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The impact of social exclusion on anticipatory attentional processing

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Abstract

The importance of understanding how we anticipate and prepare for social rejection is underscored by the mental and physical toll of continual social vigilance. In this study, we investigate the impact of social rejection on anticipatory attentional processes using the well-known Cyberball task, a paradigm in which participants engage in a game of catch with virtual avatars who after an initial period of fair-play (inclusion condition) then exclude the participant from the game (exclusion condition). The degree of anticipatory attention allocated by subjects towards the avatars was assessed by measuring P3b responses towards the avatars' preparatory actions (i.e. the phase preceding their exclusionary actions) using high density EEG. The results of the study show that relative to the inclusion, participants exhibit elevated levels of anticipatory attentional allocation towards the avatars during the exclusion block. This shift was however significantly moderated by participants' self-reported cognitive regulation tendencies. Participants with higher levels of self-reported cognitive reappraisal tendencies showed larger anticipatory P3b increases from the inclusion to exclusion block relative to participants with reduced levels of reappraisal tendencies. These results highlight the impact of social exclusion on anticipatory neural processing and the moderating role of cognitive reappraisal on these effects.

Keywords

Social exclusion; Event-related potential; Electroencephalography; Cyberball; P300

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Conflicts of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijpsycho.2017.11.010.

1. Introduction

Social exclusion threatens a wide range of basic human needs (Buss, 1990; Williams, 2009b). Consequently, the experience of social rejection often sparks a cascade of psychological and physiological responses linked to numerous adverse mental and physical health outcomes. Social exclusion has been associated with a wide range of negative psychological outcomes including anxiety (Baumeister and Tice, 1990; Leary, 1990), depression (Marcus and Askari, 1999; Williams and Zadro, 2001) and cognitive impairment (Baumeister et al., 2002; Buelow et al., 2015). Social rejection and isolation have also been linked with the development of adverse health issues such as impaired immune system functioning (Kiecolt-Glaser et al., 1984), poor blood pressure regulation (Hawkley et al., 2003), reduced sleep efficiency levels (Cacioppo et al., 2002; Pereira et al., 2013), and even higher morbidity and mortality rates (Holt-Lunstad et al., 2015; House et al., 1988).

The adverse impact of social exclusion incentivizes high sensitivity in detecting potential social rejection. Many social processing frameworks such as the Need Threat Model of Ostracism (Williams, 1997) and Social Monitoring System Model (Pickett and Gardner, 2005) emphasize the role of anticipatory processes in responding to social exclusion. One key hypothesis from the Social Monitoring System model in particular is that social exclusion heightens sensitivity towards signals of potential exclusion in future interactions (Gardner et al., 2000; Pickett and Gardner, 2005; Pickett et al., 2004b). This prediction receives empirical support from a large body of research showing how exclusion-related experiences elevates future levels of rejection sensitivity (Böckler et al., 2014; Cacioppo et al., 2009; Garner et al., 2006; Kiat et al., 2017; Masten et al., 2012; see Romero-Canyas et al., 2010 for a review; Sleegers et al., 2017).

The importance of anticipatory activity in social processing is also highlighted in numerous neuroimaging studies. Research in this area has shown anticipatory neural activity towards social feedback and social stimuli to be linked with social anxiety disorders (Guyer et al., 2008; Heitmann et al., 2014; Mueller et al., 2008), social rejection sensitivity (Buckner et al., 2010; Powers et al., 2013; Rossignol et al., 2013; Van Der Molen et al., 2014) and chronic social isolation (Cacioppo et al., 2016; Qualter et al., 2013).

Anticipatory hypervigilance is linked with elevated levels of attention-related processing (Bogels and Mansell, 2004; Layden et al., 2017) and increased allocation of neural resources towards cognitive regulation (see Hofmann et al., 2012 for a review). Drawing on this body of work and research linking attentional biases towards negative social stimuli with cognitive reappraisal (Adam et al., 2014; Arndt and Fujiwara, 2012), it is likely that a significant portion of anticipatory activity towards potential exclusion is linked with reappraisal-related processes. Cognitive reappraisal, defined as the tendency to respond to (usually negative) emotion-eliciting situations by cognitively reconstruing them, is an antecedent-focused regulation strategy that occurs before the emotional response is generated (Gross and John, 2003; Paul et al., 2013). This antecedent-focused strategy stands in contrast to the response-focused strategy of emotional suppression in which affective reactions are actively inhibited. The anticipatory nature of cognitive reappraisal situates it well with regard to playing a key role in moderating anticipatory responses towards social exclusion.

In summary, a significant body of research supports the importance of assessing anticipatory processes that precede direct responses to social exclusion. While a single experience of social exclusion may lead to negative real-world consequences in and of itself, the anxiety and rumination associated with social hypervigilance may well have the greater weight in the long run. Research has shown links between social hypervigilance and negative health outcomes including poor sleep quality (Hicken et al., 2013), decreased arterial elasticity (Clark et al., 2006) and hypertension (Hicken et al., 2014). These far-reaching consequences underscore the importance of understanding the neural processes that underlie not only how we respond to, but also how we anticipate negative social outcomes.

1.1. The Cyberball task

The well-known “game of catch” Cyberball task (Williams et al., 2000), commonly used to assess direct social exclusion reactivity, has significant potential as a measure of anticipatory responses. In the Cyberball task, participants engage in a simulated ball tossing game, making and receiving ball passes from two or more on-screen virtual players. The Cyberball game typically consists of two separate trial blocks, an “inclusion” block and an “exclusion” one. During the inclusion block condition, the other avatars include the participant in the game for a set number of exchanges. In the exclusion block condition, after a brief inclusion period, the avatars start to substantially reduce the number of passes made to the player, often to the point of completely excluding the player from the game.

The Cyberball task has been behaviorally validated in a wide range of populations and contexts (Beekman et al., 2016; Boyes and French, 2009; Eisenberger et al., 2006; Gerber et al., 2017; Seidel et al., 2013; Wesselmann et al., 2012; Zadro et al., 2006). Research has shown that participants prefer to take a monetary loss than be excluded in the task (van Beest and Williams, 2006) and that even being explicitly told that the avatars are computer controlled fails to mitigate the task’s psychological impact (Zadro et al., 2004).

The Cyberball task has proven to be a valuable tool in investigating the neural mechanisms underlying how the brain processes and responds to direct social exclusion (see Wang et al., 2017 for a review). A large number of functional magnetic resonance imaging (fMRI) investigations, beginning with pioneering work by Eisenberger et al. (2003), have shown Cyberball exclusion to be associated with activation in the dorsal ACC (Eisenberger et al., 2003; Gonzalez et al., 2015; Kross et al., 2007; Slavich et al., 2010), subgenual/ventral ACC (Bolling et al., 2012; Karremans et al., 2011; Masten et al., 2009; Onoda et al., 2009; Sebastian et al., 2011; Somerville et al., 2006), posterior cingulate (Kross et al., 2007; Masten et al., 2009), insula (Eisenberger et al., 2003; Kross et al., 2007; Masten et al., 2009; Slavich et al., 2010) and various prefrontal regions (Kross et al., 2007; Masten et al., 2009; Sebastian et al., 2011).

Identifying the specific psychological processes reflected by these neural activations has however proven to be a challenge. Some researchers have proposed a social/physical pain overlap model in which exclusion-related Cyberball responses are seen associated with social pain processing, analogous to physical pain (Eisenberger, 2012; Eisenberger et al., 2006; Sleegers et al., 2017). Others however argue that these activations more likely represent a “saliency network” or the processing of expectation violations (Iannetti et al., 2013; Somerville et al., 2006). To shed additional light on these questions, researchers have focused on disentangling the time course of neural activity associated with processing outcomes on the Cyberball task. As a high degree of temporal resolution is required to disentangle this neural cascade, one of the most popular methods of choice in this line of research is the use of event-related brain potentials (ERPs) focused electroencephalography (EEG).

One of the most consistently implicated components of interest in these studies is the P300, a well-studied neural measure associated with attentional processing (Donchin, 1981). Most commonly, these studies focus on the P3b subcomponent of the P300 complex (Gutz et al., 2011; Kawamoto et al., 2010; Themanson et al., 2013; Themanson et al., 2015; Weschke and Niedeggen, 2013, 2015, 2016). The P3b is a parietally distributed positive ERP deflection typically peaking approximately 250–500 ms post-stimulus presentation (Duncan et al., 2009; Johnson and Donchin, 1980), with the specific time-window often varying as a function of the task (see Polich, 2007 for a review). The component is linked to processes associated with attentional allocation, discrepancy detection, expectancy violation and stimulus representation updating (Kiat and Cheadle, 2017; Linden, 2005; Nieuwenhuis et al., 2005; Nieuwenhuis et al., 2004; Sato et al., 2005; Yeung and Sanfey, 2004).

Of particular interest to the current study, the amplitude of the P3b response has repeatedly been shown to be positively related to the motivational significance of a stimulus (Nieuwenhuis et al., 2005; Polich, 2007; van der Veen et al., 2014). Studies have shown affectively arousing (e.g. Conroy and Polich, 2007; Cuthbert et al., 2000; see Hajcak et al., 2010 for a review) and self-relevant outcomes (Gray et al., 2004; Ninomiya et al., 1998; Turk et al., 2011; Zhou et al., 2010) to be consistently associated with elevated P3b responses.

In the context of Cyberball, researchers have focused on the P3b response towards (1) the player receiving the ball and (2) the player observing passes between the other avatars as a function of whether those events occur in the inclusion versus exclusion stage. P3b response to passes received by the player has been repeatedly shown to be more positive when they occur in the exclusion stage (Gutz et al., 2015; Weschke and Niedeggen, 2013, 2016). However, findings involving P3b differences between passes that do not include the player in the inclusion (i.e. “not-my-turn” passes) relative to exclusion condition have been less consistent. While some researchers have found evidence for elevated P3b responses towards exclusion-related passes relative to “not-my-turn” passes (Crowley et al., 2010; Themanson et al., 2013), others have found the reverse to be true (Gutz et al., 2011; Kawamoto et al., 2010; Weschke and Niedeggen, 2015).

One possible explanation for this apparent discrepancy is that multiple factors are likely to influence the P3b response. The first of these is the strength or saliency of the exclusion experience. For instance, Crowley et al. (2010) and Themanson et al. (2013) both employed Cyberball designs with a higher proportion of exclusion versus inclusion events during the exclusion stage (96% in Crowley et al., 2010, 100% in Themanson et al., 2013) relative to Gutz et al. (2011) and Weschke and Niedeggen (2015) (84% and 66% respectively). Thus in Crowley et al. (2010) and Themanson et al. (2013), the heightened motivational salience of total exclusion induced by the near absolute lack of inclusion events in the exclusion stage may have elevated attentional responses towards exclusionary outcomes.

Another possibility, given the influence of subjective probability on the P3b response (Johnson and Donchin, 1980), is that the abrupt transition from inclusion to exclusion in Crowley et al. (2010) and Themanson et al. (2013), relative to the partial exclusion manipulation in Gutz et al. (2011) and Weschke and Niedeggen (2015), led to an increase in the P3b response to exclusion outcomes driven by the strong violation of subjective expectancy. This interpretation, initially proposed by Somerville et al. (2006), is supported by work showing the P3b response to diminish over time within the Cyberball exclusion stage (Kawamoto et al., 2013; Themanson et al., 2013), as well as by manipulations of inclusion expectancy rates through increasing the number of avatars (Weschke and Niedeggen, 2015).

Taken in aggregate, these findings suggest that multiple factors have the potential to influence the P3b response to direct exclusion-related responses on the Cyberball task. Thus, in addition to having significant theoretical and real-world value, investigating anticipatory activity on the Cyberball task has the advantage of being less directly linked with expectancy violation and more cleanly associated with individual differences in levels of attention orientated towards anticipating potential social rejection.

1.2. Anticipatory activity and the Cyberball task

As previously noted, all prior Cyberball ERP investigations have focused on either (1) the neural response to the exclusion event itself (referenced from this point as the exclusion *phase* to differentiate it from the global Cyberball exclusion trial block), contrasting neural responses to passes made between the two avatars across the inclusion (i.e. “not-my-turn” tosses) and exclusion (i.e. “exclusion” tosses) blocks, or (2) on global differences in neural activity during the inclusion and exclusion blocks collapsing across all event types. To date however, to the best of our knowledge, no study has yet investigated differences in anticipatory activity (i.e. processing associated with monitoring avatars prior to their responses) within the inclusion and exclusion conditions of the Cyberball task. The distinction between anticipatory and direct exclusion phases is represented graphically in Fig. 1.

As shown in Fig. 1, Cyberball trials have a phase suitable for the assessment of anticipatory activity. Many studies already have the avatars hold on to the ball for a period of time at the start of each trial to make the task more realistic (Gutz et al., 2011; Gutz et al., 2015). Yet, to the best of our knowledge, no study has yet sought to assess differences in the level of attention oriented towards anticipatory phases of Cyberball trials as a function of the social conditions in which they occur (e.g. inclusion versus exclusion).

The current study aims to investigate differences in anticipatory-related activity on the Cyberball task across its inclusion versus exclusion blocks. As a high degree of temporal resolution is required in order to disentangle anticipatory from exclusion-related neural activity in the task, a dense-array ERP approach is utilized. The excellent temporal precision of this technique facilitates the dissociation of temporally contiguous events (Kiat et al., 2016), supporting the differentiation of exclusion-related anticipatory activity from subsequent direct exclusion-related reactions.

Building on prior Cyberball findings (Crowley et al., 2010; Gutz et al., 2011; Kawamoto et al., 2010; Themanson et al., 2013; Weschke and Niedeggen, 2015), this investigation focuses on the P3b response participants exhibit towards the virtual avatars as the avatars prepare to make their passes (i.e. anticipatory responses towards “not-my-turn” versus “exclusion” passes) utilizing an implementation of the Cyberball task with 100% exclusion in the exclusion block. In line with the work involving elevated P3b to intentional exclusion responses relative to “not my turn” responses (Crowley et al., 2010; Themanson et al., 2013), as well as skin conductance work involving the Cyberball by Kelly et al. (2012) which showed evidence of an increase in sustained arousal when participants were excluded during Cyberball, we anticipate observing a stronger anticipatory attentional response, as indexed by the P3b, during the exclusion relative to inclusion block.

Drawing on prior work linking anticipatory hypervigilance (see Hofmann et al., 2012 for a review) and attentional biases towards negative social stimuli with cognitive appraisal and control (Adam et al., 2014; Arndt and Fujiwara, 2012), we anticipate differences in the attentional response towards potential social exclusion to be significantly moderated by individual differences in cognitive reappraisal tendencies. To evaluate the specificity of the moderating influence of cognitive regulation on hypothesized changes in the anticipatory P3b response, as opposed to a general emotion regulation-related effect, we also assessed the moderating role of emotional suppression, an emotion regulation strategy focused on the suppression of affective responses (Gross and John, 2003). Emotional suppression is considered a late downstream response-focused strategy (Paul et al., 2013) which should not exert a strong moderating influence on anticipatory P3b responses during the anticipatory phases of exclusion outcome processing.

2. Material and methods

2.1. Participants

Twenty-five undergraduate psychology students (14 Female, Mean Age = 20.28, SD = 1.96), were recruited from a subject pool at a large public university for this study. All subjects had normal or corrected-to-normal vision and none of them were colorblind. Five participants were excluded from the analysis due to excessive noise and artifacts in their ongoing EEG, resulting in a final sample of twenty subjects (10 Female, Mean Age = 19.90, SD = 1.37), no other exclusion criteria were imposed. As part of the subject pool, participants were awarded course credit and $10.00. The Institutional Review Board of the University of Nebraska-Lincoln approved all study procedures and each participant gave written informed consent prior to participation.

2.2. Emotion Regulation Questionnaire (ERQ)

The ERQ is an extensively validated (e.g. Egloff et al., 2006; Goldin et al., 2008; Lamm et al., 2007) 10-item measure of emotion regulation strategies. Items are on a 7-point scale (1 = Strongly Disagree, 7 = Strongly Agree) from two independent subscales, Cognitive Reappraisal and Expressive Suppression (Gross and John, 2003). The 6-item Cognitive Reappraisal subscale focuses on assessing individual differences in the tendency to adopt a cognitive approach to resolving emotion-eliciting situations (e.g. “When I’m faced with a stressful situation, I make myself think about it in a way that helps me stay calm”) whereas the 4-item Expressive Suppression subscale focuses on inhibiting ongoing emotional behavior (e.g. “When I am feeling negative emotions, I make sure not to express them”). Scores on both subscales from the final subject sample showed good levels of internal consistency as indexed by Cronbach’s Alpha (α = 0.879 and 0.753 for Reappraisal and Suppression respectively).

2.3. Cyberball task

Cyberball is a virtual ball-tossing computer game designed to create the experience of social exclusion via participant interactions with two on-screen avatars. The standard version of the task has two separate blocks, an initial inclusion block and a subsequent exclusion one. At the start of the task participants were told that they had been assigned to the blue team and would be playing a ball-tossing game with members of a different colored team (Verbatim instructions: *Welcome to the study Blue Team member! For this part of the study, you will be playing a ball-tossing game with members of the Red Team*). This manipulation was implemented to reduce in-group versus out-group uncertainty present in the use of neutral avatars and to potentially increase the real-world validity of the situation, as sudden total exclusion by an out-group is more likely than by one’s in-group.

At the start of the inclusion block, one of the avatars passes the ball to the player who then makes a selection, via a buttonbox, to pass that ball to either one of the two avatars. In the initial inclusion block, upon receiving the ball the selected avatar would then either (1) pass the ball directly back to the player (50% chance), (2) pass the ball to the second avatar who would then pass the ball directly back to the player (40% chance) or (3) pass the ball to the second avatar who would then pass the ball back to the first avatar who would then pass the ball directly back to the player (10% chance). This sequence of events was repeated for a total of 40 passes, 26 of which were target trials which involved the player monitoring another avatar.

After these 40 exchanges had accrued, the exclusion block began after a 10 s rest break. In this block, the first 8 passes proceeded in the same manner as in the preceding inclusion block after which the exclusion trials began. After this point the avatars ceased passing the ball to the player and proceeded to pass the ball back and forth between themselves, never passing the ball to the player, until a total of 24 passes had been made. At this point the participant was told that the task had been completed. The decision to use a limited number of trials was motivated by prior work showing the Cyberball P300 effect to diminish fairly rapidly within the exclusionary block (Themanson et al., 2013).

A visual representation of a single trial of the Cyberball task is presented in Fig. 1. The hand at the bottom of the screen represented the participant in this game alongside the two virtual avatars. The visual representation of the passes was implemented via a series of 8 static screens (see Themanson et al., 2013), each of which was displayed on screen for 250 ms save for the target screen, during which the avatar was preparing to make its throw, which was presented on-screen for 1000 ms. All stimuli were presented using E-Prime 2.0 with ERPs time-locked to the onset of the first slide, beginning 200 ms before onset and continuous for 1000 ms thereafter.

2.4. Procedure

Participants provided informed consent and completed an online questionnaire prior to the EEG session, which included a simple demographics questionnaire and the ERQ scale. During the EEG session, all participants were tested individually in the session with one experimenter monitoring the participant for possible movement artifacts and a second experimenter monitoring the real-time EEG waveforms. Upon arriving at the lab and after providing informed consent for the laboratory portion of the experiment, participants were seated in a dark sound attenuated room facing a 17-inch computer monitor adjusted to be 1-meter from the midline of their faces. The participants were then fitted with the high-density EEG electrode net and were informed that they would be playing a game of catch involving a ball with two virtual avatars.

2.5. EEG collection procedure

EEG data was recorded using a 256 high-density AgCl electrode Hydrocel Geodesic Sensor Net connected to a high-input impedance NetAmps 300 amplifier (Electrical Geodesics Inc.; EGI, Eugene, OR) using Netstation version 4.4.2. Recordings were collected using a vertex reference (Cz). Electrode impedances were below 60 kΩ, a level appropriate for the high impedance system used. The EEG data was digitized at 250 Hz from the DC to 500 Hz range with a 24-bit analog-to-digital converter.

2.6. EEG preprocessing

The continuous EEG data was first digitally filtered using a 0.1 Hz first order high-pass and 30 Hz low-pass filter. The continuous data was then down sampled to 250 Hz and segmented to the ERP marker points of interest (see Fig. 1). Segmentation was locked to the onset of the first feedback slide, beginning 200 ms before onset and continuous for 1000 ms thereafter. Segments were then baseline corrected using the 200 ms prestimulus average. Ocular artifacts were reduced via decomposing the data into basic topography components using Delorme and Makeig's (2004) *runica* routine and removing components with correlations > 0.90 with a blink template created via averaging 200 blinks from open eye resting state data recorded from 40 subjects from a separate study (each subject contributing 5 blinks) using an identical system setup.

After the artifact reduction process, bad channels were then identified and interpolated in the segments using the ERP PCA Toolkit's preprocessing functions. Bad channels were identified across the entire session via poor overall correlation ($r < 0.60$) between neighboring channels and identified within each segment via either unusually high differences between an electrode's average voltage and that of their neighbors (> 30 μV) or as extreme voltage differences within the electrode (> 80 μV min to max). A channel was also marked as bad for the entire session if > 20% of its segments were classified as bad. All identified bad channels were replaced using whole head spline interpolation. After the bad channels were identified and interpolated, trials which had > 8% of their channels interpolated were removed from the analysis set.

The retained preprocessed ERPs were categorized into anticipatory responses to throws made during the inclusion (M = 23.80, SD = 0.41, Range = 23–24) and exclusion periods (M = 25.55, SD = 1.05, Range = 22–26). These trial numbers have been shown to be sufficient for reliable measurement of the P300 component (Cohen and Polich, 1997; Rietdijk et al., 2014).

3. Results

3.1. ERP results

Drawing on prior P3b focused Cyberball investigations (Gutz et al., 2011; Kawamoto et al., 2010; Weschke and Niedeggen, 2015), the amplitude of the P300 was quantified as the average amplitude in a Pz focused electrode cluster in the 300–600 ms post-stimulus onset time-window. Fig. 2a through c presents the selected electrode cluster, associated waveforms by task block, observed scalp topographies and corresponding dipole solution (for the exclusion response) at the amplitude of the peak time-point (372 ms) in the selected time-window.

The effect of trial block on observed anticipatory P3b voltages was modeled using a linear mixed effects model with robust standard errors. As shown in Fig. 2b, anticipatory P3b responses to throws made during the exclusion block were significantly more positive relative to the P3b response towards throws during the inclusion block (MD = 0.470 μV, SE = 0.192 μV), F(1,19) = 5.99, $p = 0.024$, $R^2 = 0.19$.

The moderating influence of cognitive reappraisal on this main effect was then assessed by centering and adding subject total cognitive reappraisal and suppression scores to the model as fully interacting continuous variables. In this model, the main effect of trial block remained significant in the same direction as in the prior model (MD = 0.628 μV, SE = 0.174 μV), F(1,16) = 13.10, $p = 0.002$. While emotional suppression levels did not significantly moderate anticipatory P3b levels in either the inclusion (F(1,16) = 0.15, $p = 0.701$) or exclusion (F(1,16) < 0.01, $p = 0.988$) blocks, cognitive reappraisal was shown to be a significant moderator (overall $R^2 = 0.14$). As shown in Fig. 3, the direction of the moderation effect was such that higher levels of cognitive appraisal were associated with increased P3b responses in the exclusion block (F(1,16) = 6.61, $p = 0.020$) but not in the inclusion one (F(1,16) = 0.37, $p = 0.552$). A potential outlier was noted amongst the P3b responses in the inclusion block, removal of this outlier did however not substantively impact any of the observed effects or statistical significance levels (see Supplementary Section A).

While cognitive reappraisal scores were modeled in their original continuous form, for visual representation of the EEG waveforms a median split was used to divide the sample into high and low reappraisal groups. The average waveforms on the same electrode cluster used in the main waveform contrast are shown in Fig. 2e and f alongside group average scalp topographies at the 372 ms time point.

3.2. Source localization results

Source localization of the neural sources of the observed P3b component was conducted by fitting a pair of hemispheric dipoles (mirrored in position but not orientation) for the scalp topography of anticipatory responses in the exclusion condition at the 372 ms mark in Oostenveld et al.'s (2011) Fieldtrip using a four-shell model. A grid scan first produced a rough estimate of the best starting position after an iterative algorithm identified the position of maximum fit using maximum-likelihood (Lütkenhöner, 1998). As indicated by the red marker in Fig. 2c, the source localization solution identified the parahippocampal gyrus (Talairach coordinates: X = −25, Y = −24, Z = −8) as the most likely neural generator source for this component with the solution exhibiting a good level of fit (Residual Variance = 17.88%).

4. Discussion

Social rejection is a psychologically painful aspect of life. As a result, over the course of our lives, most of us learn to anticipate and prepare for such events. The current study presents evidence of how social exclusion selectively elevates anticipatory attentional levels towards potential exclusion outcomes as a function of cognitive reappraisal tendencies. By analyzing ERP responses to preparatory actions during the Cyberball paradigm, the results of this study show evidence of increased attentional processing, as indexed by the P3b, in anticipatory responses during social exclusion relative to inclusion on the Cyberball task. In support of our hypothesis that this shift is associated with cognitive reappraisal-related processing, differences in the P3b level between the two conditions was significantly moderated by participants' self-reported cognitive reappraisal levels. To the best of our knowledge, these findings are the first to directly link individual differences in cognitive reappraisal to attentional responses related to social exclusion. These results are in line with ERP investigations by Crowley et al. (2010) and Themanson et al. (2013) that both showed an increased in attentional response as indexed by the P3b towards exclusion outcomes to be elevated relative to "not-my-turn" exclusion outcomes. The findings presented here also extend this prior work by showing that social exclusion-related increases in attentional responding extend beyond the direct social exclusion experience to encompass anticipatory stages of processing.

The absence of a moderation effect involving self-reported emotional suppression levels with regard to the observed anticipatory attentional shift suggests that this effect is not reflective of a nonspecific global emotional regulation response or affective suppression in general. Instead, in line with prior work in this area (Kiat et al., 2017; Themanson et al., 2014; Themanson et al., 2015; Xu et al., 2016), these findings suggest that social exclusion exposure leads to a rise in attentional monitoring associated with cognitive appraisal and control. This interpretation is in line with research showing elevated P3b responses as a function of increases in the motivational significance (Nieuwenhuis et al., 2005; Polich, 2007; van der Veen et al., 2014) and personal relevance (Gray et al., 2004; Ninomiya et al., 1998; Turk et al., 2011; Zhou et al., 2010) of presented information as both these factors are elevated in the context of social exclusion (Pickett and Gardner, 2005; Pickett et al., 2004a; Pickett et al., 2004b).

The source localization of the observed P3b component to the parahippocampal gyrus lends additional support to the proposed psychological processes underlying the observed shift in the component. Bilateral activation of this area has been previously noted in response to social exclusion on the Cyberball (Bolling et al., 2011; Slavich et al., 2010) and other social rejection-related paradigms (Premkumar, 2012). Of particular interest, research has shown increased Cyberball exclusion-related activation in this region to be associated with stronger inflammatory responses to other real world social stressors (Slavich et al., 2010), which is intriguing given known links between social hypervigilance and negative health outcomes (Clark et al., 2006; Hicken et al., 2013; Hicken et al., 2014). Further strengthening the link between activation in this region and social processing, research has also shown increased activation in the region in response to the evaluation of social rejection cues (Sebastian et al., 2010; Woo et al., 2014), social hierarchy linked encoding (Zink et al., 2008), empathic evaluation (Kiat and Cheadle, 2017), and uncertainty processing (Bhatt et al., 2012; Zhang et al., 2016).

The potential value of the Cyberball task with regard to the assessment of social rejection anticipation highlights this highly relevant, yet neglected, aspect of social exclusion.

The observed shift in anticipatory attentional processing induced by social exclusion supports a multi-stage view of the processes underlying the Cyberball task which incorporates both anticipatory and reactionary responses. This distinction is in line with the frameworks of the Need Threat Model of Ostracism (Williams, 1997) and Social Monitoring System model (Pickett and Gardner, 2005), as well as research showing increased vigilance towards social cues (Pickett and Gardner, 2005; Pickett et al., 2004a; Pickett et al., 2004b) and potential exclusion outcomes (Böckler et al., 2014; Cacioppo et al., 2009; Garner et al., 2006; Sleegers et al., 2017) as a result of direct social rejection experiences.

The importance of assessing anticipatory responses is underscored by well-established links between social rejection anticipation and a wide range of negative social outcomes including social anxiety disorders (Guyer et al., 2008; Heitmann et al., 2014; Mueller et al., 2008), chronic social isolation (Cacioppo et al., 2016; Qualter et al., 2013), and the undermining of intimate relationships (Downey and Feldman, 1996). It is particularly interesting to note that rejection anticipation has been experimentally linked with biases in perceiving social rejection in relatively ambiguous behavior as well as elevated real-world readiness towards perceiving intentional rejection in the actions of intimate partners (Downey and Feldman, 1996). These negative behavioral patterns have the potential to give rise to pernicious self-fulfilling feedback loops (Riva, 2016; Williams, 2009a), likely contributing to links between social rejection and wide range of negative psychological and physiological outcomes. These include enhanced reactivity towards future negative social outcomes (Will et al., 2016), elevated rates of interpersonal aggression (DeWall et al., 2009), and increased levels of social anxiety (Baumeister and Tice, 1990; Leary, 1990). A deeper understanding of the processes which driving the elevation of anticipatory responses towards social rejection, such as cognitive reappraisal, potentially sheds light on the formation and reinforcement of real-world rejection sensitivity.

These findings also lend support to the idea of elevated saliency-related processing with regard to social rejection-related processing (Masten et al., 2009; Schmälzle et al., 2017; Wagels et al., 2017). This is in line with prior work showing increases in attentional responses towards outcomes on the Cyberball and other social exclusion-related tasks as a function of social exclusion (Kiat et al., 2017; Themanson et al., 2014; Themanson et al., 2015; Xu et al., 2016). These results also contribute to the discussion on the role of unexpectedness in the Cyberball effect (Somerville et al., 2006; Weschke and Niedeggen, 2015, 2016). Our findings indicate that while unexpectedness may be one of the factors motivating shifts in attentional processing from the inclusion to exclusion block, there is likely more to the underlying narrative than a basic oddball effect. It is important to emphasize that given the aspects of neural activity and the processing phase focused on in this study, the link between Cyberball (Eisenberger, 2012; Eisenberger et al., 2006; Sleegers et al., 2017) and the inducement of neural activity associated with the experience of social pain is likely to be less directly assessed in this study. Such responses are likely best assessed by deconstructing responses to the actual exclusion experience.

It is interesting however to consider the possibility that the observed results may be driven by cognitive reappraisal being potentially linked with generally higher levels of reactivity. While, to the best of our knowledge, no prior study has assessed individual differences in general neural reactivity and cognitive reappraisal, several researchers have assessed links between reactivity to a range of stress-related outcomes and this behavioral measure. Findings in this area have generally shown self-reported cognitive reappraisal to be unrelated (de Veld et al., 2012; Shapero et al., 2016) or negatively linked (Carlson et al., 2012; Carlson and Mujica-Parodi, 2010; Egloff et al., 2006; Mauss et al., 2007) with reactivity and anxiety (though see also Lam et al., 2009). These studies indicate that a general reactivity explanation for the results presented here have relatively limited support. Furthermore, the within-subjects nature of the inclusion versus exclusion block contrast indicates that generally higher levels of reactivity towards social outcomes in general cannot account for the pattern of observed results.

While this study makes important contributions to our understanding of the anticipatory processes underlying social exclusion-related processing, it is not without limitations. Given the relatively small sample size, replication with larger samples, particularly with regard to the intriguing moderation of the P3b effect by cognitive reappraisal tendencies. Also, as the aim of this investigation was to assess anticipatory processing, the design we utilized did not contain sufficient trials to contrast “not-my-turn” and exclusion based responses. It may however be of interest to assess possible differences with regard to those reactionary responses and the anticipatory reactions identified in the current study. In particular, assessing differences in incremental predictive value between these responses with regard to real world outcomes would likely be of considerable value. Despite these limitations however, these results lay important groundwork and justification for continued exploration of the anticipatory processes underlying social exclusion.

In line with the observed moderating role of cognitive reappraisal, it may be of interest for these future investigations to consider the impact of real-world experiences, such as prior experiences of bullying and other forms of social ostracism, with regard to individual differences in anticipatory responses towards social exclusion on the Cyberball task. A deeper understanding of these factors is especially important given the potential for social rejection expectations to impact future social interactions and give rise to undesirable positive feedback loops (Riva, 2016; Williams, 2009a). It may also be of interest to assess if anticipatory P3b responses on the Cyberball task show similar patterns of reduction as those observed with regard to direct exclusion-related P3bs (Kawamoto et al., 2013; Themanson et al., 2013). Such findings could potentially shed light on issues regarding the relative roles of probability and saliency in the Cyberball task.

5. Conclusion

This study shows that anticipatory responses on the Cyberball task, as indexed by the P3b, are impacted by social exclusion exposure at processing phases that precede the direct exclusion phase itself. Furthermore, our results present evidence to suggest that this shift in attentional processing is driven by cognitive reappraisal and/or evaluation. The novel analytic perspective utilized in this study and the demonstrated link between anticipatory neural responses and social measures expand the value of the Cyberball paradigm, demonstrating its capability to assess preparatory reactions towards potential social exclusion. Given links between anticipatory social processing and real-world outcomes, these results lay the groundwork for many interesting directions for continued research into the impact of social exclusion and ostracism.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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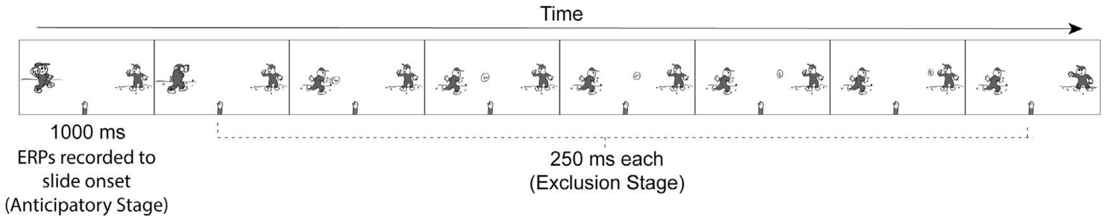

Fig. 1.
Graphical depiction of a single trial presentation structure and screen duration timings of the Cyberball task utilized in this study.

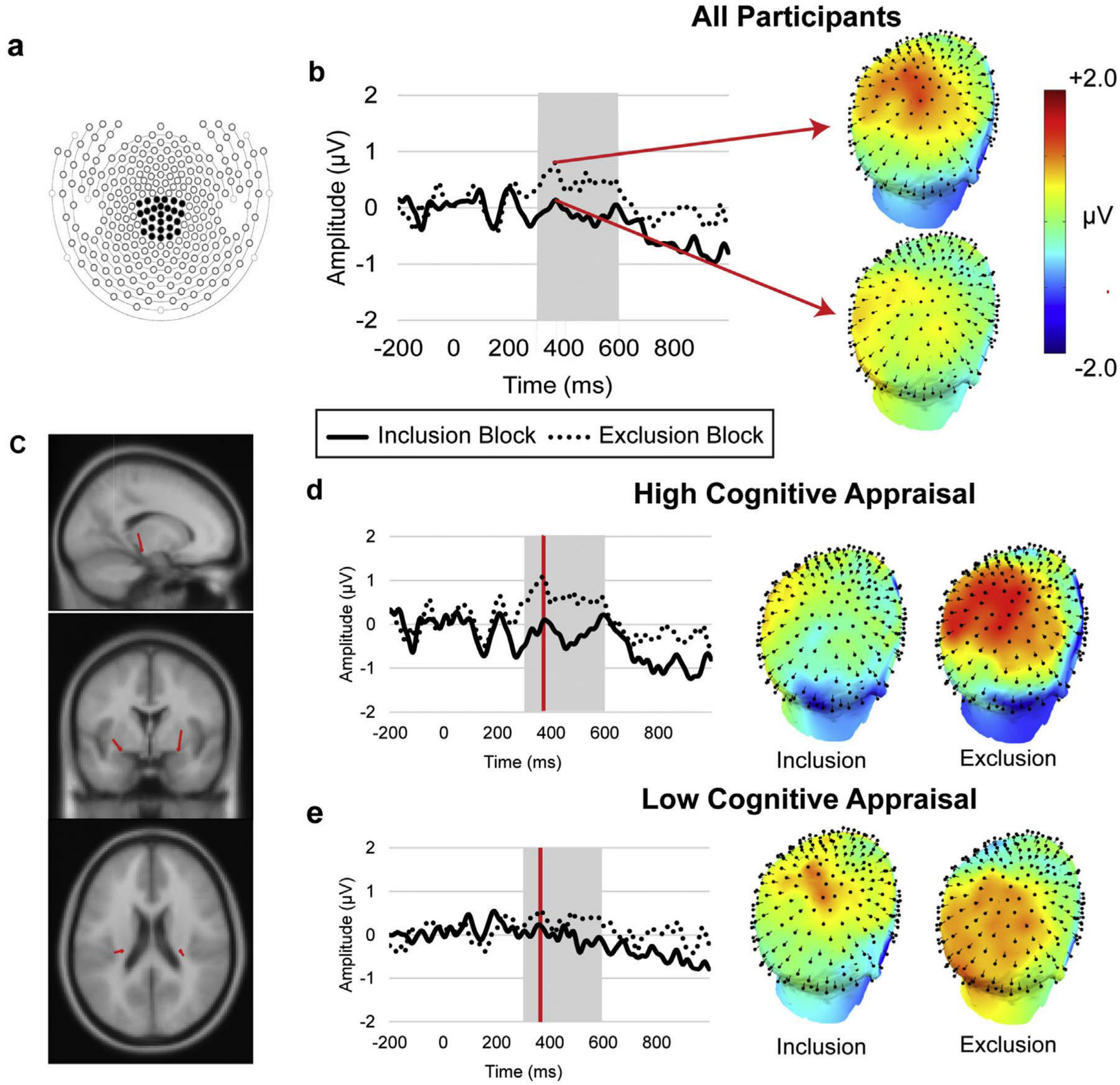

Fig. 2.

Anticipatory Cyberball P3b effect. (a) Pz electrode cluster. (b) Grand average waveforms for all participants on the Pz electrode cluster by task block with the 300–600 ms time window highlighted alongside scalp topographies at the maximum amplitude point (372 ms) of the highlighted time window. (c) Dipole solution for the topography of the exclusion blocks response at 372 ms presented in sagittal, coronal and axial view. (d) Waveforms and topographies of Fig. 2b for participants ($N = 11$) with cognitive reappraisal scores above the median. (e) Waveforms and topographies of Fig. 2b for participants with cognitive reappraisal scores below the median ($N = 9$).

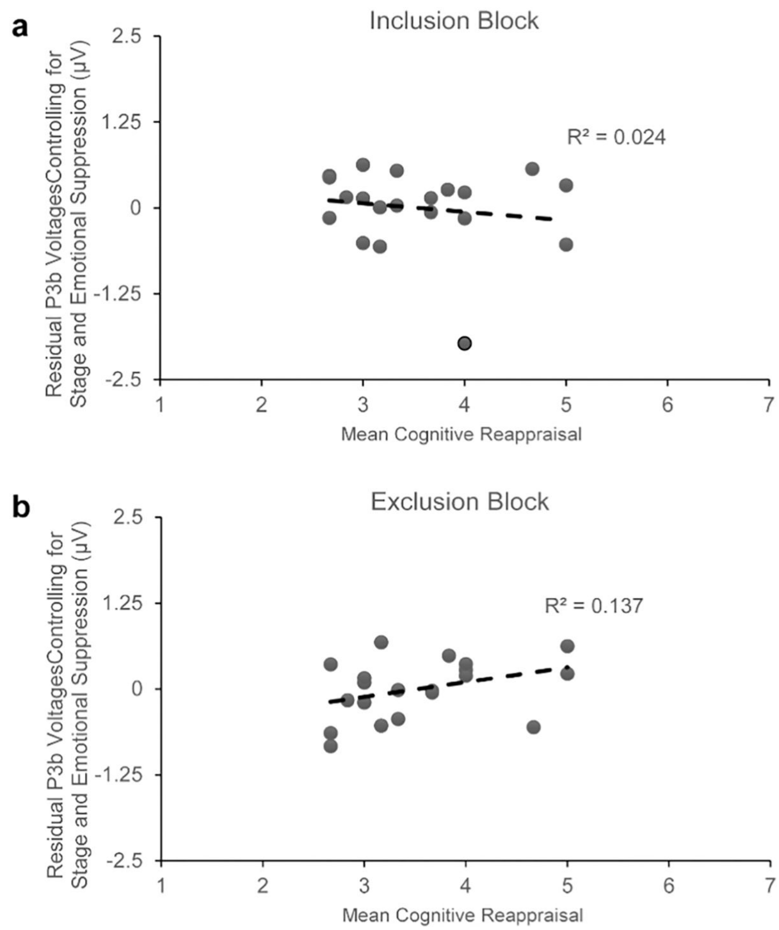

Fig. 3.

Partial correlations between cognitive reappraisal and anticipatory P3b responses in the (a) inclusion and (b) exclusion blocks.