion
Anger
Aggression

A B S T R A C T

Psychopathy is a cluster of personality traits associated with high rates of aggression. While research on psychopathic traits largely focuses on neurobiological factors implicated in aggression, other research suggests that contextual factors, such as social exclusion, also contribute to promoting aggression. Yet, the relationships among psychopathic traits, neural processing of exclusion, and aggression remain unknown. A sample of 76 adolescents and young adults completed Cyberball, a task involving conditions of social inclusion, ambiguous exclusion, and unambiguous exclusion. During Cyberball, a slow wave (SW) event-related potential (an index of elaborative processing) and self-reported anger were measured. Additionally, acts of real-world aggression were assessed. Results indicated that as psychopathic traits increased, SW during ambiguous exclusion also increased, but SW during inclusion decreased. However, the combination of *smaller* SW during ambiguous exclusion and *higher* psychopathic traits predicted heightened anger following Cyberball and more frequent real-world aggression. This response to social exclusion among individuals with elevated psychopathic traits may represent an unreflective, reactive style that exacerbates anger and aggression in certain contexts. These data suggest that neurobiological dysfunction in elaborative processing is related to psychopathic traits, and social context comprises another important influence on the aggression of individuals with elevated psychopathic traits.

1. Introduction

Aggression is hostile, unfriendly behavior that often results in physical, social, and/or emotional harm. Aggressive acts entail not only tangible costs (e.g., financial; Corso et al., 2007; Waters et al., 2005), but also intangible costs (e.g., psychological; McCollister et al., 2010). A host of factors (e.g., personality traits, environmental conditions, neural dysfunction, genetics) are known to influence risk for engaging in aggression. One factor reliably linked to higher rates and severity of aggression is psychopathy (Hare & McPherson, 1984; Kruh et al., 2005; Murrie et al., 2004; Salekin et al., 1996; Serin & Amos, 1995), a disorder characterized by a set of traits including callousness, manipulativeness, and impulsivity. Longitudinal research shows that elevated psychopathic traits in adolescence predict aggression and violent crime in adulthood (Gretton et al., 2004). Therefore, psychopathy represents a key risk factor in the development and persistence of aggressive behavior. Although there is substantial evidence that individuals with elevated psychopathic traits are more aggressive, research is lacking regarding the contexts in which they behave aggressively.

Social exclusion, sometimes referred to as ostracism or peer rejection, is a particularly powerful context that can lead to negative affect, hostility, anger, and aggression (Lansford et al., 2010; Williams, 2001; Leary et al., 2006). In a series of longitudinal studies, Dodge et al. (2003) reported that for both boys and girls social exclusion by peers around age 6 was a strong predictor of aggressive behavior around age 8, particularly for those who were already above the median on aggression at age 6. Consistent with this finding, studies focused on adolescence show that social rejection can lead to negative affect (Sebastian et al., 2010) and aggression (Reijntjes et al., 2011). The experience of social exclusion unleashes a cascade of negative consequences that span cognitive (Buelow et al., 2015), emotional, and behavioral domains (e.g., self-regulation; Baumeister et al., 2005; Chester & DeWall, 2014; risky behavior; Peake et al., 2013; Svetieva et al., 2016). Unsurprisingly, exclusion also affects interpersonal

☆ This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
* Corresponding author.
E-mail addresses: grace.m.brennan@yale.edu (G.M. Brennan), michael.crowley@yale.edu (M.J. Crowley), jia.wu@yale.edu (J. Wu), linda.mayes@yale.edu (L.C. Mayes), arielle.baskin-sommers@yale.edu (A.R. Baskin-Sommers).

https://doi.org/10.1016/j.psychres.2018.07.024
Received 5 April 2018; Received in revised form 22 June 2018; Accepted 16 July 2018
Available online 24 July 2018

functioning, such that individuals who have been excluded are less likely to engage in prosocial behavior (Twenge et al., 2007; Will et al., 2016; Moor et al., 2012) and are more likely to attribute hostile intent to others (DeWall et al., 2009a; Reijntjes et al., 2011). Thus, exclusion may heighten risk for aggression through multiple psychosocial avenues.

Social exclusion also impacts neurobiological processes, with evidence for altered perceptual and attentional processing of social cues following exclusion (Chester et al., 2014; Kawamoto et al., 2014; Dewall et al., 2009b). In a laboratory-induced form of social exclusion (i.e., the Cyberball task), the slow-wave (SW) event-related potential (ERP) is a widely studied and validated measure of cognitive-affective processing of this social context (Crowley et al., 2009; Crowley et al., 2010; White et al., 2012; Sreekrishnan et al., 2014; Baddam et al., 2016). Broadly, the SW, which is maximal at centroparietal sites and is evident from as early as 300 ms following stimulus presentation, indexes the extent to which individuals engage in elaborative processing, particularly of intrinsically motivating stimuli (Cuthbert et al., 2000; Hajcak et al., 2010; Ruchkin et al., 1992; Schupp et al., 2004). More specifically, in the Cyberball task, enhanced SW is related to experiences of heightened threat to basic needs (e.g., control, self-esteem) following exclusion (Crowley et al., 2010; Sreekrishnan et al., 2014). The SW responses to both unambiguous, clear slights (being continuously excluded by peers) and ambiguous slights (being subtly excluded in the context of overall inclusion) track cognitive-affective reactions to Cyberball (Crowley et al., 2010; Crowley et al., 2009). However, only a small number of studies examined how neural processing during exclusion relates to aggression (e.g., Chester et al., 2014; Eisenberger et al., 2007), and no studies used ERP for this purpose, despite the advantageousness of ERP for measuring how individuals process rapidly unfolding social interactions.

Moreover, no research has examined neural processing of social exclusion as it relates to psychopathic traits. There is some evidence that children with elevated psychopathic traits are at higher risk for experiencing exclusion in the first place (Waller et al., 2017) and that social exclusion mediates the relationship between psychopathic traits and later affiliation with antisocial peers (Kimonis et al., 2004). However, it is unclear if individuals with elevated psychopathic traits process the experience of exclusion differently from individuals with lower levels of these traits, and whether these potential variations in information processing are associated with engagement in real-world aggression. Exploring the relationships among psychopathic traits, neural processing of social exclusion, and aggression is especially important, as it is precisely the way in which psychopathic individuals process information that is implicated in their deviant behavior (Baskin-Sommers & Newman 2012; Brennan et al., 2017; Blair, 2010).

To examine the relationships among psychopathic traits, social exclusion, and emotional-behavioral outcomes, we used a Cyberball social exclusion task paired with dense-array electroencephalography (EEG) in an at-risk sample of adolescents and young adults. The goals of the study were three-fold. First, we were interested in the relationship between psychopathic traits and neural responses to social exclusion, specifically the SW ERP. Based on research suggesting that neural responses to ambiguous and unambiguous social exclusion index overlapping yet separable cognitive-affective reactions to the Cyberball task (Crowley et al., 2009; van Noordt et al., 2015), we examined responses to both types of exclusion events. Second, the feeling of anger is a key aspect of the exclusion-aggression link (Chow et al., 2008; Zimmer-Gembeck et al., 2016); however, since not all individuals experience exclusion in the same way, we were interested in assessing *for whom* this relationship was strongest. Specifically, we examined whether the relationship between SW and anger following the Cyberball task varied depending on level of psychopathic traits. Finally, given the association between exclusion and aggression (Lansford et al., 2010; Leary et al., 2006), we also examined whether psychopathic traits moderated the relationship between SW and real-world aggression. Delineating the relationship between psychopathic traits and responses to social exclusion is crucial for shedding light on whether aberrant processing of social contexts underlies the aggression that renders psychopathy so impairing and destructive.

2. Methods

2.1. Participants

Participants were recruited from the New Haven community. A prescreen phone interview was completed to exclude individuals who self-reported a history of schizophrenia, bipolar disorder, or psychosis, not otherwise specified; a family history of psychosis; or a history of medical problems (e.g., uncorrectable auditory or visual deficits, head injury with loss of consciousness greater than 30 min) that may have impacted their comprehension of the materials or performance on the task. In the first session, participants provided written informed consent if 18 years of age or older, and assent/parental consent if under 18 years of age, in line with the procedures set forth by the Yale University Human Investigation Committee. Then, they completed the Shipley Institute of Living Scale (Zachary, 1986), which provides an estimate of IQ and was used to exclude anyone with an IQ below 70, completed a self-report measure of psychopathic traits and behavior, and were photographed and told that the photograph would be used for a game they would play during their next visit. During the second session, participants completed the Cyberball task while neural responses were recorded using EEG. Participants were paid $30 per session. The study was approved by the Human Research Protection Program at Yale University.

An a priori power analysis based on similar published Cyberball studies (Crowley et al., 2009; Crowley et al., 2010; Gutz et al., 2015; Gutz et al., 2011) indicated that a sample size of 50 would be sufficient to detect moderate effects with 80% power. To ensure sufficient power to consider individual differences (i.e., psychopathic traits) and account for the normative loss of data for EEG, we collected data from 89 participants. Participants were 59 males and 30 females between the ages of 14 and 24 ($M = 19.65$, $SD = 2.93$). In terms of race, the majority of participants were African American (68.5%), while the remaining participants self-identified as mixed race (18%), White (11.2%), or other (2.2%). 13.5% of participants self-identified as Hispanic. The vast majority of participants reported a household income of less than $15, 000 (78.9%) and endorsed a family history of substance use disorders (92.11%). Thus, on the basis of being recruited from an urban, high-crime region where concentrated disadvantage is prevalent (Baskin-Sommers et al., 2013; Dupéré et al., 2007; Raine, 1993; Shaw et al., 2012) and exhibiting high rates of family history of externalizing psychopathology (Raine et al., 2006), the sample is "at risk" for higher levels of aggression and psychopathic traits.

2.2. Measures

2.2.1. Youth psychopathic traits inventory (YPI; Andershed et al., 2002b)

The YPI is a 50-item self-report measure that assesses psychopathic traits among youth and young adults. Items from the measure make up the following ten subscales: dishonest charm (e.g., "I have the ability to con people by using my charm and smile"), grandiosity (e.g., "I'm better than everyone on almost everything"), lying (e.g., "Sometimes I lie for no reason, other than because it's fun"), manipulation (e.g., "I can make people believe almost anything"), remorselessness (e.g., "To feel guilt and regret when you have done something wrong is a waste of time"), unemotionality (e.g., "I usually feel calm when other people are scared"), callousness (e.g., "I think that crying is a sign of weakness, even if no one sees you"), thrill seeking (e.g., "I like to be where exciting things happen"), impulsiveness (e.g., "I consider myself as a pretty impulsive person"), and irresponsibility (e.g., "I have often been late to work or classes in school"). Participants respond on a 4-point Likert scale ranging from "does not apply at all" to "applies very well." Several items in the scale are reverse-coded so that a higher total score indicates more psychopathic traits. Consistent with previous research (Andershed et al., 2007), a total YPI score was derived by computing the mean of all 50 items. The YPI was selected as a measure of psychopathic traits in the present study for several reasons: (1) it is a reliable and valid measure of psychopathic traits designed for use in non-referred, community samples of adolescents (Andershed et al., 2007; Poythress et al., 2006), (2) the YPI items were constructed with the explicit aim of framing "undesirable" traits and behaviors as strengths in order to minimize underreporting due to social desirability-based responding, and (3) unlike other self-report measures of psychopathic traits, it does not include explicit assessments of anger or aggression. This reduced the possibility of criterion contamination between our measures of psychopathic traits and anger/aggression. For this sample, excellent internal consistency (i.e., reliability) was demonstrated (Cronbach's $\alpha = 0.92$).

2.2.2. Risky, impulsive, self-destructive questionnaire (RISQ; Sadeh & Baskin-Sommers, 2016)

The RISQ is a 38-item self-report questionnaire that measures risky, impulsive, and self-destructive behaviors in eight domains: aggression, self-harm, gambling, reckless behavior, impulsive eating, risky sex, drug use, and alcohol use. For each behavior, respondents note the number of times they have engaged in the behavior in their lifetime, how many times in the past month, and how old they were when they first started engaging in the behavior. Additionally, respondents indicate if there were any consequences (e.g., legal, social, financial) as a result of their behavior. Finally, for each behavior respondents indicate how strongly they agree with statements that assess their motivation (distress relief or pleasure seeking) for engaging in the behavior. Psychometrically, this instrument has demonstrated high internal consistency and construct validity (Sadeh & Baskin-Sommers, 2016). As our measure of real-world aggression, we used the 6-item aggression subscale (example item: "gotten in a physical fight") to quantify the extent of recent engagement in aggressive behavior (i.e., frequency of aggressive behavior in the past month). For this sample, the aggression subscale exhibited excellent internal consistency (Cronbach's $\alpha = 0.95$).

2.3. Experimental procedure

Each participant sat 60 cm away from a 19-in. LCD monitor in a dimly lit (60 W bulb), sound-attenuated room.

2.3.1. Cyberball social exclusion task

The Cyberball task is a virtual ball-toss game in which a participant plays with two other players on a computer (Williams et al., 2000). Before beginning the task, participants were informed that they would play an online game with two other people. Unbeknownst to them, however, these other players were simulated. To increase realness and personal investment in the game, participants were prompted to select their "favorite" glove from six images of baseball mitts. Participants were also instructed to choose two other peers with whom they wanted to play. The other players were depicted as photographs of individuals matched to each individual participant's age, sex, and race/ethnicity. The photograph of each player (including the participant, using the photograph taken during the first session) was displayed above his or her respective glove. The participant's glove was positioned at the bottom center of the screen; the gloves of the other two players were positioned at the top left and top right of the screen (see Fig. 1). After selecting their glove and co-players, participants advanced to a Google™ page with a 'Cyberball' listing that led to a false loading screen. A pre-recorded female voice recited the game instructions, which were simultaneously displayed in writing on the screen, and then the game began.

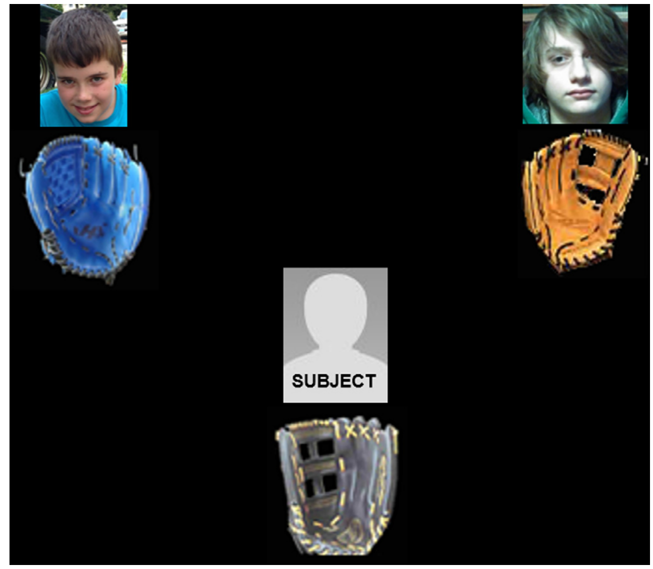

Fig. 1. Schematic depicting the appearance of the Cyberball game. The participant's photograph appeared above his or her glove at the bottom center of the screen. Participants pressed one button to throw to the player on the left and another button to throw to the player on the right.

Each trial began with the appearance of a cue signaling an impending throw. The cue was a yellow outline around the glove of the player "holding" the ball, intended to cue attention to the relevant event. After an 1150-ms delay, the ball appeared alongside the glove, oriented toward the player who was going to receive the ball next. This meant that when a cyber player held the ball, the ball appeared either: (a) oriented toward the other player's glove in yellow, indicating that the ball would not come to the participant, or (b) oriented toward the participant's glove in red, indicating that the ball would come to the participant (see Fig. 2). Participants used their left and right index fingers on a response pad to throw left or right to the other players.

Trials (155 total) were broken down into two blocks. The first block of 108 trials was an inclusion block. During the inclusion block, the participant regularly received the ball from the other players. The cyber players threw to the participant 36 times, which were favorable trials because the participant was actively included in the game. However, on 36 trials during the inclusion block, the cyber players threw to one another and not to the participant. These were microrejection events, where the participant was excluded but in the overall context of being included. For this reason, microrejection events represent a subtle and ambiguous form of rejection and signal the potential that ongoing exclusion may be imminent (Moor et al., 2012). Whether a ball was thrown to the participant during any one trial in the inclusion block was pseudorandom and predetermined within a list such that the participant waited for either 0, 1, 2 or 3 throws by the other players before receiving the ball again (frequency 12, 12, 10 and 2, respectively). The second block of 47 trials was an exclusion block. Without any pause in the game, the participant transitioned from the inclusion block to the exclusion block. During this block, the cyber players primarily tossed the ball back and forth to one another, but not to the participant. These are rejection events in that they represent clear, unambiguous rejection by the cyber players. The participant was excluded, or rejected, on 36 out of 39 trials in this block (the ball was thrown to the participant three times to maintain attention).

2.3.2. Anger questionnaire

After completing the Cyberball task, participants responded to a set of questions regarding how they felt about the game. This 9-item scale assessed the extent to which participants experienced anger (e.g., "During the game I got frustrated and angry") and desired revenge

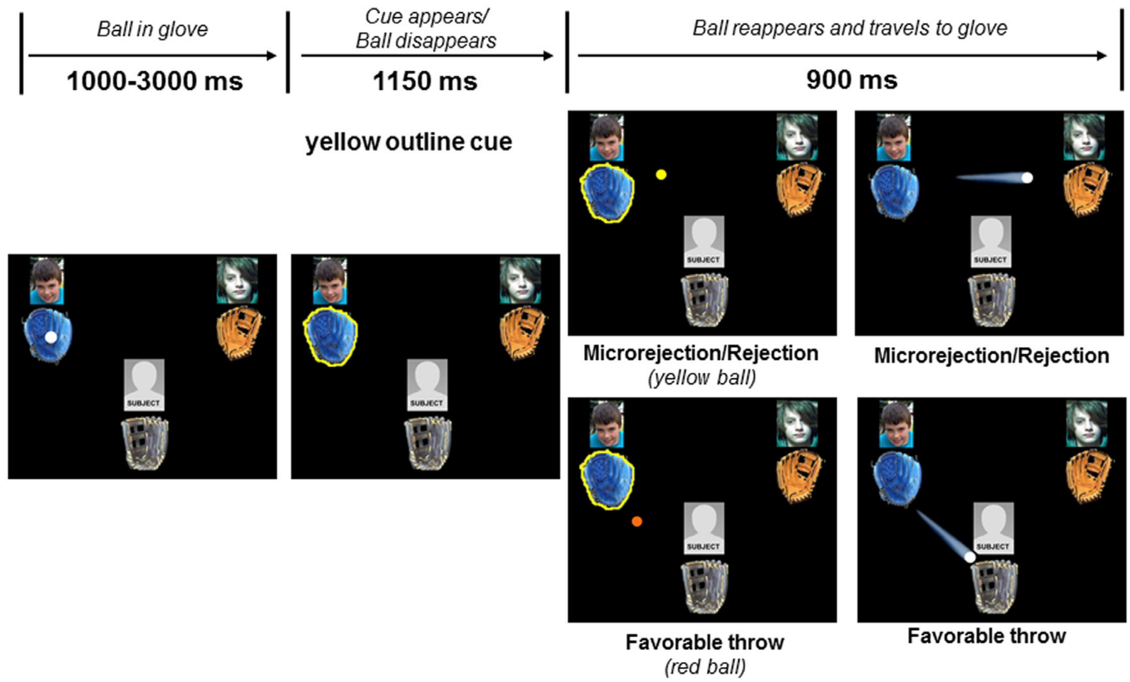

Fig. 2. Schematic illustrating the types and timecourse of the Cyberball game trials. Each trial began with the appearance of the yellow outline cue. After 1150 ms, the ball reappeared, indicating which player was going to receive it. ERP in response to the throw outcomes were examined. Trial types for responses to the outcome were microrejection (not receiving the ball during fair play) and rejection (not receiving the ball during exclusion; shown in the top images), and favorable throws (shown in the bottom images). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

against the cyber players (e.g., "I thought about how to get back at the other players"). Participants rated each item on a 5-point Likert scale ranging from 1 ("not at all true") to 5 ("extremely true"). Higher scores indicate higher levels of anger. This scale demonstrated good internal consistency (Cronbach's $\alpha = 0.87$). Principal components analysis (PCA) was applied to confirm the single-factor structure of the items. Each item loaded onto a single factor (initial Eigenvalue = 4.79) that explained 53.24% of the total variance in the items. Loadings for each item ranged from 0.55 to 0.89. The three next-largest factors had initial Eigenvalues of 1.10 (explaining 12.26% of the variance), 0.80 (explaining 8.84% of the variance), and 0.61 (explaining 6.79% of the variance). Visual examination of the scree plot for this PCA confirmed that the factor Eigenvalues showed a steep drop and leveling off after the first factor, indicating that a single-factor solution is the strongest solution for these items. Thus, the anger questionnaire was a reliable and cohesive index of Cyberball-related anger.

2.3.3. Post-session debrief

After playing the game and answering the questions, participants were debriefed about the falsity of the additional players and the game.

2.4. Psychophysiological recording and analysis

EEG was recorded throughout the experiment from 128 Ag/AgCl electrodes embedded within a Hydrocel Geodesic sensor net, using NetStation v.4.2 software (Electrical Geodesics, Incorporated [EGI]) and EGI high-impedance amplifiers, sampled at 1000 Hz (0.1 Hz high-pass, 100 Hz low-pass). All electrodes were referenced to Cz for recording. Electrooculogram (EOG) was recorded above and below the left eye (VEOG) in line with the pupil. At the start of the experimental session, impedance for each electrode was below 40 KΩ.

EEG data were preprocessed using the Physbox plugin (Curtin, 2011) within the EEGLAB toolbox (Delorme & Makeig, 2004) in MATLAB. Data were re-referenced to an average reference of all electrodes and digitally filtered offline with a 30-Hz low-pass Butterworth filter. Eyeblink artifacts were identified and removed using a regression-based procedure (Semlitsch et al., 1986). Data were segmented around stimulus onset (−100 to 900 ms) and corrected to a 100-ms pre-stimulus baseline. Trials with EEG voltages beyond ± 100 μV were discarded from further analyses.

EEG data were time-locked to the color change of the ball, which indicated the outcome of each throw. To identify a SW that is sensitive to rejection (Crowley et al., 2010), we used a cluster of channels in the parietal-occipital region (71, 72, 75, 76, 77, 78, 82, 83, 84, 85, 86, 90, 91, 92, and 97; see Fig. 2 in Crowley et al., 2010). ERP were averaged separately for all trials within each trial type (favorable throws, microrejection, rejection). Consistent with previous research (e.g., Baddam et al., 2016; Crowley et al., 2010), 11 of the 47 exclusion block trials were not used in ERP analyses: the first five trials of the exclusion block, the three throws to the participant during this block, and the three throws back from the participant to the cyber players. Thus, 36 rejection events from the exclusion block were analyzed. The grand average ERP waveform for all participants showed that the SW extended from approximately 500 to 900 ms post-stimulus onset, consistent with previous research (Crowley et al., 2010). Thus, the magnitude of the SW was measured as the mean amplitude in the timeframe of 500 to 900 ms post-stimulus onset.

Following preprocessing, all ERP data were examined for quality, and participants were excluded from analyses if, following artifact rejection, less than 20 trials from any trial type remained (Rietdijk et al., 2014). Twelve participants were excluded for this reason. Additionally, one participant was excluded due to technical issues during the experimental session. In total, 13 participants were excluded from analyses, leaving 76 participants in the final sample. Excluded participants did not differ significantly from included participants in terms of any of the following characteristics: sex, age, IQ, or YPI total score (all p values ≥ 0.096). The final analyzed sample of 76 participants consisted of 53 males (69.74%) and 23 females (30.26%). Descriptive statistics of key variables for the final sample are presented in Table 1 (see Supplementary Table 1 for correlations among study variables). Further support for the characterization of the sample as "at-risk" for higher rates of aggression is demonstrated by the fact that the mean YPI total

Table 1
Descriptive statistics for key variables.

Measure	Mean	Standard deviation	Range
YPI total mean score	1.85	0.39	1.18 – 2.90
RISQ Aggression (last month)	1.26	4.04	0 – 20
Anger questionnaire	13.21	5.55	9 – 32

Note. YPI total = total mean score on the Youth Psychopathic Traits Inventory, RISQ Aggression (last month) = number of times participant engaged in aggression in the past month, as assessed using the 6-item Aggression subscale of the Risky, Impulsive, Self-Destructive Questionnaire.

score for the sample falls between mean scores found in unselected adolescent samples (Larsson et al., 2006) and incarcerated juvenile offender samples (Skeem & Cauffman, 2003). The means for the number of trials (and the associated ranges) included in the average ERP for each condition were as follows: 34.47 favorable trials (range 21–36), 34.43 microrejection trials (range 20–36), and 34.05 rejection trials (range 22–36).

3. Results

3.1. Slow wave and psychopathic traits

SW amplitude was analyzed in a repeated measures general linear model (GLM) with trial type (favorable, microrejection, rejection) as a within-subjects categorical factor and YPI total score (mean-centered and standardized) as a between-subjects quantitative factor. Follow-up simple interaction contrasts, with favorable SW amplitude as the reference category, were used to yield the following comparisons: microrejection versus favorable and rejection versus favorable.

The trial type x psychopathic traits interaction was significant, $F(2,148) = 5.31$, $p = .006$, $\eta_p^2 = 0.07$, 90% CI [.01, 0.13]. Examination of the simple interaction contrasts indicated that the microrejection versus favorable contrast was significant, $F(1,74) = 10.97$, $p = .001$, $\eta_p^2 = 0.13$, 90% CI [.03, 0.25], whereas the rejection versus favorable contrast was not, $F(1,74) = 1.13$, $p = .291$. The simple main effect of psychopathic traits was significant in the microrejection trials, $B = 0.27$, $p = .021$, $\eta_p^2 = 0.07$, 90% CI [.01, 0.17], and in the favorable trials, $B = -0.28$, $p = .033$, $\eta_p^2 = 0.06$, 90% CI [.003, 0.16]. The main effect of psychopathic traits was not significant, $p = .689$. Together, these findings indicate that psychopathic traits were related to enhanced SW in response to microrejection and diminished SW in response to favorable events, and that these SW responses were significantly different from one another (see Fig. 3).

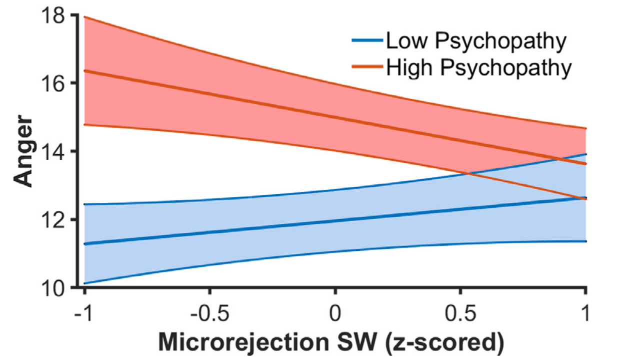

Fig. 4. Anger as a function of microrejection slow wave (SW) amplitude (continuous) and psychopathic traits (YPI total; lines represent scores at ± 1 SD from the mean). Error bands indicate 1 SE.

3.2. Slow wave, psychopathic traits, and anger

The distribution of the anger questionnaire scores was non-normal and positively skewed. Based on the characteristics of these data (Brown & Dunn, 2011; Manning & Mullahy, 2001), we used a gamma regression model with log link to examine whether psychopathic traits moderated the association between SW and self-reported post-Cyberball anger. The two outliers in the anger variable (> 3 SDs above the mean) were winsorized.

The model demonstrated good fit, $\chi^2/df = 0.15$, $p < .034$. Higher psychopathic traits were related to higher anger, OR = 1.13, $p = .007$, 95% CI [1.03, 1.22], but microrejection SW itself was not related to anger, OR = 0.97, $p = .417$. However, the interaction between microrejection SW and psychopathic traits was significant, OR = 0.92, $p = .027$, 95% CI [.86, 0.99], indicating that lower microrejection SW amplitude and higher psychopathic traits were related to more anger in response to Cyberball (see Fig. 4). The model using favorable SW as an independent variable did not demonstrate good fit, $\chi^2/df = 0.15$, $p = .085$, and thus was not examined further.

3.3. Slow wave, psychopathic traits, and aggression

Using negative binomial regression, since the aggression data were in the form of counts and demonstrated positive skewness along with overdispersion, we tested whether psychopathic traits moderated the association between SW amplitude and frequency of past-month aggressive behavior. The two outliers in the aggression variable (> 3 SDs above the mean) were winsorized.

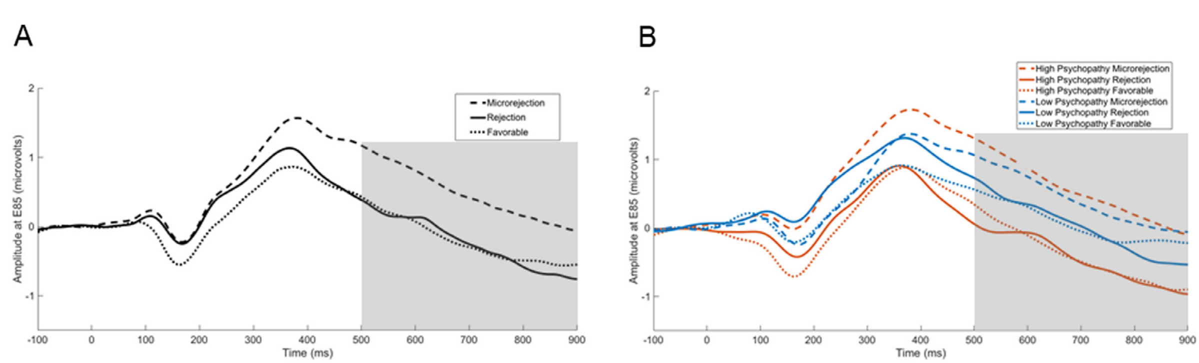

Fig. 3. Average ERP waveform at an electrode (E85) located centrally within the cluster of parietal-occipital electrodes examined. The average ERP waveform is depicted for the full sample (A) as well as for the full sample split into two groups (B): those with high levels of psychopathic traits (red) and those with low levels of psychopathic traits (blue). Though the primary analyses were conducted using continuous psychopathy scores, “high YPI” (individuals whose YPI total scores were above the median) and “low YPI” (individuals whose YPI total scores were below the median) groups were used here solely for depiction. Dashed lines represent the waveforms for microrejection trials, solid lines represent the waveforms for rejection trials, and dotted lines represent the waveforms for favorable trials. The gray box indicates the timeframe used to derive the slow wave amplitude measure. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

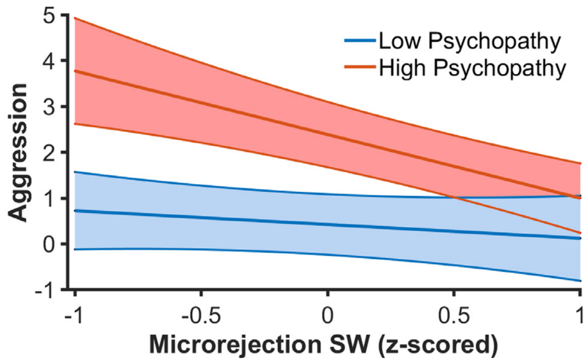

Fig. 5. Aggression as a function of microrejection slow wave (SW) amplitude (continuous) and psychopathic traits (YPI total; lines represent scores at ± 1 SD from the mean). Error bands indicate 1 SE.

The model demonstrated good fit, χ^2/df = 5.59, $p < .001$. Both higher psychopathic traits, OR = 2.61, $p < .001$, 95% CI [1.66, 4.13], and lower microrejection SW, OR = 0.65, $p = .021$, 95% CI [.46, 0.94], were related to more frequent aggression in the past month. Furthermore, the interaction between SW amplitude and psychopathic traits was significant, OR = 0.49, $p = .005$, 95% CI [.30, 0.81], indicating that lower microrejection SW amplitude and higher psychopathic traits were related to more aggression (see Fig. 5). One advantage of the RISQ measure is that it provides a metric for the extent to which a motivation to avoid negative mood states or promote positive mood states is related to engagement in risky, impulsive, and self-destructive behavior. A paired samples *t*-test indicated that, among those who endorsed engaging in aggression on the RISQ, the motivation to avoid negative mood states ($M = 0.82$, $SD = 1.34$) was significantly higher than the motivation to achieve positive mood states ($M = 0.42$, $SD = 1.00$), $t(54) = 2.12$, $p = .038$, $d = 0.29$, 95% CI [.01, 0.55].

In the model using favorable SW as an independent variable (model fit: χ^2/df = 6.13, $p = .021$), higher psychopathic traits were again related to more aggression, OR = 1.70, $p = .004$, 95% CI [1.19, 2.44], but favorable SW was not, OR = 1.03, $p = .853$. In addition, the interaction between favorable SW amplitude and psychopathic traits was not significant, OR = 1.12, $p = .540$.

4. Discussion

This study was the first to examine associations between psychopathic traits and neural responses to social exclusion. We used high-density EEG while participants played the Cyberball task in order to assess SW ERP in response to being included and excluded, both ambiguously, during fair play, and unambiguously, during the subsequent exclusion block. Additionally, we explored whether psychopathic traits moderated the associations between task-related SW and anger, and between task-related SW and aggression. Results indicated that higher levels of psychopathic traits were related to larger SW in response to microrejection, suggesting heightened elaborative processing of subtle, ambiguous exclusion. Additionally, higher levels of psychopathic traits were related to smaller SW in response to favorable throws, suggesting diminished elaborative processing of active inclusion. Furthermore, psychopathic traits interacted with SW amplitude in the prediction of both task-related anger and real-world past-month aggression. Specifically, *smaller* microrejection SW and *higher* levels of psychopathic traits were associated with the highest levels of both anger and aggression. Taken together, these results provide evidence that psychopathic traits are associated with aberrant processing of social contexts.

The enhanced elaborative processing of ambiguous exclusion in individuals with higher levels of psychopathic traits (i.e., larger SW to microrejection) is consistent with previous research showing that individuals with elevated psychopathic traits exhibit an exaggerated sense of entitlement (Lessard et al., 2011) and more intense reactions to perceived social threats (Blackburn & Lee-Evans, 1985). Greater elaborative processing of ambiguous rejection is perhaps a neurobiological reaction to violations of their entitled expectations about how they should be treated by others. Greater elaboration of these ambiguous events also may result in the strong reactions to social threats, even subtle threats. Furthermore, research in adolescents indicates that psychopathic traits are associated with heightened theory of mind, also referred to as hypermentalizing, which is characterized by over-attributing mental states to others (Sharp & Vanwoerden, 2013). Though speculative, it is possible that participants with higher levels of psychopathic traits engaged in mentalizing-related cognitive processes (e.g., judging intent, generating potential explanations for the other players' behavior) in an attempt to predict whether rejection was on the horizon.

Interestingly, we found a significant relationship between psychopathic traits and processing of ambiguous exclusion (microrejection) but not unambiguous exclusion (rejection). Researchers have posited that the unambiguous rejection of Cyberball (i.e., the exclusion block) represents a "strong situation" (McDonald & Donnellan, 2012) that leads to patterns of neural and emotional responding that are relatively insensitive to individual differences. Since participants were continuously left out during the exclusion block, it may be that *all* participants established expectations of being excluded as the block progressed and thus became accustomed to that experience. The "weaker" situation in which participants do not receive the ball but it is not obvious that they are being excluded (i.e., microrejection) may be better suited to eliciting psychopathy-related differences (Lissek et al., 2006). Furthermore, this may be consistent with research demonstrating that aggressive individuals exhibit more anger and hostility compared to non-aggressive individuals, but only when responding to a situation that is ambiguous (Dodge, 1980; Zimmer-Gembeck & Nesdale, 2013). Thus, microrejection may be analogous to the ambiguous situation, whereas rejection corresponds to the clearly hostile situation that elicits more similar reactions regardless of individual differences.

By contrast, psychopathic traits were associated with diminished elaborative processing (i.e., smaller SW) in the context of inclusion. This response may reflect a relative lack of value placed on positive social interactions. Individuals with psychopathy tend to show low communion (Sherman & Lynam, 2017), little concern about maintaining social relationships (Pardini, 2011), and devaluation of attachment bonds (Pasalich et al., 2012; Schimmenti et al., 2014). Attenuated processing of social inclusion also has been found in depression (Zhang et al., 2017) and could reflect a transdiagnostic social discounting process whereby positive interactions are discounted, albeit for different reasons (e.g., low communion in psychopathy versus general anhedonia in depression). Across conditions, then, individuals with elevated psychopathic traits exhibited different neural responses to social context, with exaggerated elaboration during ambiguous exclusion and reduced elaboration during inclusion. This differential pattern of neurobiological processing of social context may reflect the characteristic behaviors of psychopathy, such as failure to form genuine relationships and intellectualization of emotional experiences.

Psychopathic traits were not only associated with altered SW; they also moderated the links between SW and key affective and behavioral responses to social exclusion, namely anger and aggression. Since the combination of smaller microrejection SW and higher levels of psychopathic traits was related to the highest levels of both anger and aggression, it may be that diminished elaborative processing of ambiguous rejection events among individuals with elevated psychopathic traits promotes anger and aggression. These findings may be interpreted in light of theories from both the anger literature and the psychopathy literature.

Dual-process models of anger and aggression (Anderson & Bushman, 2002; Wilkowski & Robinson, 2008) provide a useful framework for understanding the role of automatic and controlled processes in appraising situations. According to such models, when individuals encounter potentially threatening or anger-provoking situations, two types of processes are relevant: (1) rapid, automatic processes that produce a broad-strokes, gist-like interpretation (Wilkowski et al., 2007), and (2) controlled, effortful processes that can expand upon or alter the initial interpretation. In the context of ambiguous provocation, the hostile attribution bias seen in aggressive individuals is an automatic process that occurs very early in information processing. However, given sufficient motivation, time, and cognitive resources, a slower and more controlled process may come online, allowing a more nuanced understanding of the situation to develop. Examples of these more controlled processes include encoding information that is inconsistent with the initial hostile interpretation (Wilkowski et al., 2007), accumulating evidence for judging intent (Dodge & Newman, 1981), considering the mental states of the individuals involved (Taubner et al., 2013), and revising prior expectations (Lochman & Dodge, 1998). For many, these effortful cognitive processes override or alter the initial affective reactions or action tendencies (Berkowitz & Harmon-Jones, 2004), potentially quelling anger and inhibiting aggression. However, some individuals fail to deploy controlled processing in certain provocative contexts, permitting initial hostile biases to go unchecked. Thus, smaller SW in participants with elevated psychopathic traits may represent a lack of elaborative processing that helps regulate automatic hostile reactions to ambiguous social exclusion, resulting in anger and aggressive acts.

Another important component of the present findings was that real-world aggression was related to a motivation to avoid negative affect, suggesting that participants who engaged in aggression tended to act based on a state of aversive emotional reactivity which may have precluded or impaired elaborative processing. Considering the heterogeneity of psychopathy is relevant for understanding this finding and may complement the dual-process interpretation regarding styles of processing social context (Poythress & Skeem, 2007). One of the leading classification schemes of psychopathy delineates subgroups based on levels of anxiety and childhood maltreatment. The primary variant of psychopathy is characterized by low anxiety and relative lack of maltreatment, while the secondary variant is characterized by high anxiety and significant maltreatment (Karpman, 1948). Broadly, these two variants of psychopathy track divergent styles of responding to provocation: whereas the primary variant is associated with control and planfulness, the secondary variant is associated with defensiveness and emotional reactivity (Hicks et al., 2004). There is evidence that heightened emotional reactivity to aversive events may interfere with the ability to pause and reflect on information (Schmitt et al., 1999; Dodge & Somberg, 1987), leading to processing that relies on simple associations (Patterson & Newman, 1993). Moreover, the secondary variant tends to be more angry and aggressive (Blackburn & Lee-Evans, 1985; Kimonis et al., 2011; Hicks et al., 2004). Thus, it may be that participants in the present study with elevated psychopathic traits combined with low reflectiveness engaged in a style of responding consistent with the emotional reactivity (i.e., heightened anger and aggression) in secondary psychopathy; conversely, participants with elevated psychopathic traits and high reflectiveness may have been able to monitor their interpretations of social context and be more controlled and deliberate in their behavior (i.e., not necessarily angry and aggressive in this context), a pattern more consistent with primary psychopathy. Since this interpretation is speculative, future research on the variants of psychopathy is needed in order to parse the neurobiological processes underlying responses to certain contextual factors.

Before concluding, limitations of the present study should be noted. First, participants were not randomly assigned to either an inclusion or exclusion condition, and anger was only assessed at the end of the task; thus, we were unable to compare affective responses to inclusion versus exclusion blocks. However, our end-of-task assessment of anger was more appropriate than multiple mid-task assessments of anger for two reasons: (1) we were interested in affective responses to social exclusion (not inclusion), and (2) mid-task reporting of anger would have disrupted the trial structure and, possibly, drawn attention to affective experiences in a way that could have altered the natural trajectory of participants' affective experiences (e.g., by giving participants time to "cool off" and reflect on the situation). Moreover, the within-subjects nature of the design did allow for the comparison of each individual's neural response to each condition. Second, consistent with previous research, we did not counterbalance blocks; inclusion always preceded exclusion. If exclusion preceded inclusion, participants might have carried this expectation into the inclusion block. Third, although SW varied by the three trial types and was related to task-induced anger and real-world aggression, we cannot know exactly what SW amplitude reflects in this context. For example, the smaller microrejection SW in those with elevated psychopathic traits could reflect a process of avoidance of negative affect (Martin et al., 2017; Puetz et al., 2016; Bushman et al., 2001; Tull et al., 2007; Strauss et al., 2015), emotional reactivity that disrupts elaborative processing (Schmitt et al., 1999; Dodge & Somberg, 1987; Patterson & Newman, 1993), or perhaps some combination of both. Future work is needed to test these possibilities in order to explore the precise neurobiological mechanisms by which SW relates to anger and aggression among individuals with elevated psychopathic traits. Fourth, our measure of aggression was limited in that it was not designed to differentiate between types of aggression (e.g., reactive and proactive aggression, which could each be associated in distinct ways with cognitive-affective processing of social context; Gillespie et al., 2018) and was derived from self-report (as opposed to an experimental measure). However, there is evidence that experimental tasks measuring aggression (e.g., the Taylor Aggression Paradigm) and self-report measures of aggression are highly correlated (Anderson & Bushman, 1997). While there are advantages associated with gathering objective estimates of aggression in the laboratory, the validity of many commonly used experimental aggression measures is limited by demand characteristics and a restricted range of behavioral options (e.g., no option to behave in a non-aggressive manner; Tedeschi & Quigley, 1996; Ritter & Eslea, 2005). Nevertheless, future work in this area should endeavor to replicate the present findings using a multi-method approach to measuring aggression. Finally, we did not examine individuals with extremely high levels of psychopathic traits (e.g., a sample consisting exclusively of those involved in the juvenile or criminal justice system). Although meaningful insights into psychopathy can be generated by studying at-risk community and non-referred samples (see Andershed et al., 2002a) future research in incarcerated populations would be helpful for assessing the generalizability of the present findings.

In conclusion, the present study demonstrates that psychopathic traits are associated with aberrant processing of cues related to social exclusion and inclusion. Moreover, it appears that the highest risk for anger and aggression in individuals with elevated psychopathic traits is found among those who are less reflective during ambiguous social exclusion. Thus, the aggressive behavior of individuals with elevated psychopathic traits is best understood using a neuroecological approach that recognizes the importance of social context as qualifying the expression of underlying neurobiological processes.

Declarations of interest

None

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2018.07.024.

References

Andershed, H., Hodgins, S., Tengström, A., 2007. Convergent validity of the youth psychopathic traits inventory (YPI): association with the psychopathy checklist: youth Version (PCL:YV). Assessment 14, 144–154.
Andershed, H., Kerr, M., Stattin, H., 2002a. Understanding the abnormal by studying the normal. Acta Psychiatr. Scand. 106, 75–80.
Andershed, H., Kerr, M., Stattin, H., Levander, S., 2002b. Psychopathic traits in non-referred youths: a new assessment tool. In: Blaauw, E., Sheridan, L. (Eds.), Psychopaths: Current International Perspectives. Elsevier, The Hague, pp. 131–158.
Anderson, C.A., Bushman, B.J., 1997. External validity of "trivial" experiments: the case of laboratory aggression. Rev. Gen. Psychol. 1, 19–41.
Anderson, C.A., Bushman, B.J., 2002. Human aggression. Ann. Rev. Psychol. 53, 27–51.
Baddam, S., Laws, H., Crawford, J.L., Wu, J., Bolling, D.Z., Mayes, L.C., Crowley, M.J., 2016. What they bring: baseline psychological distress differentially predicts neural response in social exclusion by children's friends and strangers in best friend dyads. Soc. Cogn. Affect. Neurosci. 11, 1729–1740.
Baskin-Sommers, A.R., Baskin, D.R., Sommers, I.B., Newman, J.P., 2013. The intersectionality of sex, race, and psychopathology in predicting violent crimes. Crim. Justice Behav. 40, 1068–1091.
Baskin-Sommers, A.R., Newman, J.P., 2012. Cognition–emotion interactions in psychopathy: implications for theory and practice. In: Hakkanen-Nyholm, H., Nyholm, J. (Eds.), Psychopathy and Law. Wiley, New York, pp. 79–98.
Blair, R.J.R., 2010. Neuroimaging of psychopathy and antisocial behavior: a targeted review. Curr. Psychiatry Rep. 12, 76–82.
Baumeister, R.F., DeWall, C.N., Ciarocco, N.J., Twenge, J.M., 2005. Social exclusion impairs self-regulation. J. Pers. Soc. Psychol 88, 589–604.
Berkowitz, L., Harmon-Jones, E., 2004. Toward an understanding of the determinants of anger. Emotion 4, 107–130.
Blackburn, R., Lee-Evans, J.M., 1985. Reactions of primary and secondary psychopaths to anger-evoking situations. Br. J. Clin. Psychol. 24, 93–100.
Brennan, G.M., Hyde, L., Baskin-Sommers, A., 2017. Antisocial pathways associated with substance use disorders: characterizing etiological underpinnings and implications for treatment. Curr. Opin. Behav. Sci. 13, 124–129.
Brown, J.E., Dunn, P.K., 2011. Comparisons of tobit, linear, and poisson-gamma regression models: an application of time use data. Sociol. Methods Res. 40, 511–535.
Buelow, M.T., Okdie, B.M., Brunell, A.B., Trost, Z., 2015. Stuck in a moment and you cannot get out of it: the lingering effects of ostracism on cognition and satisfaction of basic needs. Pers. Individ. Diff. 76, 39–43.
Bushman, B.J., Baumeister, R.F., Phillips, C.M., 2001. Do people aggress to improve their mood? Catharsis beliefs, affect regulation opportunity, and aggressive responding. J. Pers. Soc. Psychol 81, 17–32.
Chester, D.S., DeWall, C.N., 2014. Prefrontal recruitment during social rejection predicts greater subsequent self-regulatory imbalance and impairment: neural and longitudinal evidence. Neuroimage 101, 485–493.
Chester, D.S., Eisenberger, N.I., Pond Jr., R.S., Richman, S.B., Bushman, B.J., Dewall, C.N., 2014. The interactive effect of social pain and executive functioning on aggression: an fMRI experiment. Soc. Cogn. Affect. Neurosci. 9, 699–704.
Chow, R.M., Tiedens, L.Z., Govan, C.L., 2008. Excluded emotions: the role of anger in antisocial responses to ostracism. J. Exp. Soc. Psychol. 44, 896–903.
Corso, P.S., Mercy, J.A., Simon, T.R., Finkelstein, E.A., Miller, T.R., 2007. Medical costs and productivity losses due to interpersonal and self-directed violence in the United States. Am. J. Prev. Med. 32, 474–482.
Crowley, M.J., Wu, J., McCarty, E.R., David, D.H., Bailey, C.A., Mayes, L.C., 2009. Exclusion and micro-rejection: event-related potential response predicts mitigated distress. Neuroreport 20, 1518–1522.
Crowley, M.J., Wu, J., Molfese, P.J., Mayes, L.C., 2010. Social exclusion in middle childhood: rejection events, slow-wave neural activity, and ostracism distress. Soc. Neurosci. 5, 483–495.
Curtin, J.J., 2011. PhysBox: the psychophysiology toolbox. An open source toolbox for psychophysiological data reduction within EEGLab. http://dionysus.psych.wisc.edu/PhysBox.htm accessed 3 April 2017.
Cuthbert, B.N., Schupp, H.T., Bradley, M.M., Birbaumer, N., Lang, P.J., 2000. Brain potentials in affective picture processing: covariation with autonomic arousal and affective report. Biol. Psychol. 52, 95–111.
Delorme, A., Makeig, S., 2004. EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics. J. Neurosci. Methods 134, 9–21.
DeWall, C.N., Maner, J.K., Rouby, D.A., 2009a. Social exclusion and early-stage interpersonal perception: selective attention to signs of acceptance. J. Pers. Soc. Psychol. 96, 729–741.
DeWall, C.N., Twenge, J.M., Gitter, S.A., Baumeister, R.F., 2009b. It's the thought that counts: the role of hostile cognition in shaping aggressive responses to social exclusion. J. Pers. Soc. Psychol. 96, 45–59.
Dodge, K.A., 1980. Social cognition and children's aggressive behaviors. Child Dev 51, 162–170.
Dodge, K.A., Lansford, J.E., Burks, V.S., Bates, J.E., Pettit, G.S., Fontaine, R., Price, J.M., 2003. Peer rejection and social information-processing factors in the development of aggressive behavior problems in children. Child Dev. 74, 374–393.
Dodge, K.A., Newman, J.P., 1981. Biased decision-making processes in aggressive boys. J. Abnorm. Psychol. 90, 375.
Dodge, K.A., Somberg, D.R., 1987. Hostile attributional biases among aggressive boys are exacerbated under conditions of threats to the self. Child Dev. 58, 213–224.
Dupéré, V., Lacourse, É., Willms, J.D., Vitaro, F., Tremblay, R.E., 2007. Affiliation to youth gangs during adolescence: the interaction between childhood psychopathic tendencies and neighborhood disadvantage. J. Abnorm. Child Psychol. 35, 1035–1045.
Eisenberger, N.I., Way, B.M., Taylor, S.E., Welch, W.T., Lieberman, M.D., 2007. Understanding genetic risk for aggression: clues from the brain's response to social exclusion. Biol. Psychiatry 61, 1100–1108.
Gillespie, S.M., Kongerslev, M.T., Sharp, C., Bo, S., Abu-Akel, A.M., 2018. Does affective theory of mind contribute to proactive aggression in boys with conduct problems and psychopathic tendencies? Child Psychiatry Hum. Dev. Advance online publication. doi:10.1007/s10578-018-0806-8.
Gretton, H.M., Hare, R.D., Catchpole, R.E., 2004. Psychopathy and offending from adolescence to adulthood: a 10-year follow-up. J. Consult. Clin. Psychol. 72, 636–645.
Gutz, L., Küpper, C., Renneberg, B., Niedeggen, M., 2011. Processing social participation: an event-related brain potential study. Neuroreport 22, 453–458.
Gutz, L., Renneberg, B., Roepke, S., Niedeggen, M., 2015. Neural processing of social participation in borderline personality disorder and social anxiety disorder. J. Abnorm. Psychol. 124, 421–431.
Hajcak, G., MacNamara, A., Olvet, D.M., 2010. Event-related potentials, emotion, and emotion regulation: an integrative review. Dev. Neuropsychol. 35, 129–155.
Hare, R.D., McPherson, L.M., 1984. Violent and aggressive behavior by criminal psychopaths. Int. J. Law Psychiatry 7, 35–50.
Hicks, B.M., Markon, K.E., Patrick, C.J., Krueger, R.F., Newman, J.P., 2004. Identifying psychopathy subtypes on the basis of personality structure. Psychol. Assess. 16, 276–288.
Karpman, B., 1948. The myth of the psychopathic personality. Am. J. Psychiatry 104, 523–534.
Kawamoto, T., Nittono, H., Ura, M., 2014. Social exclusion induces early-stage perceptual and behavioral changes in response to social cues. Soc. Neurosci. 9, 174–185.
Kimonis, E.R., Frick, P.J., Barry, C.T., 2004. Callous-unemotional traits and delinquent peer affiliation. J. Consult. Clin. Psychol. 72, 956–966.
Kimonis, E.R., Skeem, J.L., Cauffman, E., Dmitrieva, J., 2011. Are secondary variants of juvenile psychopathy more reactively violent and less psychosocially mature than primary variants? Law Hum. Behav. 35, 381–391.
Kruh, I.P., Frick, P.J., Clements, C.B., 2005. Historical and personality correlates to the violence patterns of juveniles tried as adults. Crim. Justice Behav. 32, 69–96.
Lansford, J.E., Malone, P.S., Dodge, K.A., Pettit, G.S., Bates, J.E., 2010. Developmental cascades of peer rejection, social information processing biases, and aggression during middle childhood. Dev. Psychopathol. 22, 593–602.
Larsson, H., Andershed, H., Lichtenstein, P., 2006. A genetic factor explains most of the variation in the psychopathic personality. J. Abnorm. Psychol. 115, 221–230.
Leary, M.R., Twenge, J.M., Quinlivan, E., 2006. Interpersonal rejection as a determinant of anger and aggression. Pers. Soc. Psychol. Rev. 10, 111–132.
Lessard, J., Greenberger, E., Chen, C., Farruggia, S., 2011. Are youths' feelings of entitlement always "bad"? Evidence for a distinction between exploitive and non-exploitive dimensions of entitlement. J. Adol. 34, 521–529.
Lissek, S., Pine, D.S., Grillon, C., 2006. The strong situation: A potential impediment to studying the psychobiology and pharmacology of anxiety disorders. Biol. Psychol. 72, 265–270.
Lochman, J.E., Dodge, K.A., 1998. Distorted perceptions in dyadic interactions of aggressive and nonaggressive boys: effects of prior expectations, context, and boys' age. Dev. Psychopathol. 10, 495–512.
Manning, W.G., Mullahy, J., 2001. Estimating log models: to transform or not to transform? J. Health Econ 20, 461–494.
Martin, E.A., Karcher, N.R., Bartholow, B.D., Siegle, G.J., Kerns, J.G., 2017. An electrophysiological investigation of emotional abnormalities in groups at risk for schizophrenia-spectrum personality disorders. Biol. Psychol. 124, 119–132.
McCollister, K.E., French, M.T., Fang, H., 2010. The cost of crime to society: New crime-specific estimates for policy and program evaluation. Drug Alcohol Depend. 108, 98–109.
McDonald, M.M., Donnellan, M.B., 2012. Is ostracism a strong situation? The influence of personality in reactions to rejection. J. Res. Pers. 46, 614–618.
Moor, B.G., Güroğlu, B., Op de Macks, Z.A., Rombouts, S.A., Van der Molen, M.W., Crone, E.A., 2012. Social exclusion and punishment of excluders: neural correlates and developmental trajectories. Neuroimage 59, 708–717.
Murrie, D.C., Cornell, D.G., Kaplan, S., McConville, D., Levy-Elkon, A., 2004. Psychopathy scores and violence among juvenile offenders: a multi-measure study. Behav. Sci. Law 22, 49–67.
Pardini, D., 2011. Perceptions of social conflicts among incarcerated adolescents with callous unemotional traits: 'You're going to pay. It's going to hurt, but I don't care. J. Child Psychol. Psychiatry 52, 248–255.
Pasalich, D.S., Dadds, M.R., Hawes, D.J., Brennan, J., 2012. Attachment and callous-unemotional traits in children with early-onset conduct problems. J. Child Psychol. Psychiatry 53, 838–845.
Patterson, C.M., Newman, J.P., 1993. Reflectivity and learning from aversive events: toward a psychological mechanism for the syndromes of disinhibition. Psychol. Rev. 100, 716–736.
Peake, S.J., Dishion, T.J., Stormshak, E.A., Moore, W.E., Pfeifer, J.H., 2013. Risk-taking and social exclusion in adolescence: neural mechanisms underlying peer influences on decision-making. Neuroimage 82, 23–34.
Poythress, N., Dembo, R., Wareham, J., Greenbaum, P.E., 2006. Construct validity of the Youth Psychopathic Traits Inventory (YPI) and the Antisocial Process Screening Device (APSD) with justice-involved adolescents. Crim. Justice Behav. 33, 26–55.
Poythress, N.G., Skeem, J.L., 2007. Disaggregating psychopathy: Where and how to look for subtypes. In: Patrick, C.J. (Ed.), The Handbook of Psychopathy. Guilford, New York, pp. 172–183.
Puetz, V.B., Viding, E., Palmer, A., Kelly, P.A., Lickley, R., Koutoufa, I., . . . , McCrory, E.J., 2016. Altered neural response to rejection-related words in children exposed to maltreatment. J. Child Psychol. Psychiatry 57, 1165–1173.

Raine, A., 1993. The Psychopathology of Crime: Criminal Behavior as a Clinical Disorder. Academic Press, San Diego.

Raine, A., Dodge, K., Loeber, R., Gatzke-Kopp, L., Lynam, D., Reynolds, C., Liu, J., 2006. The reactive–proactive aggression questionnaire: differential correlates of reactive and proactive aggression in adolescent boys. Aggress. Behav. 32, 159–171.

Reijntjes, A., Thomaes, S., Kamphuis, J.H., Bushman, B.J., de Castro, B.O., Telch, M.J., 2011. Explaining the paradoxical rejection-aggression link: The mediating effects of hostile intent attributions, anger, and decreases in state self-esteem on peer rejection-induced aggression in youth. Pers. Soc. Psychol. Bull. 37, 955–963.

Rietdijk, W.J.R., Franken, I.H.A., Thurik, A.R., 2014. Internal consistency of event related potentials associated with cognitive control: N2/P3 and ERN/Pe. PLoS One 9, e102672.

Ruchkin, D.S., Johnson, R., Grafman, J., Canoune, H., Ritter, W., 1992. Distinctions and similarities among working memory processes: an event-related potential study. Cogn. Brain Res. 1, 53–66.

Sadeh, N., Baskin-Sommers, A.R., 2016. Risky, Impulsive, and Self-Destructive Behavior Questionnaire (RISQ): a validation study. Assessment 24, 1080–1094.

Salekin, R.T., Rogers, R., Sewell, K.W., 1996. A review and meta-analysis of the psychopathy checklist and psychopathy checklist-revised: predictive validity of dangerousness. Clin. Psychol. Sci. Pract. 3, 203–215.

Schimmenti, A., Passanisi, A., Pace, U., Manzella, S., Di Carlo, G., Caretti, V., 2014. The relationship between attachment and psychopathy: a study with a sample of violent offenders. Curr. Psychol. 33, 256–270.

Schmitt, W.A., Brinkley, C.A., Newman, J.P., 1999. Testing Damasio's somatic marker hypothesis with psychopathic individuals: risk takers or risk averse? J. Abnorm. Psychol. 108, 538–543.

Schupp, H.T., Cuthbert, B.N., Bradley, M.M., Hillman, C.H., Hamm, A.O., Lang, P.J., 2004. Brain processes in emotional perception: motivated attention. Cogn. Emot. 18, 593–611.

Sebastian, C., Viding, E., Williams, K.D., Blakemore, S.J., 2010. Social brain development and the affective consequences of ostracism in adolescence. Brain Cogn. 72, 134–145.

Semlitsch, H.V., Anderer, P., Schuster, P., Presslich, O., 1986. A solution for reliable and valid reduction of ocular artifacts, applied to the P300 ERP. Psychophysiol 23, 695–703.

Serin, R.C., Amos, N.L., 1995. The role of psychopathy in the assessment of dangerousness. Int. J. Law Psychiatry 18, 231–238.

Sharp, C., Vanwoerden, S., 2013. Social cognition: empirical contribution: the developmental building blocks of psychopathic traits: revisiting the role of theory of mind. J. Pers. Disord. 28, 78–95.

Shaw, D.S., Hyde, L.W., Brennan, L.M., 2012. Early predictors of boys' antisocial trajectories. Dev. Psychopathol. 24, 871–888.

Sherman, E.D., Lynam, D.R., 2017. Psychopathy and low communion: an overlooked and underappreciated core feature. J. Pers. Disord. 8, 309–318.

Skeem, J.L., Cauffman, E., 2003. Views of the downward extension: comparing the youth version of the psychopathy checklist with the youth psychopathic traits inventory. Behav. Sci. Law 21, 737–770.

Sreekrishnan, A., Herrera, T.A., Wu, J., Borelli, J.L., White, L.O., Rutherford, H.J.V., . . . , Crowley, M.J., 2014. Kin rejection: social signals, neural response and perceived distress during social exclusion. Dev. Sci. 17, 1029–1041.

Strauss, G.P., Kappenman, E.S., Culbreth, A.J., Catalano, L.T., Ossenfort, K.L., Lee, B.G., Gold, J.M., 2015. Emotion regulation abnormalities in schizophrenia: Directed attention strategies fail to decrease the neurophysiological response to unpleasant stimuli. J. Abnorm. Psychol. 124, 288–301.

Svetieva, E., Zadro, L., Denson, T.F., Dale, E., O'Moore, K., Zheng, W.Y., 2016. Anger mediates the effect of ostracism on risk-taking. J. Risk Res. 19, 614–631.

Taubner, S., White, L.O., Zimmermann, J., Fonagy, P., Nolte, T., 2013. Attachment-related mentalization moderates the relationship between psychopathic traits and proactive aggression in adolescence. J. Abnorm. Child Psychol. 41, 929–938.

Ritter, D., Eslea, M., 2005. Hot sauce, toy guns, and graffiti: a critical account of current laboratory aggression paradigms. Aggress. Behav. 31, 407–419.

Tedeschi, J.T., Quigley, B.M., 1996. Limitations of laboratory paradigms for studying aggression. Aggress. Violent Behav. 1, 163–177.

Tull, M.T., Jakupcak, M., Paulson, A., Gratz, K.L., 2007. The role of emotional inexpressivity and experiential avoidance in the relationship between posttraumatic stress disorder symptom severity and aggressive behavior among men exposed to interpersonal violence. Anxiety Stress Coping 20, 337–351.

Twenge, J.M., Baumeister, R.F., DeWall, C.N., Ciarocco, N.J., Bartels, J.M., 2007. Social exclusion decreases prosocial behavior. J. Pers. Soc. Psychol 92, 56–66.

van Noordt, S.J.R., White, L.O., Wu, J., Mayes, L.C., Crowley, M.J., 2015. Social exclusion modulates event-related frontal theta and tracks ostracism distress in children. Neuroimage 118, 248–255.

Waller, R., Hyde, L.W., Baskin-Sommers, A.R., Olson, S.L., 2017. Interactions between callous unemotional behaviors and executive function in early childhood predict later aggression and lower peer-liking in late-childhood. J. Abnorm. Child Psychol. 45, 597–609.

Waters, H.R., Hyder, A.A., Rajkotia, Y., Basu, S., Butchart, A., 2005. The costs of interpersonal violence—An international review. Health Policy 73, 303–315.

White, L.O., Wu, J., Borelli, J.L., Rutherford, H.J., David, D.H., Kim-Cohen, J., …, Crowley, M.J., 2012. Attachment dismissal predicts frontal slow-wave ERPs during rejection by unfamiliar peers. Emotion 12, 690–700.

Wilkowski, B.M., Robinson, M.D., 2008. The cognitive basis of trait anger and reactive aggression: an integrative analysis. Pers. Soc. Psychol. Rev. 12, 3–21.

Wilkowski, B.M., Robinson, M.D., Gordon, R.D., Troop-Gordon, W., 2007. Tracking the evil eye: trait anger and selective attention within ambiguously hostile scenes. J. Res. Pers. 41, 650–666.

Will, G.J., Crone, E.A., van Lier, P.A., Güroğlu, B., 2016. Neural correlates of retaliatory and prosocial reactions to social exclusion: associations with chronic peer rejection. Dev. Cogn. Neurosci. 19, 288–297.

Williams, K.D., 2001. Ostracism: The power of Silence. Guilford, New York.

Williams, K.D., Cheung, C.K.T., Choi, W., 2000. CyberOstracism: Effects of being ignored over the Internet. J. Pers. Soc. Psychol. 79, 748–762.

Zachary, R.A., 1986. Shipley Institute of Living Scale: Revised Manual. Western Psychological Services, Los Angeles.

Zhang, Q., Li, X., Wang, K., Zhou, X., Dong, Y., Zhang, L., . . . , Yu, F., 2017. Dull to social acceptance rather than sensitivity to social ostracism in interpersonal interaction for depression: behavioral and electrophysiological evidence from Cyberball tasks. Frontiers Hum. Neurosci. 11, 162.

Zimmer-Gembeck, M.J., Nesdale, D., 2013. Anxious and angry rejection sensitivity, social withdrawal, and retribution in high and low ambiguous situations. J. Pers. 81, 29–38.

Zimmer-Gembeck, M.J., Nesdale, D., Webb, H.J., Khatibi, M., Downey, G., 2016. A longitudinal rejection sensitivity model of depression and aggression: Unique roles of anxiety, anger, blame, withdrawal and retribution. J. Abnorm. Child Psychol. 44, 1291–1307.