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Examining the Effects of Ostracism on Neural and Behavioral Indices of Cognitive Self-Regulation

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Abstract

The impact of ostracism on a target individual produces a number of negative consequences, including deficits in cognitive functioning related to self-regulation and general cognition. While such effects have been acknowledged, there is a lack of literature regarding the effect of ostracism on action monitoring in particular. Action monitoring is a self-regulatory process in which participants ensure the accuracy of their responses to a task or situation, the authors hypothesized that it would be adversely affected by an experience of ostracism. The goal of the current study was to utilize event-related brain potentials to examine the relationship of these two factors. The authors hypothesized that upon experiencing an event of ostracism, participants would exhibit a decrease in action monitoring capability, observable through both neural and behavioral measures. Specifically, the authors predicted that participants who experienced ostracism would exhibit decreased error-related negativity (ERN) amplitude, as well as decreased post-error response accuracy and a slowing of response time during subsequent execution of the flanker task. Results indicated that participants who experienced social exclusion exhibited decreases in both ERN amplitude and post-error accuracy in a flanker task. These findings provide both neural and behavioral support for the experimenter's hypothesis that the action monitoring ability of ostracized individuals is compromised by their experience of social exclusion.

Examining the Effects of Ostracism on Neural and Behavioral Indices of Cognitive Self-Regulation

Humans are constantly monitoring their surroundings, both in terms of physical and social occurrences. One of the critical functions of this monitoring is to examine oneself to ensure that one's actions are not detrimental to the intended goals (Baumeister & Dewall, 2005). In social situations, this self-regulatory action monitoring helps individuals prevent mistakes which would result in the individual being ostracized, or socially excluded, by others. Research by Williams and his colleagues state that ostracism is the act of ignoring or excluding a target, typically without explanation, and in violation of the target individual's need for belonging (Williams, 2007a; 2007b; Zadro, Williams, & Richardson, 2004). The occurrence of being ostracized typically has devastating effects on the target individual, such as a wide array of negative emotions as well as decreases in cognitive ability. The need to belong is a fundamental characteristic of humans likely resulting from a history of interdependence (Baumeister & Dewall, 2005). As such, monitoring for the threat of ostracism is likely an adaptive trait our species has acquired through evolution (Williams, 2007a). The interdependent nature of human ancestors led to ostracism effectively acting as a death sentence. Individuals who were excluded lost access to group resources and reproductive opportunities (Williams, 2007a, 2007b; Williams, Forgas, Von Hippel, & Zadro, 2005). At the same time, research shows that individuals in a group which excludes another form a more cohesive bond (Williams, 2007a). Therefore, during human evolution ostracism was likely a means of forming tightly knit groups while removing undesirable individuals. While humans' dependence on inclusion for survival has decreased, the threat or implementation of social exclusion has a dramatic effect on the targeted individual.

The aim of the current study is to explore the relationship between the experience of ostracism and the individual's subsequent self-monitoring abilities. While previous research shows that ostracism results in an array of cognitive deficits, the effect on action monitoring has never been specifically examined, and it is the hope of the experimenter that a better understanding of this relationship will be achieved.

Models of Ostracism

The impact of ostracism on the individual results in a number of grave consequences. Those who are excluded report a gambit of negative feelings including anxiety, depression, loneliness, frustration and helplessness (Geller et al., 1974; Leary, 1990; Sommer et al., 2001; Williams, 2007, 2009; Williams et al., 2000; Williams & Zadro, 2001). Ostracism has also been shown to lead to negative self-assessments, increased risk of mental disorders, and shortened lifespans (Craighead, Kimball, & Rehak, 1979; Zadro & Williams, 1998; House, Landis, & Umberson, 1988). Such effects have been found to a smaller degree even in less severe instances of ostracism, such as the Cyberball paradigm utilized in the current study (Williams, 2007b; Zadro, Williams, & Richardson, 2004). Due to such dramatic effects, numerous theories have been proposed examining the process of ostracism and the reason for its potential for massively detrimental effects on the individual's functioning. The prominent model of ostracism is based on the human need to belong (Baumeister & Leary, 1995; Pickett & Gardener, 2005; Williams & Zadro, 2001). The need to belong has been proposed as a critical aspect of human well being which leads to mental and physical distress if compromised (Baumeister & Leary, 1995; Pickett & Gardener, 2005). Williams and Zadro (2001) have expanded on this need to belong by stating that humans constantly need inclusion within social groups to survive, regardless of whether those groups are composed of people familiar to the individual or strangers. Thus, the human need for inclusion is thought to exist across all social situations.

Williams and Zadro (2005) have also proposed that aside from the need to belong, ostracism violates the human needs for control, meaningful existence, and self-esteem (Williams, 2007b). The unpredictable nature of social exclusion leads to an apparent loss of control. The loss of social ties is a direct threat to social functioning and thus hinders meaningful existence (Williams & Zadro, 2005). Additionally, the process of analyzing an event of ostracism can result in negative self evaluation resulting in a loss of self-esteem (Williams & Zadro, 2005). In response to violations of these needs, individuals will go through stages of pain, attempts to fulfill the violated need, and potentially long term internalization of the violated need (Williams & Zadro, 2005). Such internalization results in a diminished ability to recover from unfulfilled needs, leading to chronic decreases in self-esteem, feelings of helplessness, and self-imposed isolation (Williams, 1997, 2001).

The consequences of such occurrences are dependent on several factors including the need that is compromised and who is doing the ostracizing (Williams, 2007b). Williams (2001) has also predicted that the perceived reason for ostracism affects the severity of consequences on the target. Individuals who believe they are ostracized due to personal characteristics will likely experience more severe consequences than those who feel the ostracism was a result of group affiliation or other external characteristics (Williams, 2001). The impact of ostracism is also thought to be related to several personal characteristics, such social anxiety, rejection sensitivity, individual needs for control and belonging, self-esteem, and attachment style (Hazan & Shaver, 1987; Williams, 2001; Zadro, Boland, & Richardson, 2006). The one aspect of ostracism that does not seem to change between individuals is the immediate response, which is almost always negative and strong regardless of the individual or situation (Williams & Zadro, 2005).

Cyberostracism

In order to better manipulate the ostracism experience for experimental research, the effect of cyberostracism has been examined on many occasions (Williams, 2007b; Zadro, Williams, & Richardson, 2004). The cross situational nature of the immediate effects of ostracism allow for experimental manipulation of this occurrence without personal interaction. The use of cyber exclusion allows experimenters to evoke a response to an event of ostracism while monitoring neural activity through electroencephalographic means. Thus, the success of cyberostracism is crucial to the current study. Research shows that the impact of cyberostracism yields consequences which are just as strong as face to face occurrences of exclusion (Williams, 2007b; Zadro, Williams, & Richardson, 2004).

One of the most widely used forms of cyberostracism is the Cyberball paradigm (Williams, 2007a, 2007b; Zadro, Williams, & Richardson, 2004). In Cyberball, participants are told they will be playing a virtual game of catch with two or three other participants who are not seen. The other players are actually part of a computer program. Once the game begins the participant is thrown the ball by one of the other “participants” and must respond in turn by selecting which of the other “participants” he or she wishes to receive the throw. After a few throws, the computer participants begin to throw exclusively to each other, thereby ostracizing the actual human participant. Williams et al. (2000) initially designed the Cyberball paradigm in the hopes of creating a situation of ostracism which would not produce the typical negative consequences of exclusion; however, research shows that even low levels of exclusion in Cyberball negatively impacted the four previously stated human needs relation to ostracism

(Zadro, Williams, & Richardson, 2004). In experimental settings the experience of cyberostracism through Cyberball has been examined largely through behavioral measures, such as questionnaires which examine social needs such as belonging, control, self-esteem, and meaningful existence (Zadro, Williams, & Richardson, 2004). Furthermore, research utilizing functional magnetic resonance imaging (fMRI) during such cyberostracism has indicated that the resulting neural activation in the anterior cingulate cortex matches the activation present during the experience of physical pain, a characteristic which is also present in real life ostracism (Eisenberger, Gable, & Lieberman, 2007; Zadro, Williams, & Richardson, 2004). Thus, the experience of cyberostracism utilized in the present study through the Cyberball paradigm is comparable to that of real life ostracism. However, it is the aim of the current study to examine the experience of cyberostracism through the use of event-related brain potentials (ERPs). The ERN is a form of ERP that can be affected by social factors and has been linked to action monitoring in previous studies (Hajcak, McDonald, & Simons, 2004; Olvet & Hajcak, 2009; Ridderinkhof et al., 2004; Themanson et al., 2008). Because action monitoring is a cognitive self-monitoring function, the current study's examination of the impact of social exclusion on ERP data will allow for an analysis of the relationship between ostracism and self-monitoring.

Models of Social Monitoring

Cognitive monitoring is a key component to understanding ostracism. While previous models largely explore the effects of ostracism, the Social Monitoring System (SMS) illustrates how individuals monitor the fulfillment of their need for belonging (Pickett & Gardner, 2005). The theory suggests that to ensure acceptable levels of social inclusion are being attained the individual is constantly monitoring social interaction to determine the implications of a number verbal and nonverbal cues which could indicate social acceptance or exclusion (Pickett &

Gardner, 2005). A related theory, proposed by Leary et al. (1995) suggests that self-esteem specifically serves as the means of assessment for inclusion related needs being met. Both theories suggest that when an individuals' need to belong is not fulfilled, the SMS is activated and serves as a notification that the current situation requires further evaluation and possibly the adoption of adaptive strategies to avoid negative social consequences. The functioning of the SMS is not consistent across individuals. Further, personal attributes, such as rejection sensitivity and social anxiety, may influence its accuracy (Pickett & Gardner, 2005). In such cases, individuals may be more likely to perceive exclusion in situations where social cues are ambiguous, or may simply fail to conform to social norms (Pickett & Gardner, 2005). In instances where an individual feels their need to belong is not being fulfilled they may become overly attentive to social cues and increase their social monitoring in order to ensure that they are able to attune their behaviors to ensure social inclusion.

In addition to SMS and related theories, the existence of a neural alarm system has been proposed by Eisenberger and Lieberman (2004a). The neural alarm system is thought to be an inherent cognitive response to social pain based in the anterior cingulated cortex (Lieberman & Eisenberger, 2004). This theory explores the neural response to exclusion in terms of the reallocation of cognitive resources to better evaluate the occurrence of ostracism. Under such a theory, any cognitive deficits of social exclusion are viewed as a result of a heightened focus on the actual event of ostracism and the consequential pain, leading to a reallocation of cognitive resources which decrease their availability for other tasks (Lieberman & Eisenberger, 2004).

Cognitive Effects of Ostracism

With considerations to models of exclusion and social monitoring, one can begin to better understand the consequences of ostracism. The effect of ostracism on humans today is likely a residual effect of the evolutionary basis proposed by (Williams, 2007a). Early humans were dependent on social interaction for survival, with collaboration helping to ensure that the needs of all individuals within a social group were met. Membership in a social group helped to ensure access to resources, an increased life span, and opportunities to reproduce (Williams et al., 2005). Williams, Forgas, von Hippel, and Zadro (2005) have proposed that this reliance on social inclusion resulted in humans developing an internal monitoring system involving cognitive, emotional, and behavioral cues which aided in the detection of ostracism.

While human's interdependence has decreased as we have evolved, the aversion to being excluded, and the resulting negative effects, remain. If an individual's inherent need to be accepted is not fulfilled he or she feels emotional distress, pain, and a drop in cognitive functioning surrounding the event of ostracism (Williams, 2007a, 2007b; Baumeister & Dewall, 2005). In terms of pain, the effect of ostracism is comparable in neural activation to the effect of any physical pain felt by the individual (Eisenberger, Lieberman, & Williams, 2003; Williams, 2007b). Ostracism is torture for the mind much like physical torture is for the body.

Additionally, ostracism has an immediate negative impact on the cognitive functioning of the target individual, an occurrence which has been termed cognitive deconstruction (Baumeister, Twenge, & Nuss, 2002; Williams, 2007a). Research indicates that the experience of ostracism is accompanied by a wide range of cognitive deficits following the ostracizing event (Baumeister & Dewall, 2005). Among the processes affected are self-regulation and general cognition, which are critical to ensuring appropriate levels of social inclusion in a given social situation (Baumeister & Dewall, 2005; Baumeister, Twenge, & Nuss, 2002; Williams, 2007a). Specifically, the human survival instinct often results in individuals exhibiting selfish tendencies. However, these tendencies can be self-regulated and controlled in exchange for social inclusion.

Further, intelligent thought typically allows individuals to analyze data relevant to maintaining their social ties. In the presence of ostracism, these two cognitive functions exhibit severe impairments (Baumeister & Dewall, 2005). Ostracized individuals become passive and limit their interaction with others, hindering their potential to form social ties. They also show difficulty in processing information efficiently and in a logical manner. Thus, it seems that the exclusion in a social environment results in deficits in the cognitive mechanisms utilized to ensure inclusion and prevent ostracism in the first place.

Other examples of cognitive consequences resulting from ostracism include slower reaction times and overestimation of lapsed time intervals (Twenge, Catanese, & Baumeister, 2003). Baumeister and Dewall (2005) explain such effects by arguing that ostracism produces cognitive deficits directly related to decreases in the individual's executive function. Executive function refers to cognitive processes utilized in selecting, scheduling, and coordinating processes which control perception, memory, and action (Meyer & Keiras, 1997; Norman & Shallice, 1986). For such functioning to occur individuals must be consciously allocating resources to its operation (Rogers & Monsell, 1995). As such, the operation of executive functions can be disrupted by other cognitive tasks. Thus, occurrences of ostracism may serve to deplete cognitive resources, resulting in decreases in a wider array of cognitive tasks such as intelligent thought and self regulation.

Action Monitoring and the Error-Related Negativity

The process of action monitoring fits the criteria of a cognitive task which would be adversely affected by the experience of social exclusion. Action monitoring, or response monitoring, refers to the cognitive task of analyzing one's responses to a task to determine the occurrence of errors (Olvet & Hajcak, 2008). The detection of errors plays a role in any goal directed behavior and signals a need for increased cognitive control (Holroyd & Coles, 2002; Olvet and Hajcak, 2009). Research has also shown that action monitoring, and event-related brain potentials (ERPs), can be influenced by social factors (Themanson et al., 2008). In relation to the current study, action monitoring plays a role in individuals' monitoring of social situations, allowing for the avoidance of negative social consequences such as ostracism.

One way in which action monitoring is often assessed is by utilizing ERPs to find the neural response to errors. Event related potentials are cortically derived electrical impulses which occur in response to a stimulus. Specifically, the error-related negativity (ERN), which is examined in the current study, is an ERP commonly associated with action monitoring. The ERN is a negative deflection which occurs around 50 ms following an error, and is observed in frontal-central midline sites (Gehring et al., 1993; Olvet & Hajcak, 2009). As such, the ERN is seem to be an indication of early error processing and is thought to represent the activation of an internal response-monitoring system (Hajcak, McDonald, & Simons, 2004; Olvet & Hajcak, 2009; Ridderinkhof et al., 2004).

For the current study, ERPs were monitored during participant completion of a modified Eriksen flanker task (details on the modified flanker task utilized in the current study can be found in the methods section). The flanker task has been previously utilized to study the action monitoring process, and has been found to elicit enough errors for ERN analysis (Holroyd and Coles, 2002; Yeung, Botvinick, and Cohen, 2004; Themanson et al., 2008).

Present Study

The goal of the current study was to examine the relationship between ostracism and subsequent cognitive self-regulation. To achieve this goal, neural (ERN) and behavioral (post-error accuracy and response time) indices were assessed prior to and following a social event

(Cyberball) in which participants were either ostracized or fully included. Due to the noted effects on ostracism on social monitoring processes, and the previously determined effect of social factors on ERN and action monitoring, it was hypothesized that ostracism would result in a decrease in ERN amplitude signifying decreased action monitoring. Similarly, the effect of ostracism was expected to be portrayed behaviorally through slowed reaction time in post-error trials of the flanker task and a decrease in post-error response accuracy. Such results would indicate a degradation of the individual's self-regulatory functioning, corroborating and furthering previous research on the subject (Baumeister et al., 2005). Thus, the current study would further research on the impact of social exclusion to address a hole in the literature regarding the effect on neural indices of self-regulatory action monitoring. Specifically, the authors predicted that participants who experience ostracism during Cyberball would exhibit this effect through decreased ERN amplitude, decreased post-error accuracy and post-error response time during subsequent performance of the flanker task.

Methods

Participants

Twenty-nine participants were initially recruited for the current study from a pool of students enrolled in a General Psychology course at Illinois Wesleyan University. Following the experiment, eight participants were dropped from analysis due to issues with their data. Specifically, there was either an excess number of EEG artifacts, the commission of too few errors for ERN analysis, or an excessive number of errors during flanker trails (so that the participants' percent correct dropped below chance). Characteristics of the remaining participants are exhibited in Table 1. Participants were between 18-25 years of age and received course credit for taking part in the experiment. Participants were randomly assigned to either an exclusion group or an inclusion group. The study was approved by the Institutional Review Board at Illinois Wesleyan University.

Assessments and Manipulations

Preliminary Assessments. Prior to beginning the experiment participants were administered a series of questionnaires including a health and demographics questionnaire, the Edinburg 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 obtained from the International Personality Item Pool (IPIP, http://ipip.ori.org) which assesses participants' personalities based on the Big Five personality factors (Goldberg et al., 2006). These measures were collected for use in future studies. Immediately before and after each block of Cyberball participants also completed a brief needs and feelings assessment based on the social needs model of ostracism (Williams, Cheung, & Choi, 2000; Zadro, Williams, & Richardson, 2004) and the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). These assessments were utilized so that the influence of individuals' differences on the neuroelectric and behavioral measures present in the current study could be evaluated.

Cognitive Assessment. A modified version of the Eriksen flanker task (Eriksen & Eriksen, 1974) was utilized to assess cognitive ability in the current study. Previous research has utilized the flanker task to assess action monitoring processes (Holroyd and Coles, 2002; Yeung, Botvinick, and Cohen, 2004). Specifically, during completion of the flanker task participants' error-related negativities (ERN) have been monitored, providing a neural measure of the individual's action monitoring. Additionally, studies have determined that the modified version of the flanker task utilized in the current study give rise to a large enough number of errors to analyze the ERN (Olvet & Hajcak, 2009; Themanson et al. 2008). While the original version utilized letters (Eriksen & Eriksen, 1974), the current version of the flanker task utilized stimuli in the form of 4 cm high white symbols (“<” and “>”) presented on a black screen. The target stimuli were flanked by two symbols on either side which were either congruent (“<<<<<” or “>>>>>”) or incongruent (“<<><<” or “>><>>”) with the target. In congruent stimuli the flanking symbols were identical to the target symbol, and thus did not evoke activation of the incorrect response mapping. In contrast, the flanking symbols in incongruent stimuli did not match the target symbol, leading to an activation of the incorrect response mapping. Incongruent stimuli were designed to elicit a larger number of response errors and delays (Themanson, Pontifex, & Hillman, 2008). Stimuli were presented on screen for 200 ms with inter-stimulus intervals (ISI) varying randomly between either 1200, 1500, or 1800 ms. Participants were instructed to respond to stimuli as quickly and accurately as possible by pressing a button on a control pad corresponding to the direction the target symbol is pointing. Blocks contained 300 stimuli with congruent and incongruent conditions randomly ordered and equally probable. Participants completed two blocks of the task for a total of 600 trials both before and after the Cyberball paradigm to ensure enough errors (greater than or equal to six) were obtained for each participant prior to, and following, the social task. Blocks of the flanker task were counterbalanced across participants (Olvet & Hajcak, 2009; Pontifex et al., 2010). Average response times (RT) on the flanker task was calculated for 1) correct trials, 2) error trials, and 3) correct trials following an error trial (post-error RT).

Ostracism Manipulation. Participants were told that during the course of the experiment they would be playing a computerized game of “catch” (Cyberball) over the internet with two other players. The current study employed a cover story similar to that used in previous ostracism research where fMRI data was recorded (Eisenberger et al., 2003). Participants were told that two other participants were taking part in the game of Cyberball at other universities where their neural activity was also being monitored. The universities named were the University of Illinois and Illinois State University, due to their geographic proximity with Illinois Wesleyan University. Participants were also told that there was no ultimate goal of the game, and that it served only to allow the researchers to monitor social activity while taking neural measurements. In reality, the other players in the game were part of the Cyberball program and their actions were controlled by the computer program. Further, their actions, along with those of the participants, were electronically stored on the computer the participant uses during the task (Williams, Cheung, & Choi, 2000).

Blocks of the Cyberball task were designed to either include or exclude the participant by altering a pre-programmed sequence of throws. Each participant was randomly assigned to either the include group or exclude group prior to the experiment. For the current study, in the inclusion block there was a 50% probability that computer throws would be to the participant, and thus the participant was fully included in the game. In the exclusion block participants received ten throws with 50% probability to start the game and then they did not receive any further throws for the remainder of the block (approximately 40-50 throws). Instead, the computer players threw the ball exclusively to each other.

Neural Assessment. Neural assessment took the form of an electroencephalogram recorded via 64 sintered Ag-AgCl electrodes embedded in a lycra electrode cap (Neuro Inc., El Paso, TX). Electroencephalographic data was collected during all blocks of the study but the primary analysis involved only data from the flanker task. Electrodes in the cap were arranged in a 10-10 system montage (Chatrain, Lettich, & Nelson, 1985) and prepared using Quik gel

(Neuro Inc., El Paso, TX). An electrode at the midpoint between Cz and CPz was be utilized as an online reference while AFz served as a ground site. Eye movements were monitored using vertical and horizontal bipolar electrooculographic activity (EOG) recorded by Ag-AgCl electrodes placed above and below the right orbit and near the canthus of each eye. Impedances of less than 10 kΩ were maintained for all electrodes. A Neuroscan Synamps2 bioamplifier (Neuro Inc., El Paso, TX), with a 24 bit A/D converter and +/- 200 millivolt (mV) input range, was used to continuously digitize (500 Hz sampling rate), amplify (gain of 10), and filter (70 Hz low-pass filter, including a 60 Hz notch filter) the raw EEG signal in DC mode (763 µV/bit resolution). Neuroscan Scan software (v 4.3.1) was used to record EEG activity and Neuroscan Stim (v 2.0) was used to control stimulus presentation, timing, and measurement of behavioral response time and accuracy.

Offline EEG processing included eye blink correction using a spatial filter (Compumedics Neuroscan, 2003) and re-referencing to average mastoids. Response locked epochs were created (-400 ms to 1000 ms relative to the behavioral response) and the data was low-pass filtered at 15 Hz (24dB/octave). To protect against differential artifacts from activity related to the stimuli average ERP waveforms for correct trials were matched to error trial waveforms on response time and the number of trials (Coles, Scheffers, & Holroyd, 2001). To remove any differences that may exist in the timing of processing due to differences in response latency for correct and error trials matching involved selecting individual correct trials for each participant, without replacement, that matched the response time for each of the error trials for the individual (Yeung et al., 2004). This process also resulted in an equal number of matched correct trials and error trials for each individual to compare differences across accuracy conditions (Themanson & Hillman, 2006; Themanson et al., 2008). ERN amplitude was quantified as the average amplitude between 0-100 ms post-response at FCz in the average waveforms for both error trials and matched-correct trials. The data for each participant was then outputted in ASCII format so that it could be analyzed statistically in SPSS 17.0. Utilizing these measures, a comparison between pre- and post-Cyberball ERN's was made, signifying the impact of the ostracism manipulation on action monitoring.

Procedure

The procedure took place in one session lasting approximately 120 minutes. Upon arrival, participants provided informed consent and were then told the cover story. Participants then completed a packet of forms including a health history questionnaire, the Edinburg handedness inventory (Oldfield, 1971), the Social Phobia and Anxiety Inventory (SPAI; Turner, Beidel, Dancu, & Stanley, 1989; Zadro et al., 2006), the Rejection Sensitivity Questionnaire (RSQ; Downey & Feldman, 1996), and the brief personality assessment mentioned previously (Goldberg et al., 2006). Participants were then seated in a comfortable chair one meter away from a computer screen and prepared for neuroelectric assessment in accordance with the guidelines of the Society for Psychophysiological Research (Picton et al., 2000). Once acceptable levels of electrical impedance were obtained the lights were dimmed and the participant was given instructions for the flanker task, followed by 20 practice trials of the task. Participants then completed the first two blocks (600 trials) of the flanker task. Upon completion of these flanker task blocks, participants were given a feeling and social needs questionnaire (Williams et al., 2000; Zadro et al., 2004) and the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). Participants were then given instructions about the Cyberball paradigm and allowed to ask questions. Participants then took part in two Cyberball games. Those who were randomly assigned to the inclusion group took part in two blocks of

Cyberball in which they were included in the game for its full duration. Participants in the exclusion group also completed two blocks of the Cyberball paradigm, with the first including them and the second excluding them. Following each block of Cyberball participants again filled out the previously mentioned feeling and social needs questionnaire and PANAS. Finally, participants completed another two blocks (600 trials) of the flanker task. Throughout the process of testing, participants were monitored by the experimenter, ensuring they adhered to proper testing protocol. After the completion of the final block of flanker task trials, participants were debriefed on the goals of the experiment and allowed to ask any questions they had about the experimental process.

Statistical Analyses

Initial analyses were conducted utilizing mixed-model ANOVA. Follow-up analyses utilized univariate ANOVA and two-tailed paired-samples *t* tests with Bonferroni correction. An experiment-wise alpha level of $p \leq .05$ was set for all analyses prior to Bonferroni correction. The analytical approach utilized in the current study was based on recommendations of the Society for Psychophysiological Research (Vasey & Thayer, 1987). ERN, post-error accuracy, and post-error response time were analyzed separately using omnibus 2 (time: pre, post) × 2 (group: inclusion, exclusion) mixed-model ANOVAs. Any significant zero-order correlations between potential moderators and the dependent measures were to be examined for moderation in accordance with the analytical procedures outlined by Baron and Kenny (1986).

Hypothesized statistical findings would show that the experience of exclusion results in decrease in ERN, a decrease in post-error response accuracy, and slowing of the individual's post-error response time. Thus, prior to the ostracism manipulation, ERN amplitudes should be comparable in both the inclusion and exclusion groups. However, in the post condition, the ERN in the inclusion group should theoretically show an increase in area due to a practice effect while those in the exclusion group should show no change or a decrease in area as a result of the detrimental consequences of ostracism on self-regulatory action monitoring. Similar findings would be evidenced for the behavioral measures as well, with decreased post-error response accuracy following ostracism compared to following inclusion and a slowing of post-error reaction time following ostracism compared to following inclusion in the Cyberball paradigm. Finally, analyses of the preliminary questionnaires utilized in the study will be conducted as a part of future research to explore the relationship of interpersonal factors with the variables of interest and are not germane to the present investigation. The PANAS and needs and feelings questionnaire results will be utilized to allow researchers to evaluate the effectiveness of the ostracism manipulation.

Results

Participant Characteristics

Table 1 summarizes participants' sex, age, rejection sensitivity scores (RSQ total), and social anxiety scores (SPAI; SP - AG). Participant scores did not significantly differ across social task (Cyberball) groups, t's(19) $\leq$ 1.0, p's $\geq$ .33. Separate 2 (Time: T1, T2) × 2 (Group: inclusion, exclusion) mixed model 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 differences across groups during their participation in the Cyberball paradigm. As predicted, all needs and feelings measures showed significant time × block effects (F's(1, 19) $\geq$ 7.3, p's $\leq$ .01, partial $\eta 2$ $\geq$ .28). More specifically, all of the needs and feeling scales (including both manipulation check measures) in the needs and feeling assessment showed the exclusion group to have a significant decrease in the fulfillment of their needs and positivity of their feelings across time whereas the inclusion group did not show this change across time. In relation to the PANAS, the Positive Affect subscale showed a similar, but marginal, time × block effect ($F(1, 19) = 4.0$, $p = .06$, partial η2 = .17) and the Negative Affect subscale showed no time × block effect ($F(1, 19) = 1.7$, $p = .21$, partial η2 = .08), suggesting affect was not as greatly influenced by the social exclusion manipulation when compared to needs and mood (see Table 2 for mean scores (SD) by block on each subscale/measure).

Flanker Task Check

An omnibus 2 (Congruency: congruent, incongruent) × 2 (Time: T1/pre, T2/post) × 2 (Group: inclusion, exclusion) mixed-model ANOVA was conducted for both overall response accuracy (% correct) and response time (RT) to ensure these data conformed to the expected effects. For response accuracy, only a significant congruency main effect was found $F(1, 19) = 54.4$, $p < .001$, partial $\eta^2 = .74$, suggesting participants performed more accurately on congruent trials (M = 92.9, SD = 6.1) than on incongruent trials (M = 81.1, SD = 11.1). The analysis of RT revealed a time main effect ($F(1, 19) = 18.5$, $p < .001$, partial $\eta^2 = .49$) and a congruency main effect ($F(1, 19) = 243.6$, $p < .001$, partial $\eta^2 = .93$), suggesting that participants responded more quickly at T2 (M = 379.7 ms, SD = 41.8 ms) compared to T1 (M = 397.0 ms, SD = 46.0 ms) and to congruent trials (M = 361.1 ms, SD = 42.5 ms) compared to incongruent trials (M = 415.1 ms, SD = 44.9 ms), respectively. These main effects were modified by a significant time × congruency interaction (F(1, 19) = 12.9, $p = .002$, partial $\eta^2 = .40$). Follow up *t* tests (with Bonferroni correction) were conducted to examine the changes in RT for each congruency across time. These analyses showed a significant time effect for incongruent trials ($t(20) = 4.7$, $p < .001$ and congruent trials ($t(20) = 3.6$, $p = .002$), indicating that the decrease in RT between T1 and T2 was greater for incongruent trials (RT Δ M = 21.8 ms, SD = 21.2) than congruent trials (RT Δ M = 12.8 ms, SD = 16.2).

ERN Area

Figure 1 provides grand-averaged waveforms by group (inclusion, exclusion) and time of flanker task (T1/pre, T2/post) at FCz. The omnibus 2 (Time: T1, T2) × 2 (Group: inclusion, exclusion) mixed model ANOVA revealed a significant time × group interaction effect ($F(1, 19) = 4.6$, $p < .05$, partial $\eta^2 = .20$), indicating that ERN values in the inclusion group (T1 M = -3.6, SD = 2.3; T2 M = -3.7, SD = 1.7) got more negative over time, while the ERN values from the exclusion group (T1 M = -3.5, SD = 3.4; T2 M = -2.0, SD = 2.6) became more positive over time (see Figure 2). Follow up *t* tests (with Bonferroni correction) were conducted to examine the changes in ERN for each group across time. These analyses showed a significant time effect for excluded participants ($t(9) = 3.4$, $p = .007$, and no significant effect for included participants ($t(10) = .2$, $p =.83$, indicating that the decrease in ERN negativity between time one and time two was greater for the exclusion group than the inclusion group.

Post-Error Accuracy

The omnibus 2 (time: T1, T2) × 2 (group: inclusion, exclusion) mixed model ANOVA showed a significant time × group interaction ($F(1, 19) = 4.5$, $p < .05$, partial $\eta^2 = .19$). This finding indicates that while post-error accuracy increased between T1 (M = 86.5, SD = 8.0) and T2 (M = 92.7, SD = 6.9) for the inclusion group, a decrease in post-error accuracy was observed from T1 (M = 85.4, SD = 6.3) to T2 (M = 76.0, SD = 23.9) for the exclusion group (see Figure 3). Follow up *t* tests (with Bonferroni correction) were conducted to examine the changes in post-error accuray for each group across time. These analyses showed a significant time effect for included participants ($t(10) = 2.7$, $p = .02$), and no significant effect for excluded participants

($t(9) = 1.3$, $p = .22$), indicating that the increase in post-error accuracy between T1 and T2 was greater for the inclusion group than the exclusion group.

Post-Error RT

An omnibus 2 (time: T1, T2) × 2 (group: inclusion, exclusion) mixed model ANOVA revealed a significant time main effect ($F(1,19) = 4.9$, $p < .05$, partial $\eta^2 = .21$), indicating that post-error RT was significantly faster at T2 (M = 390.5 ms, SD = 52.3 ms) compared to T1 (M = 410.7 ms, SD = 54.1 ms), regardless of group membership (inclusion, exclusion). No group effects were revealed in the analysis of post-error RT.

Discussion

The present data confirm the negative impact of social exclusion on cognitive self-regulation as observed through electroencephalographic means while supporting the hypotheses proposed by the authors. The first aim of the current study was to determine the impact of an experience of social exclusion on ERNs measured through electroencephalographic means. The authors hypothesized that because social exclusion has been shown to influence an individual's social monitoring ability; action monitoring would also be impacted. Because action monitoring has previously been associated with the ERN, changes in this measure would provide an easy means to observe the effect of social exclusion on self-regulatory abilities (Hajcak, Mcdonald, & Simons, 2004; Olvet & Hajcak, 2009; Ridderinkhof et al., 2004). Specifically, it was hypothesized that following an experience of social exclusion via the Cyberball paradigm, participants' ERNs during a subsequent flanker task would decrease in area. The results of the current study support this hypothesis, indicating that the ERN can be used as an observable indicator of the cognitive consequences of social exclusion. In a broader sense, because the literature on ostracism has previously not included research utilizing neuroelectric measurements, this finding indicates that the previously noted effects of ostracism can be observed on a neural level, as well as the previously observed behavioral level.

Additionally, the authors predicted that along with a decrease in ERN amplitude, participants who were excluded would exhibit deficits in behavioral measures of cognitive performance during the subsequent flanker task. Such data would support current research indicating cognitive consequences of social exclusion, but would also provide novel data which indicate that cognitive deconstruction can be observed through direct measures of self-regulation following error commission. Specifically, it was hypothesized that following and event of social exclusion in the form of the Cyberball paradigm, participants would exhibit a decrease in post-error accuracy in the flanker task. This hypothesis was supported, with included participants exhibiting a significant increase in post-error accuracy between T1 and T2 (which can likely be attributed to an expected practice effect), while excluded participants exhibited a decrease in post-error accuracy between T1 and T2.

These findings corroborate previous research stating that social exclusion results in cognitive deconstruction characterized by a decrease in the individual's self-monitoring capabilities (Baumeister, Twenge, & Nuss, 2002; Williams, 2007a). Additionally, the current study examined the use of the ERN as a neural index of self-monitoring deficits following an event of social exclusion. The finding that ERN area decreased in subsequent task performance, when following an event of ostracism, indicates that the current literature can be expanded to include action monitoring among the constructs which are negatively impacted by social exclusion. Present results also indicate that the impact of social exclusion can be observed through behavioral measures, as exhibited by the observed decrease in post-error response accuracy during the flanker task in individuals who were excluded during the Cyberball paradigm.

ERN Deficits

One of the goals of the current study was to explore the applicability of ERN data to previous research stating that ostracism has a negative impact on an individual's self regulatory ability. Individuals who experience ostracism exhibit an immediate drop in cognitive functioning surrounding the event of exclusion (Williams, 2007a, 2007b; Baumeister & Dewall, 2005). These cognitive consequences include general cognition, and more pertinent to the current study, self-regulatory ability (Baumeister & Dewall, 2005; Baumeister, Twenge, & Nuss, 2002). The ERN is an evoked response which has been previously linked to the process of self-regulatory action monitoring in prior studies by numerous researchers (Hajcak, Mcdonald, & Simons, 2004; Olvet & Hajcak, 2009; Ridderinkhof et al., 2004). As such, the authors of the current study hypothesized that the ERN, as an index of action monitoring, would be negatively impacted by ostracism in a manner similar to other self-regulatory measures.

The current study confirms that experience of ostracism results in cognitive consequences in the form of decreased ERN amplitude. Specifically, following the Cyberball manipulation, individuals who were part of the exclusion group exhibited a decrease in ERN amplitude, while those who were included in Cyberball demonstrated an increase in ERN amplitude. Because a slight increase in ERN was expected due to the effect of practice, the decrease in ERN exhibited by the exclusion group demonstrates a significant deviation from normal functioning. This finding confirms that ostracism inhibits the individual's subsequent self-regulatory action monitoring ability (in this case in the form of ERNs). Also, this finding extends the literature to include neural measures of self-regulation, as the ERN is believed to index the initial detection of erroneous task execution or response conflict as part of the larger self-regulatory action monitoring system. Because the neural aspects of the cognitive deconstruction process have previously been unexplored, this finding provides a novel means of assessing the cognitive deficits associated with social exclusions. Additionally, the finding that the ERN is impacted by events of social exclusion demonstrates that the previously noted consequences of ostracism also occur at a neural level.

Post-Error Behavior

As with ERN data, post-error accuracy provides a valuable indicator of the extent of self-regulatory deficits following an event of ostracism. Current literature has not explored the behavioral measures of self-regulatory functioning following the commission of errors, and as such the findings regarding the impact of ostracism on post-error accuracy further the literature on social exclusion. Because post-error accuracy is a behavioral component of the individual's regulatory response to the commission of errors, the observed decrease in post-error accuracy following social exclusion can be viewed as an occurrence of cognitive deconstruction (Baumeister, Twenge, & Nuss, 2002; Williams, 2007a).

Specifically, in the current study, participants in the exclusion group exhibited a decrease in post-error accuracy at T2 in comparison to T1, while participants in the inclusion condition showed a significant increase in post-error accuracy from T1 to T2. This suggests that participants who were excluded were less able to compensate for the commission of errors than those who were not excluded, suggesting that the occurrence of ostracism resulted in a decrease in action monitoring capability, which conforms to the expectations of the cognitive deconstruction theory of ostracism. This data extends current findings on the topic to include direct measures of self-regulatory outcomes following error commission.

Limitations of the Current Study

Although the current data present an interesting depiction of the effects of ostracism on neural and behavioral indices of self-regulation, there are a number of limitations present in the current study. While the observed effects proved to be significant with the current pool of participants, an ideal study of the current hypothesis would include a larger subject pool. Complications with participant data (such as the presence of excessive amounts of artifacts in EEG data, or too many or too few errors during the flanker task) resulted in several participants being dropped from the study and weakening the overall power of the analyses. Additionally, because participants were drawn from a pool of general psychology students at Illinois Wesleyan University, a large level of uniformity exists in the participants' demographic characteristics. This limits the generalizability of the current findings, and would have to be remedied by expanding the participant pool to include individuals outside of the university setting of the current study.

Summary

In conclusion, the influence of social exclusion on cognitive self-monitoring was examined in healthy, college-age individuals. Findings supported previous research indicating that social exclusion results in a number of cognitive deficits, including a decrease in self-regulatory abilities (Baumeister, Twenge, & Nuss, 2002; Williams, 2007a). Additionally, the researchers of the current study found that individuals who experience an event of ostracism exhibited a decrease in ERN, showing that the effects of cognitive deconstruction from ostracism can be measured through electroencephalographic means. This finding also expands the literature on the topic to include action monitoring among the regulatory functions that are impacted by social exclusion. The current study also supported the findings of previous research indicating that cognitive deconstruction can be observed through behavioral measures. The use of post-error response time as an index of self-regulation is notable, as this provides a look at an actual self-regulatory response to the commission of an error, which previous studies involving the impact of ostracism on self-regulation have failed to do.

The observed decreases in self-regulatory performance ability are likely due to the reallocation of cognitive resources to the social interaction following an event of ostracism. Such results provide support for the neural alarm system proposed by Eisenberger and Lieberman (2004a). This theory suggests that an increase in activation of the anterior cingulate cortex (ACC) occurs following an event of ostracism. This increased activation is typically viewed as a reallocation of resources to better evaluate the event of ostracism, so that the individual can strive towards re-inclusion (Eisenberger & Lieberman, 2004b). In order to accommodate increased activity in the ACC, neural resources are withdrawn from other cognitive systems, resulting in the occurrence of cognitive deconstruction, which is exhibited in one form through the deficits in the ostracized individual's self-regulatory capabilities observed in the current study.

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Table 1

Mean (Standard Deviation) Demographic and Self-Report Information for All Participants and for Participants Categorized by Their Cyberball Manipulation Group

Variable	All Participants M (SD)	Inclusion M (SD)	Exclusion M (SD)
Sample size (*n*)	21	11	10
Sex (M/F)	12/9	6/5	6/4
Age (years)	18.6 (.9)	18.5 (.9)	18.8 (.9)
Social Anxiety score (SP-AG)	58.7 (17.8)	55.0 (18.5)	62.7 (17.0)
Rejection Sensitivity score (RSQ total)	14.1 (2.8)	14.1 (3.2)	14.1 (2.3)

Table 2

Mean (Standard Deviation) Scale/Subscale Scores on the Self-Report PANAS and Needs and Feelings Assessment for All Participants Categorized by Group and Cyberball Block

	Inclusion Group		Exclusion Group	
Variable	Time 1 M (SD)	Time 2 M (SD)	Time 1 M (SD)	Time 2 M (SD)
Positive Affect (PANAS)	24.3 (8.6)	24.2 (6.2)	21.5 (5.3)	16.1 (6.0)
Negative Affect (PANAS)	12.9 (2.7)	12.4 (3.6)	14.0 (6.2)	15.1 (4.5)
Need to Belong	4.2 (.7)	4.2 (.3)	4.2 (.7)	2.4 (.7)
Need for Self-esteem	3.6 (.6)	3.5 (.5)	3.5 (.7)	2.5 (.4)
Need for Meaningful Existence	4.0 (.7)	4.2 (.4)	4.0 (.5)	2.4 (.8)
Need for Control	3.3 (.4)	3.3 (.7)	3.6 (.6)	2.0 (.7)
Mood	3.9 (.5)	4.0 (.4)	3.8 (.6)	2.8 (.7)
Manipulation Check (extent ignored/excluded)	1.6 (1.0)	1.7 (.7)	1.3 (.7)	4.0 (.9)
Percentage of Throws Received	37.6 (7.4)	34.0 (7.9)	41.4 (17.5)	9.2 (6.9)

Figure Captions

Figure 1. Grand averaged response-locked waveforms for the inclusion and exclusion participant groups on both T1 (pre-Cyberball) and T2 (post-Cyberball) error trials during the flanker task at the FCz electrode site.

Figure 2. Mean ERN amplitudes for the inclusion and exclusion participant groups on both T1 (pre-Cyberball) and T2 (post-Cyberball) error trials during the flanker task at the FCz electrode site.

Figure 3. Mean post-error response accuracy values (% Correct) for the inclusion and exclusion participant groups on both T1 (pre-Cyberball) and T2 (post-Cyberball) flanker task performances.

Figure 1.

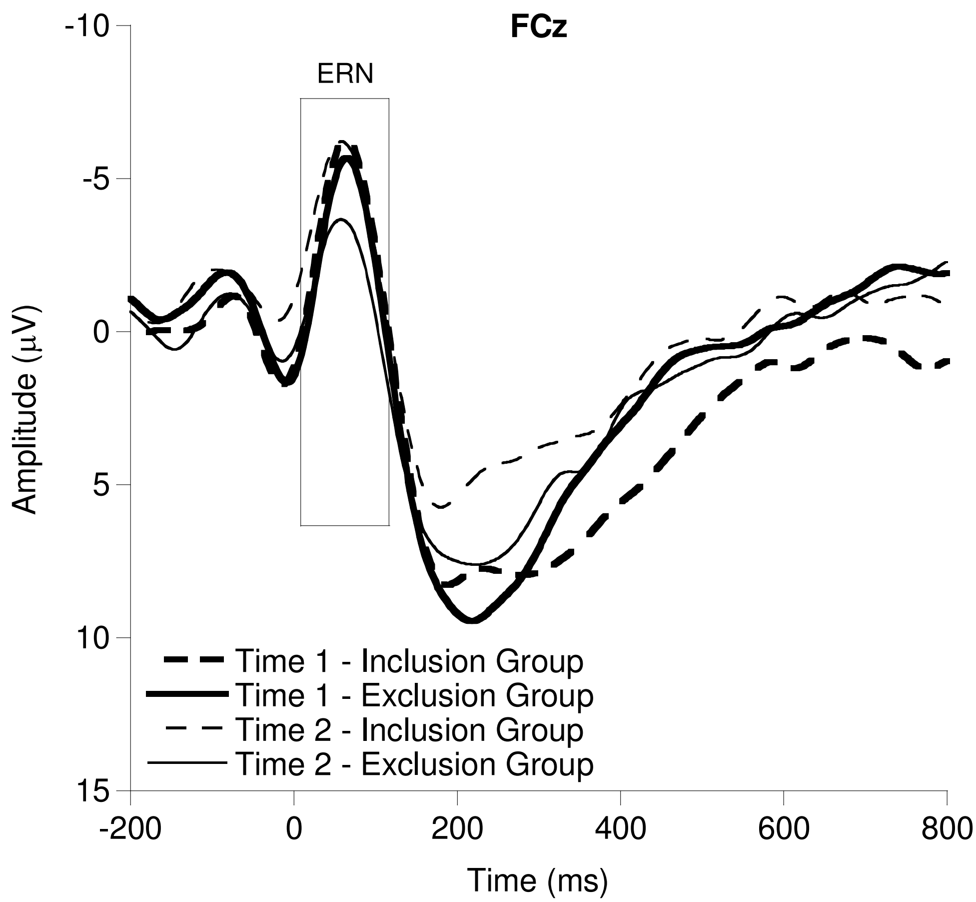

FCz
ERN
-10
-5
0
5
10
15
Amplitude (μV)
-200
0
200
400
600
800
Time (ms)
Time 1 - Inclusion Group
Time 1 - Exclusion Group
Time 2 - Inclusion Group
Time 2 - Exclusion Group

Figure 2.

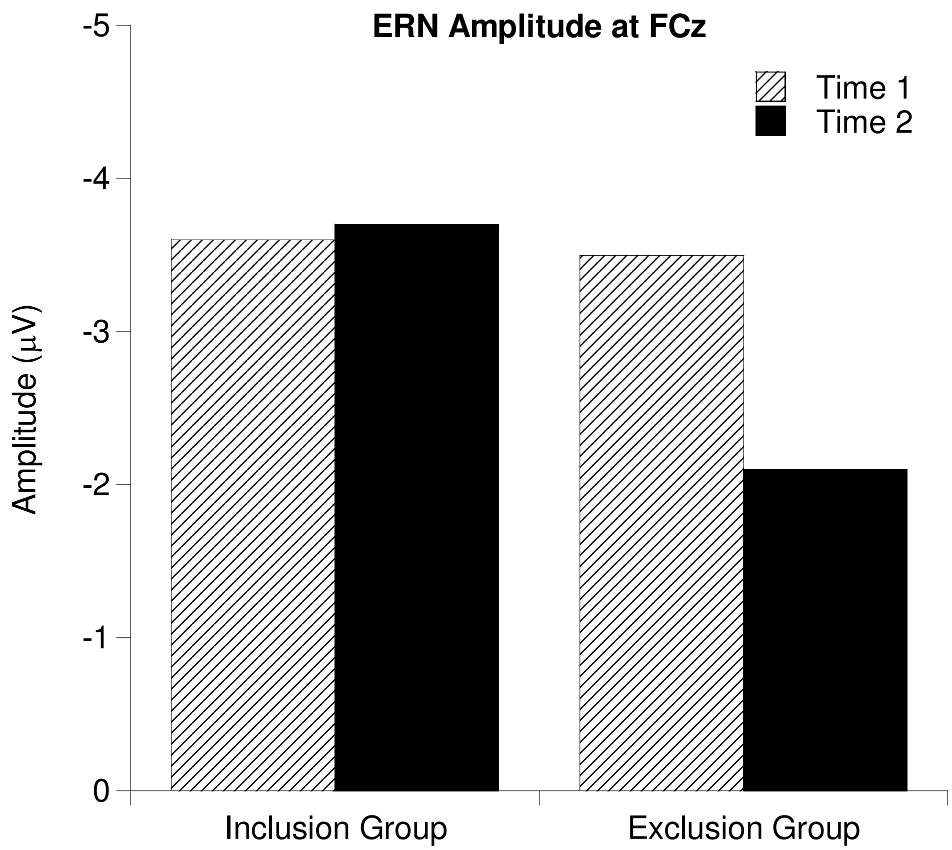
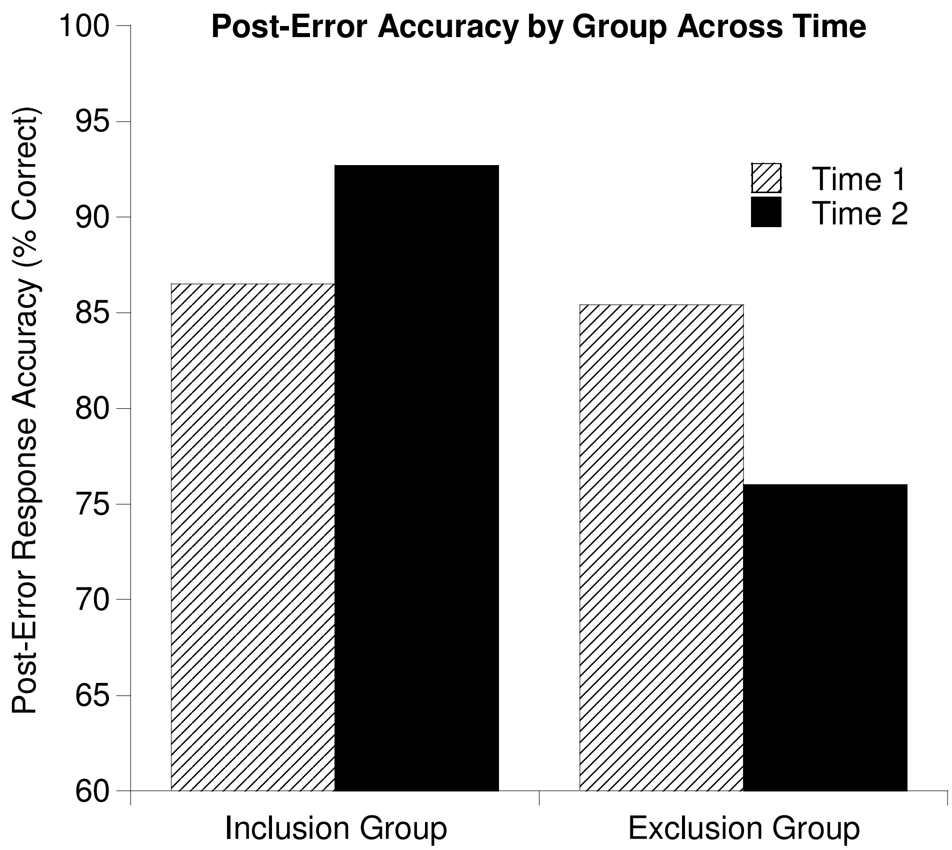

ERN Amplitude at FCz
Time 1
Time 2
Amplitude (µV)
-5
-4
-3
-2
-1
0
Inclusion Group
Exclusion Group

Figure 3.


Post-Error Accuracy by Group Across Time
Post-Error Response Accuracy (% Correct)
100
95
90
85
80
75
70
65
60
Time 1
Time 2
Inclusion Group
Exclusion Group