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Abstract

Social exclusion has been brought to the forefront of media attention in recent years due to the recent tragedies like campus shootings and cyberbullying on social networking websites. In order to gain a deeper understanding of social exclusion, this study examined the relation between social exclusion and event-related brain potential (ERP) activity. ERPs were collected while participants completed three blocks of the Cyberball paradigm during which they experienced situations of social inclusion, exclusion, and re-inclusion. This well-established paradigm mimics actual social behavior experienced in real-world situations. Results showed larger N2 and smaller P3 amplitudes during throws where participants were excluded compared to when they were included, regardless of the interaction's overall context (inclusion, exclusion, re-inclusion), suggesting the conflict-driven "neural alarm" and the allocation of attention are determined more by specific events within the interaction rather than the larger context of the social exchange. Further, during the exclusionary interaction, both the N2 and P3 showed larger amplitudes in the earlier stages of exclusion compared to the later stages, suggesting heightened early sensitivity for both components, and P3 amplitude was larger to exclusionary events compared to the two inclusionary interactions, indicating a contextual influence of exclusion. These findings suggest that discrete events occurring during a social interaction may provide additional insights into social exclusion compared to more global "inclusionary" or "exclusionary" classifications of social interactions.

Neural Activity During Social Task Performance: An Exploratory Examination

Human beings, by nature, are social creatures (Williams, Forgas, von Hippel, & Zadro, 2005). As such, we have evolved to rely on our many complex social relationships as a means to our survival. While these relationships can foster in us the sentiments of friendship, connection, belongingness, love, and even survival, the smallest strains in our social relationships can cause us to feel ostracized (Williams et al., 2005). Given the complexity and number of social interactions we encounter on a daily basis, we are susceptible to social exclusion in many different forms. Social exclusion refers to not being included in a social interaction. We may act as perpetrators and give someone the cold shoulder, end a romantic relationship, or distance ourselves from other individuals (Leary, Kowalski, Smith, & Phillips, 2003). We also find ourselves as victims of this exclusion. Other people may avoid our eye contact, fail to return our emails, or choose not to invite us to social gatherings. Regardless of intention, all of these actions have the potential to elicit a sense of distress in the recipient (Wesselmann, Bagg, & Williams, 2009). In a study conducted in Australia, participants reported experiencing social exclusion in some form at least once a day (Williams, Wheeler, & Harvey, 2001; as cited in Williams, 2007). Cross cultural research demonstrates that social exclusion is experienced by everyone in varying degrees, making it important to study the negative outcomes it causes in our lives. Recent research has suggested that social exclusion leads to psychological distress, negative affect, and is one of the greatest predictors for future aggression (Leary et al., 2003). Current research has suggested that humans possess a fast-acting detection system for exclusion which allows individuals to prevent future social rejections (Wesselmann, Bagg, & Williams, 2009). In order to further understand the degree to which the brain processes acts of exclusion, as well as methods of combating its aversive effects, this study explores the effects of social

exclusion by examining event-related brain potentials (ERPs) associated with social exclusion.

Notably, much prior research in this domain has relied primarily on either self-report or functional magnetic resonance imaging (fMRI) measures as a means to collect data. While both of these methods are useful, self-report data are limited as they only allow for the examination of behaviors and feelings of the participant. Meanwhile, fMRI data only allow for examination of specific brain areas after exclusion occurs and does not have the temporal sensitivity to monitor moment-to-moment events within a social interaction. ERP analysis allows us to obtain more precise information about the exact time course of neural events related to exclusion. These millisecond-to-millisecond recordings allow us to examine minute changes in brain activity as they are occurring. To better understand the relationship between social exclusion and neuroelectric activity, it is necessary to examine existing literature on the social nature of humans, the detrimental effects of social exclusion, and current social monitoring theories. First, an overview of the evolution of humans as social creatures will be provided to establish why social inclusion is vital to survival. Second, the detrimental effects of social exclusion will be discussed to establish how social exclusion is damaging to behavioral, physical, and psychological functioning. Next, the current theoretical models of social monitoring processes will be introduced to provide a background for detection of social exclusion and the neural activity involved in these processes. Lastly, recent studies will be reviewed in order to demonstrate the gaps in our understanding of these neural processes and provide justification for the study currently being proposed.

Humans as Social Animals

According to Williams, Forgas, Von Hippel, & Zadro (2005), a primitive need for social inclusion led to the development of an innate system, involving cognitive, behavioral, and

emotional processes, so that humans would be better equipped to recognize social rejection.

Since the beginning of time, humans have been living as social creatures. It was necessary for

primitive beings to communicate and socialize in order to survive. As a member of one of these

primitive social groups, humans were able to collaborate in order to fulfill their most basic needs

of livelihood (Williams et al., 2005). By working together to protect themselves from predators,

construct shelter, find means to sustenance, and various other activities, they were able to ensure

their lengthened vitality as well as a heightened quality of life (Lakin & Chartrand, 2005).

Living without group membership benefits would be extremely costly (Williams et al., 2005).

According to Gruter and Masters (1986), exclusion of a social creature equated to death (as cited

in Williams, 2007). The immense vulnerability to the elements and attack of animals or other

savage beings warranted association with others as a means of protection (Williams et al., 2005).

Increased association with other beings was also helpful in procuring sustenance. Having more

hunters and gatherers in a society equaled a higher probability of finding food (Williams et al.,

2005). In order to maintain their membership status, humans learned to sacrifice their own needs

for collective group needs (Baumeister & DeWall, 2005). Rejection from this social group

would have led to the ostracized person's demise (Williams et al., 2005).

     One of the most devastating features of rejection is that it prevents excluded individuals

from pursuing their innate drive to procreate (Williams et al., 2005). This most basic of instincts

requires that humans form a bond with at least one member of the opposite sex in order to

continue their clan and race as a whole. Smith and colleagues (2003) conducted a study of the

Meriam tribe of the island Mer in which they found that the more successful hunters of the tribe

achieved higher reproductive success (Smith, Bird, & Bird, 2003). This success included an

earlier onset of reproduction, higher quality reproductive mates, and an overall increased average

number of mates (Smith et al., 2003). Because these hunters were more socially accepted than other less successful tribesmen, they received heightened reproductive and social benefits (Smith et al., 2003).

Though interpersonal relationships may have roots in procreation and survival of the species, the relationships between humans have become increasingly complex over time. As our means of communication, intelligence, and technology evolved, so have our social relationships (Williams et al., 2005). These novel means allow us to rely less directly on others for survival. These new relationships have made living more efficient but also complex due to our indirect relationships with others (Williams et al., 2005). Through the diversification of labors and advances in technology, we are permitted to become specialized in our jobs. For example, inhabitants of industrialized nations rarely resort to hunting as a primary means of providing nourishment for our families. Instead, we rely on some distant cattle farmer to raise and subsequently kill our meat for us. After the meat has been cleaned and rendered ready for cooking, we go to the butcher and buy this meat for a modest sum. This extremely complex cascade of events can also be applied to many other routine activities in modern society.

Despite this diversification of societal roles and duties, there still exists a great potential for social exclusion (Williams et al., 2005). Cyberbullying, defined as aggressive behavior or intentional harm-causing behavior taking place in cyberspace, is one phenomenon that has gained more recent attention (Huang & Chou, 2010). This form of bullying can occur in an even more powerful way than physical schoolhouse bullying (Huang & Chou, 2010). While victims of physical bullying are able to walk away from most harmful situations, cyberbullying is quicker, inescapable, and irrepressible; leaving its victims with emotional damage (Huang & Chou, 2010).

Detrimental Effects of Social Exclusion

      Behavioral Effects. In recent years, there has been an increased need to understand which individuals are susceptible to the harmful effects of social exclusion as well as why social exclusion produces such harmful effects (Huang & Chou, 2010). Most notoriously, the wave of campus shootings and other acts of violence have been vivid causes for public alarm (Gaertner & Iuzzini, 2005). After case study examination, researchers identified a significant correlation between social exclusion and these acts of aggression (Gaertner & Iuzzini, 2005). One newspaper reporting on the Columbine High School shootings revealed that the perpetrators of the shootings, "uniformly have felt like outsiders taunted by peers" (Peterson, 1999; as cited in Leary et al., 2003). In examination of 15 of these violent crimes, it was discovered that 12 of the perpetrators had previously endured extreme chronic social exclusion from peers, including malicious bullying, teasing, and taunting (Leary et al., 2003). While the victims of these attacks varied in number from one through several hundred, it has been hypothesized that the aggressors attacked the people perceived to be to be sources of the aggressor's feelings of rejection (Gaertner & Iuzzini, 2005).

      Researchers have attempted to determine the behavioral effects of social rejection by simulating real-world situations in the laboratory (Catanese & Tice, 2005). This allows for the empirical investigation of the effects of negative social behaviors in a less aversive and more controlled manner. In a study conducted by Catanese and Tice (2005), participants were randomly assigned to receive one of three false predictions about their future companionship based on their degree of extraversion measured in the personality inventory. They were either told that they would spend their future without stable relationships (the "future alone" condition), that they would endure many lasting and fulfilling relationships (the "future belong" condition),

or that they would likely encounter various physical maladies (the "misfortune control" condition) (Catanese & Tice, 2005). The researchers hypothesized that participants in the "future alone" condition would criticize another person much more aggressively and detrimentally than in the other conditions. The results of this study supported the hypotheses, and demonstrated that those participants who were assigned to both the "future alone" and negative feedback conditions delivered the most negative evaluations of others, more so than those who had received negative feedback alone (Catanese & Tice, 2005). This is just one of many studies demonstrating the correlation between social rejection and adverse behavior.

Physical Effects. Experiences of social exclusion have also been correlated with diminished physical health. Some who suffer from social exclusion possess an increased risk of cardiomyopathy, decreased regulation of blood pressure, and inability to sleep sufficiently (Pickett & Gardener, 2005). Others have suggested social exclusion contributes to immune system deficiencies in addition to other maladies, so much so that it rivals the deleterious effects of the more notorious culprits like smoking and diabetes (Gardener, Pickett, & Knowles, 2005). In fact, recent research has demonstrated that social pain, like physical pain, can be reduced with acetaminophen (DeWall, MacDonald, Webster, Masten, Baumeister, Powell, Combs, Schurtz, Stillman, Tice, & Eisenberger, 2010). Due to the overlap of underlying neural systems of social and physical pain, it is apparent that social exclusion has a strong impact on multiple systems (DeWall et al., 2010).

Psychological Effects. In addition to physical impairments, social exclusion has been shown to cause, and to be related with, psychological impairments. Elevated sensitivity to social rejection is generally associated with depression, hostility, and social stress (Gardner, Pickett, & Knowles, 2005). When the exclusion occurs for an extended duration of time, these adverse

effects are especially evident. Anxiety, negative affect, and lessened self-esteem have also

proven to be destructive states associated with social exclusion (Pickett & Gardener, 2005). This

emotional distress may cause the individual to suffer short-term cognitive impairment

(Baumeister & DeWall, 2005). These dangerous emotional states may also lead to affiliative

behavioral alterations, causing the person to make riskier and more dangerous decisions in order

to regain admission to a social group and alleviate their psychological maladies. In doing so, the

rejected individual may act in ways contrary to how they would normally act when not under

duress (Lakin & Chartrand, 2005).

Need-Threat Model of Exclusion

The most popular theory of social exclusion, William's Need-Threat Model of Exclusion,

stems from the Need to Belong theory of Baumeister and Leary (Baumeister & Leary, 1995).

Baumeister and Leary (1995) argued that belongingness is so fundamental to the well-being of

humans that lack of belonging triggers physical and psychological distress. Therefore, early and

accurate detection of social exclusion by the individual was essential for survival (Baumeister &

Leary, 1995). This model was then furthered by Williams and Zadro (2005). This new model of

social exclusion proposed that social exclusion threatens four primitive needs: belonging, self-

esteem, control, and meaningful existence (Williams & Zadro, 2005). Of these needs,

belongingness is considered the most crucial social requirement which supports the Need to

Belong theory. However, Williams and Zadro (2005) insist that not only do we need to feel a

connectedness with a select group of "important others" in our lives, but we also need to

experience similar connectedness with strangers in order to inhibit our brain from eliciting a

negative behavioral, physical, and psychological responses.

Williams and Zadro (2005) also argue that self-esteem is another crucial piece of the

puzzle. Because social exclusion usually occurs without explanation, the target is left to determine the reason for the exclusion. In identifying possible causes for their maltreatment, the target could compose quite an extensive list of probable causes, which is very likely to be self-defeating (Williams & Zadro, 2005). Such self-defeatedness leads to threatened self-esteem and its negative consequences because the ostracized person often feels that they have wronged the other individual involved and are therefore being punished. The third social need is the need to exercise control over one's personal environment (Williams & Zadro, 2005). When one is involved in an argument with another, that individual is able to control the nature and direction of the conversation. But in acts of social exclusion, no such control exists because, by definition, there is a lack of interpersonal interaction. As such, their control is threatened and the individual will attempt to regain it (Williams & Zadro, 2005). The fourth social need is meaningful existence. Meaningful existence is related to the notion that one's existence is a culmination of that person's feelings concerning their mortality - which leads the person to derive their purpose and meaning of life (Williams & Zadro, 2005). Social exclusion is salient to ideas of mortality and the meaning of life as it is an extreme punishment of "social death" with a striking metaphor similar to actual death itself (Williams & Zadro, 2005).

According to this model of social exclusion, when any need is violated, the target of the rejection then experiences three stages of handling their experience (Williams & Zadro, 2005). These chronological stages of reaction include immediate pain and hurt, short-term attempts to regain the threatened need, and, if the experience lasts long enough, long-term internalization of the lacking need. However, the degree to which one is affected by social exclusion depends on a variety of dimensions and moderating variables (Williams & Zadro, 2005).

Williams and Zadro (2005) also postulate that the reasons others choose to ostracize

someone (antecedents of social exclusion) have an effect on the degree to which an individual subsequently responds to being excluded (consequences of social exclusion). These antecedents, including source variables, target variables, and social pressures, all potentially influence an individual's other moderating variables and methods of dealing with their social rejection (Williams & Zadro, 2005). Other moderators that vary from person to person include an individual's needs (e.g. attachment styles or self-esteem) or attributions (e.g. blaming others rather than self) (Williams & Zadro, 2005). If an individual is ostracized by an outgroup and possesses high self-esteem, for example, the destructive effects on the individual's well-being are theorized to be less than the effects on an individual who suffers from low self-esteem or is ostracized by an ingroup (Williams & Zadro, 2005). The study aims to utilize ERP data time-locked with exclusionary events in order to determine whether the neuroelectric evidence supports this theory. Further, the correlations between ERPs and potential moderating variables such as rejection sensitivity and social anxiousness were explored.

In order to examine the Need-Threat model more closely, a new social paradigm was created (Williams & Zadro, 2005). This ball-toss paradigm, Cyberball, allows researchers to manipulate whether a subject is included or excluded in a nonverbal social interaction (Williams, Cheung, & Choi, 2001; Williams & Zadro, 2005; Williams & Jarvis, 2006). Many experimental studies have been conducted that test the theory developed by Williams and Zadro (2005) using the Cyberball paradigm established by Williams, Cheung, and Choi (2000). Overwhelmingly, results of these studies have shown that the power of social exclusion supersedes all other postulated moderators that were believed to limit its negative outcomes in the short-term (Williams & Zadro, 2005). In one such study examining the effects of the participant's relationship with his rejecter, it was found that it made no difference if the exclusion came from

an in-group or out-group. Even if the participant was told that the out-group was the Klu Klux Klan, participants continued to experience the same negative affect as they did following rejection by an in-group (Williams, 2007). However, Zadro, Boland, and Richardson (2005) discovered that situational and individual differences affect the long-term moods and needs of the participant (as cited in Williams & Zadro, 2005). Socially anxious persons continued to experience lower levels of self-reported affect than that of their normally functioning counterparts. While normally functioning individuals seemed to return to normal levels of functioning 45 minutes after the exclusion episode, the socially anxious individuals continued to suffer (Zadro, Boland, & Richardson, 2005, as cited in Williams & Zadro, 2005).

Based on the results of this research, Williams and Zadro (2005) believe that coping mechanisms associated with social exclusion are affected the most by various moderating variables. Such coping mechanisms include forgiveness-seeking, discussion, defensive exclusion and acceptance. Those with functional coping mechanisms will endure less long-term suffering than those who are lacking (Williams & Zadro, 2005). According to Zadro (2004), our Ostracism Sensitivity Threshold (OST), an innate mechanism to identify social exclusion, functions normally when we experience a normal amount of ostracism. But those persons who experience chronic social exclusion have a weakened OST and become hypersensitive to all social situations. This hypersensitivity leads the person to seek out instances of social exclusion in all potential sources, even if no true exclusion is occurring. Because of this lowered tolerance for exclusion, the individual is more likely to experience or feel chronic acts of social exclusion and elevated internalization responses (Williams & Zadro, 2005). In order to more completely understand why and how the OST changes, further research needs to be conducted to examine the degree to which certain events seem exclusionary to a person in addition to a more detailed

understanding to which the timing of these exclusionary events have an injurious effect on a

person's basic needs (Williams & Zadro, 2005). By comparing ERP data before, during, and

after periods of social exclusion, this study examines evidence in support of the OST and

investigates the degree of sensitivity experiences after instances of exclusion.

"Neural Alarm" System

A newer theory to the field of social neuropsychology is the "neural alarm system" theory

proposed by Eisenberger, Lieberman, and Williams (2003). This alarm system is initiated in the

anterior cingulate cortex (ACC), which acts as a conflict monitor that detects when a response is

in conflict with one's current goals. The ACC has been shown to be involved in processes

involved with detection and pain in order to promote social connectedness of the subject.

Additionally, damage to the ACC in animals disrupts maternal behaviors such as keeping pups

near, and in human females the ACC is activated by the sound of infant cries (Eisenberger et al.,

2003). Researchers utilized fMRI scans on humans during both conditions of explicit social

exclusion and implicit social exclusion on their subjects (Eisenberger et al., 2003). Participants

played the Cyberball paradigm while in the fMRI scanner with two other players, whom they

believed to be other participants in fMRI scanners, even though in reality they were played with

a predetermined computer program (Eisenberger et al., 2003). During the course of the

experiment, subjects were either implicitly or explicitly ignored while the fMRI scanner

monitored their brain activation patterns (Eisenberger et al., 2003). Results of this study suggest

that regulation of social and physical pain share a common underlying neurophysiological basis,

since both produce similar activation patterns (Eisenberger et al., 2003). Further, activity in the

dorsal ACC, an area linked to brain distress, was increased following social exclusion

(Eisenberger et al., 2003).

In order to identify the physical structures involved in the proposed social rejection pathways, Eisenberger, Gable, and Lieberman (2007) have utilized functional magnetic resonance imaging (fMRI) technology. These scientists propose that both social and physical pain rely on the same underlying neural mechanisms (Eisenberger, Gable, & Lieberman, 2007). In their fMRI study, they found that subjects experiencing social exclusion via the Cyberball paradigm showed activation of dorsal anterior cingulate cortex (dACC), amygdala, and periaqueductal grey (PAG) areas in response to the social pain. Other researchers took this fMRI research a step further and demonstrated the beneficial effects of acetominophen on reducing social pain (DeWall et al., 2010).

This suggests that social pain, like the pain from social exclusion, alerts us to negative changes in our social environment (Eisenberger et al., 2003). By noticing these changes sooner, we are able to take restorative measures to regain lost social connections needed for survival. In order to find support for this theory during our investigation, we would expect to find a neural response to every individual act of social exclusion that would set off this "neural alarm."

Other Models of Social Exclusion

Another theory related to the regulation of belongingness is the Social Monitoring System (SMS). This system regulates the mental mechanisms that evaluate if an individual's belonging and inclusionary needs are being met (Pickett & Gardener, 2005), and is based in part on Leary's Sociometer theory. The Sociometer theory suggests that an individual's self-esteem serves as an assessment mechanism for psychological well-being and postulates that our innate evaluations of our current social disposition send signals to our social regulatory systems (Leary 1999; Leary et al., 1995, as cited in Pickett & Gardener, 2005). If our needs are being met, the regulatory system is in a state of equilibrium. But in the case of need deficits, the SMS notifies

us of changes of social dynamics (both positive and negative) so that we may properly interpret

this new social information (Pickett & Gardener, 2005). When an individual is experiencing a

deficit in belonging need, the SMS heightens sensitivity to social information in order to process

the increased need to compensate (Pickett and Gardener, 2005). Individuals who possess

defective social monitoring systems may not realize cues that would indicate social rejection,

may fail to develop effective coping mechanisms, and therefore report higher overall negative

affect following acts of social exclusion than an individual with an intact monitoring system

(Pickett and Gardener, 2005).

Event-Related Brain Potentials (ERPs) and Social Exclusion

This investigation specifically looks at the N2 and P3 components of the ERP, both of

which have been previously linked to functions of the attentional network, including the ACC.

The N2 component, found in the frontocentral (caudal) region of the ACC, has been correlated

with error response (van Veen & Carter, 2002). This wave component is a negative deflection in

the ERP that typically occurs 200 to 400 ms after stimulus presentation (Yeung, Botvinick, &

Cohen, 2004). Kopp et al. (1996) have demonstrated that the amplitude of the N2 component

increases with the degree of activation of the incorrect response or response conflict and has

been cited as the neuroelectric correlate of the conflict detection signal generated by the ACC

(van Veen & Carter, 2002; Yeung et al., 2004) . Thus, while the task in this experiment does not

involve the detection of errors, we predict that this component will become enhanced during

trials where the participant is excluded from the interaction. This exclusion will act as conflict

between the participant's actual social outcome (social exclusion) will conflict with the desired

outcome (social inclusion). This heightened conflict between actual social outcomes and desired

social outcomes is hypothesized to be part of the same conflict detection process (Botvinick,

Braver, Barch, Carter, & Cohen, 2001) cited by Eisenberger and colleagues (2003) in their work

describing the neural alarm system.

Another component of the ERP is the P3. This is a positive deflection occurring between

250 to 500 ms after stimulus onset (Polich, 2007). The amplitude of this component is sensitive

to the amount of attentional resources engaged in the task, while P3 latency has been shown to be

proportional to the time required to evaluate a target stimulus (Polich, 2007). This component

requires a circuit of interactions between the frontal and temporal/parietal lobes and studies using

fMRI and ERPs have shown that the frontal lobe is active during detection of rare or physically

alerting stimuli (Polich, 2007). Importantly, P3 amplitude is thought to reflect changes in the

neural representation of the stimulus environment and is proportional to the amount of

attentional resources needed to engage a given stimulus or task, with larger (more positive) P3

amplitudes associated with greater attentional allocation (Polich & Heine, 1996). Generally, the

P3 is influenced by the cognitive demands during task processing (Polich, 2007), thus the

elicitation and generation of the P3 component is a constant and ongoing process that is

influenced by a number of factors including subjective probability and task relevance of a

stimulus, with less frequently occurring and more relevant stimuli eliciting larger P3 amplitudes

(Donchin, 1981). Due to its overt role in stimulus-related cognition and its activation in response

to alerting or relevant stimuli, we predict that this component will also be noticeably more

activated during social interactions. Specifically, we expect the P3 component to show a larger

peak amplitude during acts of social exclusion compared to social inclusion, indicating that a

greater allocation of attentional resources were used to assess the reason for the exclusion.

Current Research

While great strides have been made by social theorists in the progression of social

exclusion theories, gaps still exist in our knowledge. Although the aforementioned brain regions involved in these social mechanisms have been identified and positively correlated with our psychological and emotional states, no research has been able to establish how long it takes the brain to recognize and react to exclusion. Additionally, no one has yet established how simple or complex an act of social exclusion must be in order to elicit a neural response.

The current study aims to fill these gaps by utilizing ERPs to identify exactly what constitutes a recognizable act of social exclusion in addition to identifying how long it takes for the brain to react to these acts. Also, this study investigated whether participants' ERP activity demonstrated heightened sensitivity following brief, as well as prolonged, periods of social exclusion. It is expected that neural activity will be hypersensitive during and immediately following a period of social exclusion, with larger (more negative) N2 components during social exclusion and larger (more positive) P3 components following social exclusion when compared to inclusionary interactions preceding social exclusion. Additionally, it is hypothesized that the neural responses to exclusion (N2, P3) will become larger as exclusion persists, reflecting the participants' increased conflict at realizing he/she is the target of exclusion and the attention given to combat the exclusion process. This study also aims to demonstrate that socially anxious individuals are more sensitive to social exclusion and will show larger N2 and P3 amplitudes during and following exclusion compared to less socially anxious participants.

Method

Participants

Twenty-five participants were recruited from undergraduate students currently enrolled in General Psychology courses at Illinois Wesleyan University. This study included both male ($n = 9$) and female ($n = 16$) students between the ages of 18 - 25. Participants in the study were

awarded credit towards their General Psychology class requirement, but no other compensation was provided. Three participants were excluded from the analyses due to excessive noise and artifacts obtained during ERP data collection, leaving a final sample of 22 participants (15 females and 7 males).

Assessments

      Preliminary Assessments. After obtaining written informed consent, each participant completed a series of questionnaires. These self-reports included a simple demographics questionnaire, the Edinburgh Handedness Inventory (Oldfield 1971), the Social Phobia and Anxiety Inventory (SPAI; Turner, Beidel, Dancu, & Stanley, 1989), the Rejection Sensitivity Questionnaire (RSQ; Downey & Feldman, 1996), and a personality assessment utilizing the International Personality Item Pool (IPIP; http://ipip.ori.org). The IPIP assessment is a survey of the participant's personality based on the Big Five personality traits (Goldberg et al., 2006). Each participant then completed the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) and a brief needs and feelings assessment. The needs assessment was administered before the Cyberball task began in addition to completion after each of the three subsequent blocks of the task during the experiment.

      Cyberball Manipulation. In this experiment, participants were told that they would be playing an online game of "catch" (Cyberball) with two other participants, each located at a different university (either University of Illinois at Urbana-Champaign or Illinois State University). However, the "other participants" in the study were actually computer-generated. Similar cover stories have been utilized in previous social exclusion research (Williams, 2007). The participants was then told that this study examines the relationship between social activity and the neuroelectric response of the brain, and that the game of catch they are playing serves no

other purpose than a sample of a social interaction. During this computer-generated game, neuroelectric measurements, as well as the participants' responses to stimuli, will be recorded and saved to the computer used to collect the data (Williams, Cheung, & Choi, 2000).

Every participant completed the same three pre-determined blocks of the Cyberball paradigm, completing the needs and feelings and PANAS assessment after each one. In each block, the sequence of 80 throws was pre-determined. The first block was an inclusion block where the participant has a 50% chance of receiving the ball each throw. In this block, the participant was fully included and received the ball equally in comparison with the other two players. The two players remained the same throughout the entire experiment. The second block was an exclusion block where the participant had the same 50% chance of receiving the ball for approximately the first 20 throws of the session. However, after these throws, the participant was no longer included in any of the remaining approximately 60 throws for the rest of the block. Instead, the other two players played an exclusive game of catch and socially rejected the participant. The third block was a re-inclusion block identical to the first inclusion block.

For the current project, Cyberball was adapted for use in a software program that creates event-related markers on a computer collecting ERP data from a participant while engaged in the Cyberball paradigm. The markers were inserted at each point in the game where the screen provides information on where the ball is going to go (i.e., the screen picture shows the ball starting to go toward the recipient of the toss instead of the other player – see Figure 1). Thus, the markers are independent of any participant movement or action – the timing is locked with the informational frames in the ongoing social interaction (frames are timed 450 ms apart). This allows for the quantification of moment-to-moment ERP activity in response to being included

or excluded in the game.

Neuroelectric Assessment. Neural activity was recorded via electroencephalogram (EEG) with 64 sintered Ag-AgCl electrodes in a lycra cap (Neuro Inc., El Paso TX). These electrodes are arranged in a 10-10 system montage (Chatrain, Lettich, & Nelson, 1985) and were filled with Quik gel (Neuro Inc., El Paso, TX). The AFz site served as a ground site and an electrode between Cz and CPz served as an online reference site. Eye movements were recorded via vertical and horizontal bipolar electrooculographic activity (EOG) with Ag-AgCl electrodes placed above and below the left orbit as well as near the canthus of each eye. One Ag-AgCl electrode was also placed on each of the participant's mastoid processes for re-referencing purposes following data collection. All electrodes were held to impedence levels less than 10 kΩ. A Neuroscan Synamps2 bioamplifier with a 24 bit A/D converter and +/- 200 millivolt (mV) input range (Neuro Inc., El Paso, TX) was utilized to digitize, amplify, and filter neural activity continuously as it was collected. Neuroscan Scan software v. 4.3.1 was used to record neural activity and Neuroscan Stim software v. 2.0 was used to control the presentation of the Cyberball task, stimulus timing, and recording of participants' responses.

Following task completion, EEG activity was re-referenced to the averaged mastoids and eye movements were corrected using a spatial filter (Compumedics Neuroscan, 2003). To further clean the data, it was low-pass filtered at 30 Hz (24dB/octave). Stimulus-locked epochs were created -800 ms to 2500 ms relative to the stimulus marker created with each throw in the Cyberball paradigm. The data for each participant was output in ASCII format so it could then be analyzed in SPSS 17.0. The N2 component was quantified as the average amplitude in the discrete latency window running from 200-320 ms after stimulus presentation whereas the P3 component was quantified as the average amplitude in the discrete latency window running from

320-450 ms following stimulus presentation.

Procedure

The experiment occurred in one session lasting approximately 90 minutes. First, the

participants filled out a written informed consent from and completed all aforementioned

preliminary questionnaires. Following their completion, each participant was then seated one

meter away from the computer screen where they were told the cover story for the experiment

and then completed the Cyberball task. Once the participant had been attached to the cap and all

electrodes had sufficient impedance levels, the researcher then explained in further detail how to

complete the ball-throwing task and asked for any questions. The lights were then dimmed, and

the participant was left alone to complete each of three blocks of the Cyberball paradigm. In

between each block, a research assistant re-entered the participant's room to make sure the

participant was doing well and administered the previously mentioned feeling and social needs

and PANAS questionnaires. In order to limit potential confounding variables, the interactions

between the participant and research assistant were limited to making sure the participant was

feeling well physically and administering the questionnaire. Following completion of the

questionnaires at the end of the third block, participants were debriefed and told the true aims of

the study as well as the reason why deception was necessary for this task. They were then

allowed the opportunity to ask questions or make comments and were thanked for their time.

Statistical Analyses

Omnibus 3 (block: inclusion, exclusion, re-inclusion) × 2 (throw type: including the

participant, excluding the participant) repeated-measures analyses of variance (ANOVAs) were

conducted separately to compare the mean N2 and P3 values across the different trial blocks and

types of throw within the Cyberball paradigm. The N2 was quantified at the FCz electrode site

while the P3 was quantified at the Pz electrode site. Additionally, bivariate Pearson Product

Moment correlations were calculated between the dependent variables (N2 and P3 amplitude)

and social anxiety, rejection sensitivity, and personality measures to determine the extent to

which these individual difference factors were related with neural activity associated with social

exclusion.

Results

Participant Characteristics. Table 1 summarizes participants' age, rejection sensitivity

scores (RSQ total), personality scores, and social anxiety scores (SPAI; SP - AG) overall and

separately by sex. Participant scores did not significantly differ across sex for any of the

measures, t's(20) $\leq$ 1.7, p's $\geq$ .10. Separate three-level (block: inclusion, exclusion, re-inclusion)

repeated-measures ANOVAs were conducted on related self-reported measures (PANAS, needs

and feeling assessment) to verify the expected pattern of findings with alterations in affect, needs

fulfillment, and feeling states due to social exclusion across blocks of Cyberball. As predicted,

all measures showed significant block effects (F's(2, 20) $\geq$ 6.1, p's $\leq$ .008, partial $\eta 2 \geq$ .38).

More specifically, the positive affect scale of the PANAS showed greater positive affect in the

inclusion block compared to the exclusion and re-inclusion blocks whereas the negative affect

subscale in the PANAS and all of the needs and feeling scales (including both manipulation

check measures) in the needs and feeling assessment showed the exclusion block to be

significantly different from both the inclusion and re-inclusion blocks (see Table 2 for mean

scores (SD) by block on each subscale/measure). No significant correlation was observed

between rejection sensitivity or social anxiety scores (Table 1) and amplitude differences in

either the N2 or P3 ERP peak components (specifically, all r's were smaller in magnitude than $\pm$

.31, and all p values were $\geq$ .16).

N2 Component. Figure 2 shows grand-averaged waveforms by Cyberball block (inclusion, exclusion, re-inclusion) and throw type (including the participant, excluding the participant) at Fz, FCz, Cz, and Pz. The omnibus 3×2 repeated-measures ANOVA revealed a significant throw type main effect ($F(1,21) = 57.6$, $p < .001$, partial $\eta2 = .73$), but no significant block main effect or block $\times$ throw type interaction. Specifically, N2 amplitude was greater (more negative) for exclusionary throws (M = .3 µV, SD = 1.7) compared to inclusionary throws (M = 3.1 µV, SD = 2.0) regardless of whether the overall Cyberball interaction was inclusionary or exclusionary in nature. These findings suggest that the neural response to conflict associated with social exclusion was sensitive to the momentary "exclusion" when the participant did not receive the ball. However, the larger social context of the interaction, being included or excluded in general, did not exhibit an influence on the conflict monitoring signal from the ACC indexed by the N2 component.

To examine the possible modulation of the N2 component over the course of the exclusionary process during the exclusion block of Cyberball, the first 20 exclusionary throws and second 20 exclusionary throws were averaged separately and examined in a two-level (time: first 20 throws, second 20 throws) repeated-measures ANOVA. The analysis revealed a significant effect ($F(1,21) = 4.7$, $p = .04$, partial $\eta2 = .18$) with larger (more negative) N2 amplitude in the first 20 exclusionary throws (M = -.1 µV, SD = 2.2) compared to the second 20 exclusionary throws (M = 1.0 µV, SD = 1.7), suggesting a decrease in the neural conflict signal to exclusionary throws as the larger exclusion progressed (see Figure 3).

P3 Component. The omnibus 3×2 repeated-measures ANOVA revealed a significant throw type main effect ($F(1,21) = 111.9$, $p < .001$, partial $\eta2 = .84$), suggesting P3 amplitude was greater (more positive) for inclusionary throws (M = 7.6 µV, SD = 2.9) compared to

exclusionary throws (M = .8 µV, SD = 1.9) regardless of whether the overall Cyberball

interaction was inclusionary or exclusionary in nature (see Figure 2). This main effect was

modified by a significant block × throw type interaction ($F(2,20) = 3.6$, $p < .05$, partial η2 = .27).

Follow up repeated-measures ANOVAs (with Bonferroni correction) were conducted to examine

the changes in P3 amplitude for each throw type separately across the three Cyberball blocks.

These analyses showed no significant block effect for inclusionary throws ($F(2,20) = .01$, $p =$

.99, partial η2 = .01). However, a significant block effect was present for exclusionary throws

($F(2,20) = 15.7$, $p < .001$, partial η2 = .61). Bonferroni-corrected paired-samples t tests

comparing P3 amplitudes for exclusionary throws in each Cyberball block revealed that P3

amplitude was larger in the exclusion block (M = 2.1 µV, SD = 2.0) compared to both the

inclusion block (M = .2 µV, SD = 2.4; $t(21) = 4.2$, $p < .001$) and re-inclusion block (M = .1 µV,

SD = 3.0; $t(21) = 3.5$, $p = .002$), while no difference was present in P3 amplitude between the

inclusion and re-inclusion block ($t(21) = .1$, $p = .95$). These findings suggest that the attentional

processes reflected by P3 amplitude are heightened to exclusion throws during the exclusion

block compared to exclusionary throws during either the inclusion or re-inclusion blocks (see

Figure 4).

To examine the possible modulation of the P3 component over the course of the

exclusionary process during the exclusion block of Cyberball, the first 20 exclusionary throws

and second 20 exclusionary throws were averaged separately and examined in a two-level (time:

first 20 throws, second 20 throws) repeated-measures ANOVA. This procedure was identical to

the one utilized to examine N2 modulation across the exclusion block. The analysis revealed a

significant effect ($F(1,21) = 5.0$, $p = .04$, partial η2 = .19) with larger (more positive) P3

amplitude in the first 20 exclusionary throws (M = 3.0 µV, SD = 3.6) compared to the second 20

exclusionary throws (M = 1.0 µV, SD = 2.4), suggesting a decrease in the neural attentional

signal to exclusionary throws as the larger exclusion progressed (see Figure 5).

Discussion

General Results Observed

The present study was conducted to explore the exact nature of neural activation during

and after acts of social exclusion to better determine what constitutes a recognizable

exclusionary event. We also aimed to investigate the quality of neural response following an

exclusionary event. Specifically, it was hypothesized that neural activity would be greater

following social exclusion, suggesting a heightened sensitivity to social information, and that

neural responses to social exclusion would become larger as exclusion persisted, indicating that

the target of exclusion would exhibit a greater response as the exclusion continued. Contrary to

expectations, the current study showed no heightened neural activity following exclusion and

neural activation was larger in amplitude in the earlier stages of exclusion. Additionally,

changes in neural activity were shown to be sensitive to specific events within the social

interactions, not the overall social context (inclusion, exclusion, re-inclusion) of the interactions,

indicating that one's responses to social events are driven by each individual event. These

findings suggest that humans possess a "neural alarm" system which alerts them to individual

acts of social exclusion. This alarm is not triggered by the overall realization that an individual

is being left out. Rather, this alarm appears to be triggered by each individual exclusionary event,

regardless of the overarching context of the social interaction.

N2 Component. Consistent with results observed by Eisenberger et al. (2003), it appears

that the N2 component associated with the anterior cingulate cortex (ACC) functions as a neural

conflict monitor, or "alarm system," to signal a person that they are being excluded from a social

interaction. Rather than functioning at a global level, this conflict monitor functions on a momentary throw-by-throw basis to alert the subject to their exclusion during that specific throw. This phenomenon occurs in all three social interaction conditions in the Cyberball paradigm, not just in the social exclusion task condition. Furthermore, there is no significant difference between the amplitude of the N2 peak sizes between the three blocks. Regardless of what block type the participant was engaged in, the N2 differences showed no significant effect in the larger context of the interaction. This suggests that the neural alarm is not triggered by the compounding realization that person is being purposely left out. Rather, activation of the neural alarm is initiated by the single event when the person is being excluded, regardless of whether that person has been included in the previous throw or had been included in general.

Further, during the exclusionary interaction, the N2 amplitude during the first 20 throws of the exclusion was larger than the N2 amplitude from the second 20 throws. This finding suggests that there was either a decrease in neural conflict over time, implying that the participants effectively became habituated to being ignored by the other participants, or that the neural alarm system became exhausted from the continual signaling that there was social conflict present, resulting in a cognitive deficit in this self-regulatory process similar to that hypothesized in cognitive deconstuction (Baumeister, Twenge, & Nuss, 2002). Based on our hypotheses, this result was unexpected. According to the Ostracism Sensitivity Threshold theory proposed by Zadro, individuals who experience abnormally high amounts of ostracism should be hypersensitive to increasing amounts of exclusion. Thus the "neural alarm" should get larger and larger until the conflict (exclusion) has been resolved.

P3 Component. Similar results were found for the P3 component. There was a significant difference in peak amplitude for throws where the participant was included compared

to throws where the participant was excluded, regardless of the larger context of the social situation. This indicates that inclusion is what the participants expect as normal social treatment and any other treatment that varies elicits a neural response to an unexpected situation. Also, for the exclusionary throws, there was a larger P3 amplitude in the exclusionary interaction compared to the inclusionary social interactions. This increased activity may be a result of the surprise and increased attentional allocation the participants direct to the exclusionary events upon realizing that they are being excluded in the larger block context.

When the first 20 and second 20 exclusionary throws of the exclusionary block were compared to one another, a larger (more positive) P3 component was discovered for the first 20 throws. Similar to the N2 component, this component became less pronounced over time, suggesting that the participants became accustomed to the social exclusion or that the neural circuitry associated with the detection and response to social exclusion became deficient over time.

Evaluation of Hypotheses

The first question this study aimed to answer was: What constitutes a recognizable act of social exclusion and how long does the brain take to identify these acts? Based on our results, it is apparent that each individual throw in which the participant is not included is recognized as an act of social exclusion. This neural recognition can occur as soon as 200 ms following onset of the first act of exclusion, since this is generally the earliest onset of the N2 component. Practically, neural recognition of social exclusion happens immediately after the exclusionary event. Therefore, one does not need to experience minutes of an exclusionary social interaction to experience a neural reaction to exclusion.

The second question this study aimed to answer was: Does participants' ERP activity

demonstrate heightened sensitivity following brief, as well as prolonged, periods of social exclusion? Does the neural response to exclusion (N2, P3) become larger as exclusion persists? We expected that neural activity would be hypersensitive during and immediately following a period of social exclusion, with larger (more negative) N2 components during social exclusion and larger (more positive) P3 components following social exclusion when compared to inclusionary interactions preceding social exclusion. However, this hypersensitivity was not observed. In fact, sensitivity to social exclusion appeared to decline over time for both ERP components during the exclusion block. Further, there was no difference in peak amplitude of throws without the participant between the first (inclusion) and third (re-inclusion) blocks of the social interaction, displaying further evidence of a lack of sensitivity to social exclusion.

Third, we aimed to answer: Are socially anxious individuals more sensitive to social exclusion and show larger N2 and P3 amplitudes during and following exclusion compared to less socially anxious participants? From our data, this appears to be "no." There was no significant correlation found between individual difference variables, such as social anxiety, and the amplitude of their resulting ERP components assessed (N2, P3) compared to normally functioning individuals for either throw type (inclusionary, exclusionary) or within any of the social interactions (inclusion, exclusion, re-inclusion) in our study design. Though other research has theorized the existence of a relationship between social anxiety and the severity of consequences from social exclusion (Lakin & Chartrand, 2005), our research suggests that the neural responses to social exclusion are insensitive to individual differences. Influences related with individual differences (social anxiety) may be associated with a more global synthesis of the interaction as a whole. Thus, individual variation would show in self-reported behavioral measures rather than neural assessment reflecting the events within the social interaction.

Limitations and Future Directions

While the relationship between social exclusion and the associated neural responses that follow is very fascinating, further examination of the neural responses is necessary to more precisely determine the time course of exclusionary events. By increasing the temporal duration of each throw, less overlap and interference between ERP components could potentially be observed. Because each throw frame was spaced 450 ms apart, it is possible that the P3 component of each ERP incurred some type of interference from stimulus-locked activity from the next frame since the next throw frame was beginning at the same time that the P3 component was ending. Had this neural process been allowed to "finish," the resulting peak amplitude of this component may have yielded different results.

Another potential limitation of this study is the demographic composition of the participants. Out of an already small sample of 22 participants, seven of the participants were male and 15 were female. In order to increase external validity and examine the differences of these neural indices between the sexes, it would be preferential to use a larger sample size with a more equal gender distribution.

In the future, it would be interesting to investigate whether variables like placement, timing, and amount of exclusion have any effects on neural indices or behavioral assessments following acts of social exclusion. In this study, the exclusionary period occurred at the end of the exclusion block. Future studies could manipulate this exclusionary period by placing it at the very beginning of the exclusion block, so that the participants are included in the final 20 throws of the block, or placing it in the middle of the block, so participants are included momentarily at both the beginning and the end of the block. Altering this placement would allow researchers to examine if those inclusionary throws occurring immediately after the exclusionary phase would

yield any different changes than those observed in the re-inclusion block of this study. Another potential manipulation of the exclusionary block would be altering the Cyberball game so that the participant is slowly "phased out" of the group by slowly fading from partial exclusion into total exclusion.

Summary

The Social Monitoring System (SMS) theory proposed by Pickett and Gardener (2005) does appear to have some merit in this setting. Since the SMS alerts the individual to changes in social information and our need deficits, it makes sense that this system would alert us when we are being excluded from a social interaction. Surprisingly, however, an alerting neural response is seen after every individual act of exclusion, not only after it has happened multiple times in a row. This finding could mean that individuals are experiencing a deficit in belonging need after every single throw that they are not involved in, or that this system is not the system that alerts us to these changes and perhaps the neural alarm system is more engaged during momentary social exclusions. It seems to fit that the SMS system is at least partially involved in the neurological response to exclusionary events, due to its proposed role in making sure our basic needs are being met.

These results, however, do not support the Ostracism Sensitivity Threshold (OST) theory, proposed by Zadro (2004). This theory postulated that persons who experience chronic social exclusion have a weakened OST and become hypersensitive to all social situations and have a lower tolerance for exclusion (Williams & Zadro, 2005). After every exclusionary event in this experiment, even those throws without the participant in the inclusion or re-inclusion blocks, every participant's brain responded similarly. There was no significant difference in amplitude between the neurological responses between persons who were socially anxious compared to

those functioning normally.

Perhaps most importantly, this study allowed us to gain significant insight into the neural activation, specifically event-related brain potentials (ERPs), occurring during social interactions (inclusion, exclusion). Results indicated that both the N2 and P3 were sensitive to individual events within the interaction rather than the global context of the interaction. This indicated that the "neural alarm" system (Eisenberger et al., 2003) theorized to detect social pain (indexed by the N2) functions on a moment-by-moment basis to alert the person to their exclusion during that specific instance rather than on a globalized level of the exchange. Additionally, exclusionary events appear to engage more attention from a person when they occur within a larger exclusionary context, as indexed by a larger P3 amplitude. Finally, both neural indices were larger during the earlier portion of the exclusionary block, suggesting a heightened sensitivity to the social conflict (N2) and an increase in attentional allocation to the social events (P3) during the initial stages of exclusion. These findings suggest that discrete event occurring during a social interaction may provide additional insights into social exclusion compared to more global "inclusionary" or "exclusionary" classifications of social interactions. In future studies, it would be beneficial to examine how elongated frames of the Cyberball paradigm, location/timing of exclusion within the exclusionary block, and acts of partial exclusion would effect the N2 and P3 components of ERPs and an individual's assessment of needs.

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Table 1

Mean (Standard Deviation) Demographic and Self-Report Information for All Participants and

for Participants Categorized by Their Sex

Variable	All Participants	Males	Females
	M (SD)	M (SD)	M (SD)
Sample size (n)	22	7	15
Age (years)	18.6 (.7)	18.3 (.5)	18.8 (.7)
Extraversion	70.3 (14.4)	68.4 (14.5)	71.2 (14.7)
Agreeableness	79.4 (8.1)	78.1 (8.4)	80.1 (8.2)
Conscientiousness	73.7 (10.6)	70.0 (8.5)	75.4 (11.4)
Emotional Stability	69.3 (11.8)	73.3 (9.1)	67.4 (12.7)
Intellect/Imagination	73.3 (9.2)	69.0 (9.5)	75.2 (8.7)
Social Anxiety score (SP-AG)	54.6 (20.4)	49.8 (11.6)	56.9 (23.7)
Rejection Sensitivity score (RSQ total)	17.2 (4.6)	17.9 (2.5)	16.8 (5.3)

Table 2

Mean (Standard Deviation) Scale/Subscale Scores on the Self-Report PANAS and Needs and

Feelings Assessment for All Participants Categorized by Cyberball Block

Variable	Inclusion	Exclusion	Re-inclusion
	M (SD)	M (SD)	M (SD)
Positive Affect (PANAS)	23.6 (6.3)	18.7 (7.3)	19.9 (8.4)
Negative Affect (PANAS)	11.2 (2.0)	13.0 (2.9)	11.4 (1.7)
Need to Belong	4.1 (.6)	2.2 (.7)*	4.2 (.6)
Need for Self-esteem	3.6 (.7)	2.6 (.7)*	3.6 (.7)
Need for Meaningful Existence	4.0 (.6)	2.6 (.9)*	4.1 (.6)
Need for Control	3.2 (.8)	1.8 (.7)*	3.3 (.8)
Mood	4.0 (.5)	3.3 (.8)*	3.9 (.5)
Manipulation Check (extent ignored/excluded)	1.4 (.7)	4.3 (1.1)*	1.4 (.6)
Percentage of Throws Received	35.5 (11.1)	8.5 (4.1)*	41.0 (12.0)

*$p < .05$

Inclusion   Exclusion
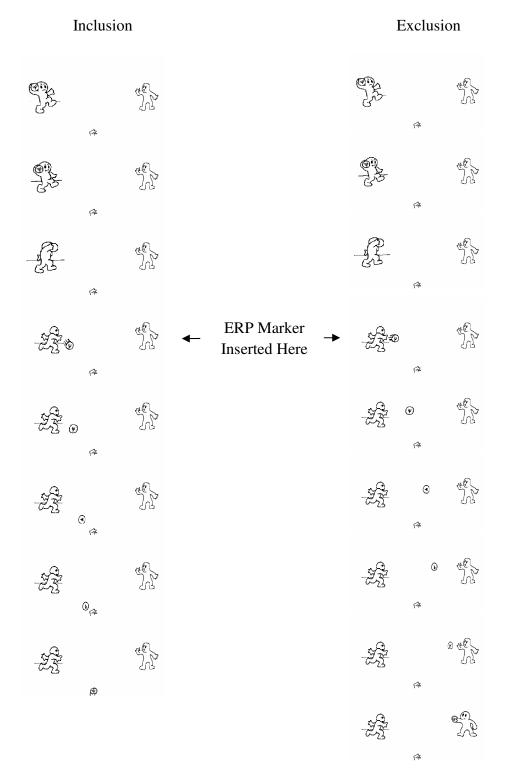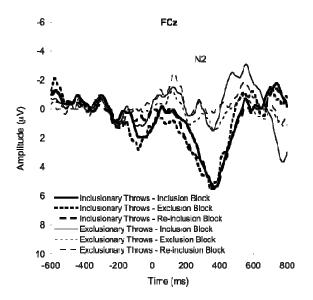

ERP Marker
Inserted Here

Figure 1. Frame-by-frame demonstration of inclusionary vs. exclusionary throws.
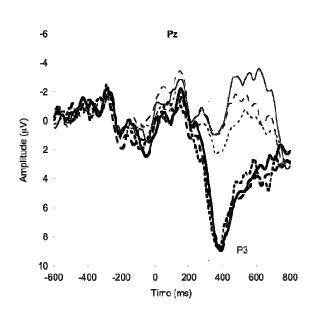
Figure 2. Grand-averaged stimulus-locked ERP waveforms by Cyberball block and throw type
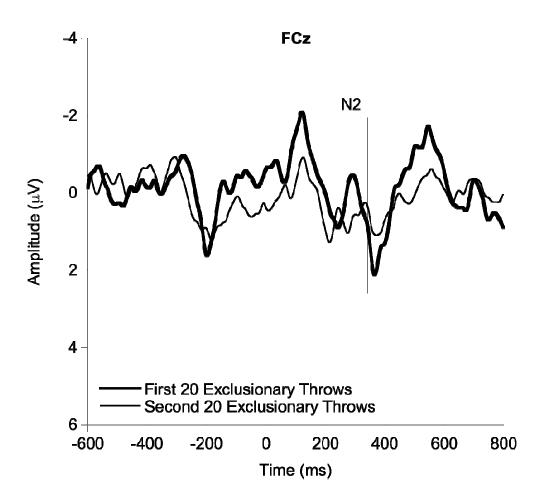
at electrode sites FCz and Pz.

Figure 3. N2 amplitude at FCz during the first 20 vs. second 20 exclusionary throws within the exclusion block.
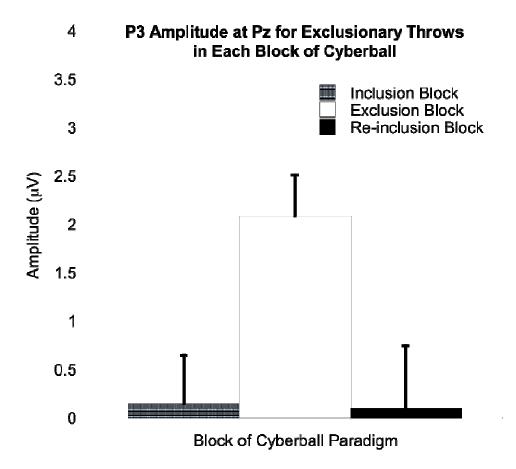
Figure 4. P3 amplitude at Pz for exclusionary throws in each block of Cyberball. This figure

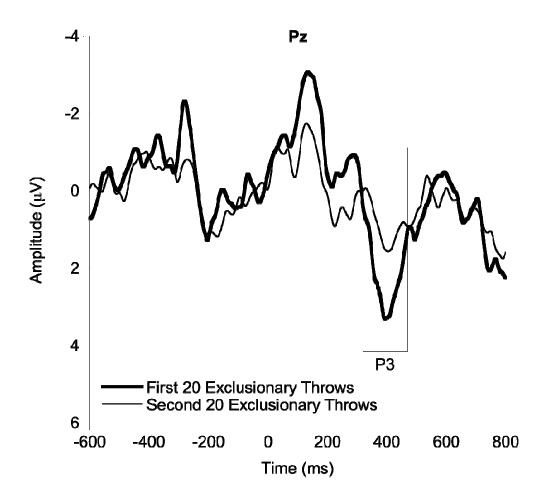demonstrates the Throw Type × Cyberball Block interaction effect.

Figure 5. P3 amplitude at Pz during the first 20 vs. second 20 exclusionary throws within the

exclusion block.