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The Evolution of Social Pain: Understanding the Neural Network of Social Ostracism through Electroencephalography

Daniel M. Kern
dkern@iwu.edu

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Daniel Michael Kern

Illinois Wesleyan University

Abstract

The lack of belonging or frequent exposure to social ostracism has maladaptive psychological and physical consequences. However, little is known about the mechanisms underlying the neural processes of social ostracism. Previously, Williams (2009) showed a decrease in theta power in the frontal lobe when female participants were ostracized in a virtual chat-room. Using male and female Illinois Wesleyan college students, this study manipulated two powerful social cues (biological sex and attractiveness level) to determine their effect on prefrontal brain activity in response to social ostracism in a virtual chat-room environment. Using EEG technology, frontal theta power (4-8Hz) was measured using three cortical electrodes (the F3, F4, and Fz sites). Using a similar procedure to Williams (2009), social ostracism was elicited using a well-established chat-room paradigm that involved 4 phases. In the introduction, inclusion, and re-inclusion phases, participants were actively involved in the conversation, in contrast to being actively ignored during the exclusionary phase. During the exclusionary phase of the experiment, we hypothesize a significant decrease in theta power across gender and attractiveness levels in the frontal lobe. Results revealed the virtual chat-room paradigm was successful in eliciting feelings of social ostracism. Participants reported lower levels of enjoyment, $F(2, 35) = 103.413$, $p = .000$, interest, $F(2, 35) = 89.89$, $p = .000$, and participation $F(2, 35) = 197.76$, $p = .000$, as well as lines typed, $F(1.564, 35) = 104.98$, $p = .000$, during the exclusionary phase in comparison to the inclusionary phases. In addition, males reported experiencing a significantly higher degree of ostracism than females, $F(1, 34) = 5.527$, $p = .025$. Theta power showed a non-significant, $F(2, 30) = 1.203$, $p = .180$, decrease in between phases, with inclusion showing the highest overall theta power and exclusion and re-inclusion showing lower degrees of theta power.

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Social interaction or affiliation is an instinctive behavior that all humans desire and certainly need (Leary, 2010). Unfortunately, the vast majority of adolescents and adults have experienced some sort of rejection or social ostracism (Leary, 2010). This type of behavior induces social pain, while simultaneously denying the social need for acceptance (Leary, 2010). Two contributing factors that influence individuals' motivation to interact and socialize include the particular sex and attractiveness level of the individual (Stroud, Salovey, & Epel, 2002). Although the need to belong is crucial for psychological homeostasis, the lack of belonging or frequent exclusive experiences have been shown to cause maladaptive psychological and physical consequences. To date, there has been little research examining these contributing factors and how they influence reactions to social ostracism (Eisenberger, 2006). This study examines whether attractiveness and biological sex contribute to individuals' responses to social ostracism as measured by alterations in neural activity. It is evolutionarily adaptive to possess a protective social neural alarm system that alerts an individual to the possibility of being ostracized, while relaying crucial information to specific structures responsible for providing an appropriate response to eliminate or minimize the possible negative psychological implications of being ostracized (Lorenz, Minoshima, & Casey, 2003). By examining the psychological effects of ostracism, and the environmental cues that affect its severity, researchers can better understand the specific structures involved and their overall contribution to an appropriate response.

Psychological Effects of Social Ostracism

Although people differ in how they respond and deal with rejection, it is clear that social ostracism is a painful and sometimes hostile experience that can impair individuals' emotional well-being, self-esteem, and social behavior (Ford & Collins, 2010). Being excluded has been shown to reduce one's sensitivity to physical pain as well as one's empathy towards an individual who has suffered some sort of physical or social injury (DeWall, & Baumeister, 2006). Instead of trying to change social routines or mannerisms to increase chances of social acceptance, most excluded individuals begin to socially malfunction by adopting self-defeating behaviors such as aggression, failure to self-regulate, decrease in intellectual functioning, and increases in risk taking behavior (DeWall, & Baumeister, 2006). Self regulation or self control is the ability for individuals to actively change specific behaviors, thoughts, and emotions to minimize pain and ensure positive outcomes (Krug, & Carter, 2010). If this regulatory system is not maintained through reliable social support groups, excluded individuals have trouble reacting to social ostracism in an effective way (Heckel, & Shumaker, 2001). Being excluded from a peer group or intimate relationship not only causes immense pain, but also elicits aggression that could be used to harm innocent bystanders. This aggression has been displayed in several school shootings such as Columbine and Virginia Tech, in which the perpetrators were both highly aggressive individuals who were rejected by fellow peers (Heckel, & Shumaker, 2001). Social ostracism disrupts self-control by preventing individuals from developing adequate personal and social skills necessary for inclusion eventually decreasing one's self-esteem, and increasing the possibility of psychological problems (Leary, 2010).

High self-esteem correlates with emotional well-being; whereas low self-esteem has been shown to contribute to symptoms of anxiety, depression, and conformity (Eisenberger, &Lieberman, 2004). In order to induce survival, humans have evolved to instinctively require the regulatory processes of self-esteem on the basis that the creation and maintenance of self-esteem is heavily dependent on the evaluation of interpersonal relationships (Williams, & Carter-Sowell, 2009). Self-esteem acts as a regulatory process by indirectly representing social connectedness through the manipulation of psychological health (Eisenberger, &Lieberman, 2004). Socially ostracized individuals experience increased negative self-feelings and a reduction in self-esteem that could possibly constrict relationship enhancement processes (Eisenberger, &Lieberman, 2004). In a study measuring psychological responses to interpersonal rejection, individuals with low trait self-esteem compared to individuals with high trait self-esteem responded to rejection pessimistically, exhibiting increased self-blaming attributions and aggression towards the rejecter (Ford, & Collins, 2010). In addition, individuals with a high sensitivity to rejection and a low self-esteem may try to alleviate the rejection or social ostracism by conforming to a group's certain set of unfamiliar rules or norms (Romero-Canyas, Downey, Reddy, Rodriguez, & Cavanaugh et al., 2010). Unknowingly, individuals may adopt new personal goals inevitably inducing maladaptive behaviors that make individuals susceptible to manipulation or abuse (Romero-Canyas et al., 2010). In addition to recognizing social ostracism's psychological effects, it is important to examine important social cues and their effect on influencing the severity of ostracism.

Sex Differences in Social Ostracism

Social interaction is based on the premise that human thought, emotion, and behavior is molded and institutionalized by human interaction based on characteristics including biological sex, age, race socioeconomic status and attractiveness level

(Eisenberger, & Lieberman, 2004). These differences serve as stereotypical moderators for personal and social evaluations that impact social interaction, as well as social ostracism (Ritts, Patterson, & Tubbs, 1992). Starting from birth, males and females are culturally categorized into socialized gender roles that condition individuals to follow a socially acceptable set of rules (Wester, Vogel, Pressly, & Heesacker, 2002). The interpretation and reaction to social ostracism is highly influenced by these normative guidelines (Wester, Vogel, Pressly, & Heesacker, 2002). Although previous literature has shown no moderation in self-reported distress levels with respect to sex differences during ostracism (Williams, & Sommer, 1997), recent brain imaging studies have revealed significant sex differences in the cortical electrophysiological processing of emotional stimuli (Kemp, Silberstein, Armstrong, & Nathan, 2004).By showing differences in the neural processing of emotion, it is possible males and females may demonstrate neural differences in processing ostracism, while failing to show any self-reported psychological differences.

Numerous studies have documented sex differences in the neural processing of emotion as well as threat detection, facial processing, reward/outcome processing, and nonverbal interpretation. The differences in processing these social cues can be seen by different brain activations and interpersonal sensitivity to specific emotional stimuli (Hall & Mast, 2008). It appears females are predisposed to process and react to emotionally-relevant stimuli due to their heightened response and unique bilateral activations of several neural structures that include the insular, prefrontal and parietal cortices, bilateral visual processing areas, thalamic nuclei, amygdala, caudate, putamen, and the postcentral and parahippocampal gyri (Kemp, Silberstein, Armstrong, & Nathan, 2004). Furthermore, George et al. (1996), observed increased activity for females in the bilateral anterior cingulate, left medial prefrontal cortex, left insula, and thalamus compared to males who failed to activate any of the prefrontal or anterior cingulate cortex (Kemp, Silberstein, Armstrong, & Nathan, 2004). This increase in activation is the underlying premise of Hankin and Abramson's (2001) cognitive vulnerability-transactional stress theory, which highlights the overrepresentation of females over thirteen diagnosed with depression (Kemp, Silberstein, Armstrong, & Nathan, 2004).

In addition to differences in neural processing of emotional stimuli, researchers have also found significant differences in the detection of nonverbal social cues such as facial expressions, body movements, postures, and tone of voice (Hall & Mast, 2008). Previous literature highlights female's enhanced ability to accurately judge a profile of personality, as well as remember dynamic cues such as shrugging, smiling, gazing, nodding, licking lips, and touching hair compared to males (Hall & Mast, 2008). By excelling in the detection, interpretation, and memory of emotional social cues, females may preferentially respond to social ostracism's negative effects. In a study measuring picture processing, females were more likely to respond to aversive stimuli with greater defensive reactivity than males, highlighting female's susceptibility to social ostracism (Bradley, Codispoti, Sabatinelli, & Lang, 2001).

Although currently there are no sex differences in psychological responses to ostracism, males and females may differ in how they detect and neurologically process ostracism. To date, there has been little research investigating biological differences in detecting and neurologically processing ostracism in a virtual chat-room paradigm. Combining females' hyperactivity of the limbic system, and advanced ability in detecting nonverbal social cues, it is possible sex differences may influence individuals' detection of social ostracism by detecting and neurologically processing emotional stimuli such as ostracism differentially.

Attractiveness Levels in Social Ostracism

Similar to biological sex, differences in attractiveness might also influence social interaction by allowing individuals to positively evaluate a significant other in order to determine their desirability to approach and interact or to protect and defend (Ritts, Patterson, & Tubbs, 1992). In today's society, being physically attractive is not only advantageous, but also a crucial characteristic that influences social interaction. Although physical attractiveness is a subjective and abstract concept, the majority of individuals, both male and female agree, on what is physically attractive (Franzoi, & Herzog, 1987). Researchers have also observed attractive students being stereotypically rated friendlier, more attentive, more popular, smarter, and more outgoing (Ritts, Patterson, & Tubbs, 1992). It appears "what is beautiful is good" (Dion, Berscheid, & Walster, 1972, 675). These characteristics not only help foster social relationships, but more importantly represent status, power, and success. In a study investigating jealously, a social characteristic involved in social relationships, Harmon-Jones, Peterson, and Harris (2009) observed increased cortical activation in the left frontal region when participants were exposed to sexually desired confederates during a modified version of the cyberball task. Highlighting the power of environmental cues such as desirability, this study supports the claim that specific environmental influences can alter biological and psychological responses to ostracism. Acting as a major contributor to desirability, attractiveness levels also have the capability to influence individuals' stress response, by altering perception and reaction to the social ostracism stimuli. In addition, an experiment measuring attractiveness and its effect on social interactions, found that when given the opportunity to converse with attractive females, males generally interacted less with the females and more with the males for fear of rejection (Reis, Wheeler, Spiegel, Kernis, Nezlek, & Perri, 1982). Attractiveness is not only a determining factor in whether to socialize with an individual or not, but also a contributing force to the severity of rejection and its tendency to elicit maladaptive behaviors.

A Common Neural Network

Using brain scanning techniques such as functional magnetic resonance imaging, a common neural network between physical and social pain has been found (Eisenberger, Lieberman, & Williams, 2003). Although social and physical pain may cause similar psychological trauma, perception and response to each particular pain vary greatly. Physical pain is any sort of distressing or unpleasant experience caused by actual physical tissue damage, whereas social pain is any distressing or painful experience in the face of psychological distance or exclusion by family, friends, or social groups (Eisenberger, & Lieberman, 2004). This adaptive overlap adopts the understood and accepted social attachment system evolved in mammalian species to prevent social separation inducing optimal survival (Eisenberger & Lieberman, 2004). In a study conducted by Eisenberger, Lieberman, and Williams (2003), participants who were intentionally excluded from a virtual ball tossing game demonstrated similar neural activation in brain structures that regulate physical pain. Furthermore, chronic social isolation through exclusion or marginalization may create long-term consequences on the physiological responses individuals have in social situations by increasing the levels of stress hormone cortisol via the neuroendocrine system (Ford, & Collins, 2010). In a study conducted by Ford and Collins (2010), researchers found that even minuscule cues of possible social rejection or exclusion were sufficient to evoke a full physiological stress response through greater cortisol reactivity. This response impairs individuals' social skills by quickly initiating defensive behaviors in the presence of possible threat or rejection (Ford, & Collins, 2010). Interaction has become so crucial for survival in today's society that over time specific social experiences such as inclusion and exclusion have become relevant causing the need for humans to evolve and adopt a neural network that regulates and controls these experiences. Following the social attachment system formulated by psychoanalyst John Bowlby, specific social experiences are controlled by the same neural structures as the physical pain system to serve as a strong foundation in the protection and regulation of the evolved attachment system seen in humans (Lieberman, & Eisenberger, 2006). This common neural alarm system detects, interprets, and reacts, to social stimuli to ensure safety and emotional well-being by activating and disrupting neural activity in specific brain structures responsible for the regulation of pain.

Structures Involved in Regulation

The neural network of social pain consists of brain structures such as the dorsal anterior cingulate cortex (dACC), right ventral prefrontal cortex (RVPFC), inferior frontal gyrus, posterior superior temporal sulcus (pSTS), temporo-parietal junction (TPJ), amygdala, and anterior insula (Sebastian, Viding, Williams, & Blakemore, 2010). Specifically the dACC has been shown to be influenced by the right ventral prefrontal cortex by disrupting the dACC's neural alarm system (Eisenberger, Jarcho, Lieberman, & Naliboff, 2006). In a study using fMRI images to determine when specific brain structures like the dACC and RVPFC are activated, researchers found that the dACC was more activated when participants were excluded and was inversely correlated with the RVPFC in self-reported distress (Eisenberger, Lieberman, & Williams, 2003). These findings parallel the results recorded by these two structures when testing physical pain.

This helps to answer why humans demonstrate an anxious attachment style when suffering from chronic pain disorders, as well as reporting lower levels of physical pain by increased social support during painful experiences such as cancer treatment and surgery (Eisenberger, & Lieberman, 2004).

Dorsal Anterior Cingulate Cortex

The dACC regulates and resolves conflict that endangers or threatens individuals' automatic or goal-directed behavior by monitoring the environment for possible threats or discrepancies and alerting prefrontal regions if a violation occurs (Eisenberger, & Lieberman, 2004). For example, in the Stroop task, a task that measures discrepancy detection using colors, researchers found that participants produced activation in neighboring and even overlapping regions of the dACC when a violation of the norm was presented (Eisenberger, & Lieberman, 2004). Furthermore, individuals with low social support showed greater activation in the dACC compared to controls when participating in a cyberball task (Masten, & Eisenberger, 2009). In this task, participants interacted in a computerized virtual ball tossing game designed to include participants in one stage and then exclude them in another to determine the neural activations caused by this specific type of ostracism (Williams, & Carter-Sowell, 2009). During the exclusionary stage of this task, participants' demonstrated activation in the dACC compared to when included (DeWall, & Baumeister, 2006). These studies demonstrate not only dACC's important role in monitoring the environment, an obvious evolutionary trait, but also the crucial role in creating a common computational basis for both physical and social pain. In studies measuring physical and social pain, the dACC has shown similar results, indicating its broad role in pain regulation (DeWall, & Baumeister, 2006). During physical pain, nociceptors send electrical impulses to the brain causing specific neurotransmitters and brain structures to become activated. Researchers concluded that the dACC was responsible for regulating the distressing and dreadful sensitivity to physical pain by demonstrating greater activation in high pain sensitivity participants (Masten, & Eisenberger, 2009). Similar to the regulatory processes of physical pain, the dACC monitors the environment for threatening stimuli such as social ostracism and transfers this information to the brain regions responsible for interpretation.

The Ventral Medial Prefrontal Cortex

After the dorsal anterior cingulate cortex becomes activated it alerts prefrontal regions like the right ventral medial prefrontal cortex (RVMPFC) to create an appropriate behavioral response (Eisenberger, & Lieberman, 2004). The RVMPFC, a structure responsible for coordinating complex behaviors, contributes to self-referential processing that incorporates and interprets information about the environment, the self, and others (Tesink, Buitelaar, Petersson, Gaag, Kan et al., 2009). Individuals with lesions to this area of the cortex show deficiencies in obeying normal social cues, impulse control, as well as conducting appropriate responses to social cues (Tesink et al., 2009). Similar to individuals with autism spectrum disorders, individuals with VMPFC lesions have trouble interpreting environmental stimuli, as well as maintaining normal emotional and social conduct (Dimitrov, Phipps, Zahn, & Grafman, 1999). Although these brain structures work in conjunction, it is important to note that there exists a negative relationship between activations. The RVMPFC has shown increased activation as a result from decreased dACC activation. This strong negative relationship could perhaps demonstrate the RVMPFC's responsibility as a self-regulatory structure responsible for disrupting dACC activity (Eisenberger, & Lieberman, 2004). It appears the RVMPFC functions as a physical and social pain mediator by reducing the distressing effects associated with it. This can be seen by such experiments as Zhang, Tang, Yuan, & Jia (1997), in which the sensation of pain is reduced through increased stimulation and activation of the RVPFC. In a study conducted by Kross, Egner, Ochsner, Hirsch, & Downey (2007) using fMRI technology, researchers found that high rejection sensitivity individuals failed to show any left prefrontal cortex activation compared to low rejection sensitivity individuals. This study supports the prefrontal cortex's role in top down cognitive control and interpretation of somatic information recognized by the amygdala (Kross et al., 2007).

The Amygdala

Similar to the dACC, this negative relationship has also been observed between the RVMPFC and the amygdala (Masten, & Eisenberger, 2009). The amygdala, a structure responsible for aiding in threat detection is decreased with increased activation of the RVMPFC (Masten, & Eisenberger, 2009). This structure is understood to be involved with social behavior and emotion, specifically recognizing and controlling emotional responses to facial expressions (Yang, Menon, Eliez, Blasey, White, Reid, Gotlib, & Reiss, 2002). The recognition of broad emotional expression may provide critical information in solving or reacting to difficult social situations such as ostracism. Recognizing broad and fearful facial expressions, the amygdala plays an important communicative role in threat detection and face processing (Morris, Friston, Buchel, Frith, Young, Calder, & Dolan, 1998). This structure evaluates the emotional significance of stimuli such as complex judgments of trusting other individuals (Adolphs, 2003). Participants with bilateral amygdala damage have shown abnormalities in their judgments of trustworthy people, rating individuals more trustworthy and approachable than normal viewers (Adolphs, 2003). By rapidly processing ambiguous emotional and threatening stimuli, the amygdala plays an important role in linking perceptual representations to cognition, influencing appropriate behavioral responses (Adolphs, 2001). Once activated, the amygdala tags somatic information gathered from the environment and transfers this vital information to the RVMPFC for interpretation (Bechara, Damasio, & Damasio, 2003).

Purpose of Study

Rather than using traditional functional magnetic resonance images (fMRI) to observe the neural network of pain modulation, this study adopts an innovative technique of electroencephalographic (EEG) recordings to examine theta rhythm. Due to the large emphasis on fMRI research and the limited use of EEG recordings, it is important to investigate whether each pair of these methods complement or contradict each other. In addition, fMRI studies rely on hypothetical scenarios that place the participant in a nonrealistic supine body position (Harmon-Jones, Peterson, & Harris, 2009). These two characteristics present limitations capable of altering results. For example, supine body positions during an fMRI have been shown to reduce the neural response to anger (Harmon-Jones, & Peterson, 2009). Using real-life scenarios and testing in an upright body position, EEG recordings offer an alternative to these limitations and offer a different perspective on neural activity. This noninvasive measure of electrical brain activity measures several brain wave frequencies such as theta (4-8 Hz), alpha (8-12 Hz), Beta (12-30), and Gamma (30-100+ Hz) (Nunez, & Srinivasan, 1981, 78). This study measures theta waves, specifically differences in amplitude, because it appears to be involved in the mediation of emotional processing such as empathy for pain in the anterior cingulate cortex, prefrontal cortex and insula (Mu, Fan, Mao, & Han, 2008). In a study measuring empathy for pain, participants showed increased theta event-related synchronization in the presence of painful stimuli highlighting theta's waves possible role in affective processing of empathy for pain (Mu, Fan, Mao, & Han, 2008). By utilizing theta waves' emotional characteristics in a relevant environment, a better understanding about the psychological effects of social interaction in a virtual chat-room can be investigated.

Using a virtual chat room paradigm to elicit cyber-ostracism is not only appropriate, but also extremely relevant as a result of today's emphasis on computerized communication such as on-line dating networks, as well as Twitter and Facebook. As social interaction becomes more virtualized, the importance and necessity for humans to receive immense social nurturing and adequate social inclusion has been supported by showing the serious mental and physical health concerns for those who have not had this need fully satisfied. Understanding how the brain perceives and reacts to social ostracism in a modern virtual environment will help clinicians create practical intervention programs, as well as offer a greater understanding as to how humans have evolved into a social species. As societies continue to grow and evolve placing greater importance on social instincts, it is crucial to understand the neural structures involved in the formation and denial of relationships. Due to previous research highlighting social ostracism's detrimental effects on individual's physiological and psychological well-being, the current study purposely ignores subjects in a specific part of the simulated chat room conversation to observe the unique activations of the social neural alarm system. Understanding social interaction is highly influenced by physical and environmental cues, sex differences and attractiveness levels were manipulated to determine if any significant differences arose in how participants perceived and reacted to social rejection. During the exclusionary phase of the experiment, we hypothesize a significant decrease in theta power causing a de-synchronization of theta activity across gender and attractiveness levels in the frontal lobe for college students during a virtual chat room study.

Method

Participants

There were 34 participants recruited for the study. There was no exclusionary criterion required to complete this study, except that the participants needed to be 18 years or older and have no previous knowledge about the current experimental procedures.

Attractiveness Manipulation

In order to create an appropriate attractiveness manipulation, several profile pictures were obtained through the web and pilot tested to acquire a general attractiveness rating. These pictures were normalized by only showing the face, and by having similar facial expressions and backgrounds. The pictures which included both males and females were rated on a 1-9 scale with 1 being the lowest and 9 the highest. The two pictures with the highest rating for both males and females were included into the study and represented the attractive manipulation (ratings between 7-9), while the two lowest pictures for both males and females were included to represent the unattractive manipulation (ratings between 1-3).

Social Ostracism Manipulation

Using a simulated chat room paradigm, this study investigated the effects of gender and attractiveness on social rejection through theta activity. This experiment was conducted at Illinois Wesleyan University in a psychology research laboratory under the guidelines of the university's Institutional Review Board (IRB). The laboratory consisted of two rooms separated by a one-way mirror. One room housed the researchers and three computers, while the other consisted of the EEG equipment and the computer used by participants.

Due to the nature of the experiment, participants were given a fictitious cover story that described the study's purpose as a measurement of EEG activity associated with one's personality and communication styles in a chat room setting. Participants were told they would be conversing with two other students from Illinois State University and University of Illinois, who in reality were two research assistants in an adjacent room serving as research confederates.

Procedure

Upon entering the laboratory, participants were asked to read and complete the informed consent, demographic information form, and if they heard or have any prior knowledge to the current experiment. Once this was completed, participants had their picture taken with a digital camera that uploaded to their online profile. Online profiles were viewable by all members in the chat room and consisted of participants' nickname, age, gender, major, university, favorite movies, books, bands, sports and activities/interests. In addition to the cover story, a mock phone call was implemented by a research assistant pretending to talk to another researcher from one of the two universities to support the cover story. Participants were then seated in front of a computer and asked to complete the rest of their online profile while research assistants fitted and programmed the EEG cap.

Electrophysiological Recording

Using the guidelines provided by Neurocognitive Kinesiology Laboratory and International 10-20 system, researchers fit the 64 electrode Quik-EEG cap by measuring the circumference of the participant's head (Eaton, OH). This was conducted by measuring in centimeters from the external occipital protuberance to the nasion (bridge of nose) and multiplying by one-tenth to ensure optimal conductance. In addition to scalp electrodes, six reference electrodes were used. Two vertical electroocular. graphic (VEOG) electrodes were positioned above (VEOU) and below (VEOL) the left eye to measure eye blinks. Two horizontal electroocularggraphic (HEOG) electrodes were used to measure horizontal eye movement, and positioned on the corner of the left (HEOL) and right (HEOR) eye. Furthermore, two mastoid (M) electrodes were used to serve as reference. These electrodes were positioned on the left (M1) and right (M2) Mastoid Process. To maximize the electrode-scalp junction, Electro-Gel was inserted using a blunt needle into the cortical electrodes. To ensure optimal conductance and contact, a chin strap was fitted to secure the electrodes against the scalp. In addition, mesh elastic gauze covered all cortical electrodes on the cap's exterior for improved connection. The EEG cap was connected to a computer in the adjacent room where data were recorded and saved by a Source 5 interface. When the participant was properly fitted and connected to the interface, the chat room portion commenced.

Chat Room

The chat room consisted of four members and two rooms; one room consisted of the participant, while the adjacent room consisted of two research confederates acting as students from University of Illinois and Illinois State University, in addition to the administrator. To ensure and maintain consistency between subjects, both confederates and administrator followed a detailed script and set of instructions for the exclusionary phase of the experiment. Upon starting the chat room, the participant was informed that the administrator was not affiliated with any of the universities, and was only responsible for administering instructions and controlling phase duration. As soon as the participant logged on to the simulated chat room, profiles were available to be viewed throughout the entire experiment. Upon entry, the administrator quickly welcomed everyone and instructed that the introduction phase was about to begin. This eight minute phase was designed to allow students to become familiar with the chat room setting, as well as a time to introduce themselves describing characteristics such as major, year in school, future plans, and hometown. After eight minutes the introductory phase ended and the administrator instructed the participant to complete one of the four concurrent measures of the experiment. These measures were administered after every trial of the experiment to assess participants' experiences and perceptions. In addition, the concurrent measures were used to determine if the exclusionary phase was a successful paradigm in creating feelings of ostracism.

Upon completion of the introduction phase, three eight minute experimental trials were conducted. These trials involved describing participants' favorite TV shows, hobbies/interests, and favorite restaurants. The first phase, the inclusionary phase, involved the participant and confederates conversing about one of the specific topics mentioned above. In this phase confederates involved the participant in conversation as much as possible, by mentioning the participants name several times, as well as asking relevant questions about his or her statements. The second phase, the exclusionary phase, involved the participant being completely excluded from the conversation. This was done by two confederates following a detailed script that described an ambiguous topic with total disregard to anything mentioned by the participant. For the third and final phase, the re-inclusionary phase, confederates discussed the last topic with the participant by once again including the participant as much as possible.

After the final concurrent measurement was completed, research assistants helped the participant log off, remove the EEG cap, and administer the final overall experimental questionnaire. This questionnaire differed from the concurrent measures by assessing the participant's overall experience, opinion on the attractiveness manipulation, as well their belief in the virtual chat room paradigm. Upon completion of the final questionnaire, participants were thoroughly debriefed about the true nature of the experiment and the reasons why they were deceived. In addition, participants were told that the exclusionary phase was simply an experimental design that was irrelevant to any individualistic characteristics, and that the two students from Illinois State University and University of Illinois were merely research confederates. Any questions or concerns about the experiment or confidentiality were answered thoroughly and participants were encouraged to contact external resources if needed.

Results

Success of Social Ostracism Paradigm

After each phase of the experiment, participants completed a concurrent measure designed to evaluate participants' interest, enjoyment, and participation during each phase. The data was analyzed by using a one-way repeated measures ANOVA with level of interest, enjoyment, and participation as dependent variables, task phase as a within-subjects variable, and gender and the attractiveness manipulation as between-subject variables.

Enjoyment

The self-report scores for participant enjoyment, $F(2, 35) = 103.413$, $p = .000$, revealed a significant main effect of phase (see Figure 1). Subsequent t-tests revealed significant differences in enjoyment between the inclusion and exclusion phases, $t(34) =$

11.225, p = .000, and the exclusion and re-inclusion phases, $t(34) = -12.317$, p = .000, but not the inclusion and re-inclusion phases, $t(34) = -1.435$, p = .160. Participants reported lower levels of enjoyment during the exclusionary phase of the experiment, compared to an increased level of enjoyment during the inclusionary phases.

Interest

The self-report for participant interest, $F(2, 35) = 89.890$, p = .000, revealed a significant main effect of phase (see Figure 1). Subsequent t-tests revealed significant differences in interest between the inclusion and exclusion phases, $t(34) = 9.937$, p = .000, the exclusion and re-inclusion phases, $t(34) = -12.395$, p = .000, and inclusion and re-inclusion phases, $t(34) = -2.420$, p = .021. Participants reported lower levels of interest during the exclusionary phase of the experiment, compared to an increased level of interest during the inclusionary phases. Participants also reported a greater level of interest during the re-inclusionary phase compared to the inclusionary phase.

Participation

The self-report for participant participation, $F(2, 35) = 197.761$, p = .000, revealed a significant main effect of phase (see Figure 1). Subsequent t-tests revealed significant differences in participation between the inclusion and exclusion phases, $t(34) = 15.305$, p = .000, the exclusion and re-inclusion phases, $t(34) = -17.456$, p = .000, and inclusion and re-inclusion phases, $t(34) = -2.172$, p = .037. Participants reported lower levels of participation during the exclusionary phase of the experiment, compared to an increased level of participation during the inclusionary phases. Participants also reported a greater level of participation during the re-inclusionary phase compared to the inclusionary phase.

Lines Typed

In addition to assessing participants' self-reported contribution to the chat-room, participation was also assessed objectively by analyzing the amount of lines typed within each phase of the experiment. A one-way repeated measures ANOVA with task phase as a within-subjects variable, and lines typed as the dependent variable, revealed a significant main effect for phase, $F(1.564, 35) = 104.983$, $p = .000$ (see Figure 2). Subsequent t-tests revealed significant differences in the number of lines typed during the inclusion and exclusion phases $t(34) = 11.129$, $p = .000$, and the exclusion and re-inclusion phases $t(34) = -11.853$, $p = .000$, but not the inclusion and re-inclusion phases $t(34) = -.714$, $p = .480$. During the exclusionary phase of the experiment, participants did not participate as much as during the inclusionary phases.

Social Ostracism Manipulation

A correlation was found between participants' degree of being left-out and how much this upset him or her, $r = .345$, n = 35, $p = .042$, indicating the more a participant felt ostracized, the more this upset him or her.

Attractiveness Manipulation

A Pearson correlation coefficient was computed to assess the relationship between the attractiveness manipulation and participant ratings. There was a strong correlation between the attractive and unattractive photos and participants' rating of the photos, $r = .775$, n = 35, $p = .000$, indicating the attractiveness manipulation was successful in portraying attractive and unattractive individuals (See Figure 3). Participants accurately rated the "attractive" chat-room members as attractive, and the "unattractive" chat-room members as unattractive.

Effects of Gender and Attractiveness Manipulation on Social Ostracism Paradigm

Attractiveness Manipulation

There was a significant between-subjects main effect of the attractiveness manipulation on participants' reported level of participation, $F(1, 31) = 4.201$, $p = .049$, (see Figure 4). Participants' reported participating more with the unattractive chat-room members in all phases of the experiment.

There were no significant between-subjects main effects for the attractiveness manipulation and participants' reported level of enjoyment, $F(1, 31) = 1.906$, $p = .177$, and interest, $F(1, 31) = 1.635$, $p = .210$, (see Figure 4). Participants reported similar levels of enjoyment and interest when talking to the attractive and unattractive chat-room members.

There were no significant between-subjects main effects for the attractiveness manipulation and number of lines typed during the chat-room, $F(1, 31) = 3.419$, $p = .074$. There were no differences in the amount of lines typed when participants interacted with the attractive and unattractive chat-room members.

Sex Differences

After the chat-room was completed, participants' completed a series of questions about the overall chat-room experience. Personal reactions to the ostracism were measured by such questions as, "Did you ever at any time feel left out of the chat room," and "If left out, to what degree did this rejection upset you". There was a significant between-subjects main effect of biological sex, $F(1, 34) = 5.527$, $p = .025$, indicating males reported experiencing a significantly higher degree of ostracism than females (See Figure 5).

There were no significant between-subjects main effects for participants' sex and reported level of participation, $F(1, 31) = 1.450$, $p = .238$ enjoyment, $F(1, 31) = .220$, $p = .642$, interest, $F(1, 31) = .300$, $p = .588$, and lines typed, $F(1, 31) = .597$, $p = .446$.

Participants' biological sex did not affect reported levels of participation, enjoyment, interest, and lines typed; males and females showed similar self reports, and lines typed within each phase of the experiment.

Interaction Effects

There were no significant between-subject interaction effects between the attractiveness manipulation and the participant's biological sex for self-reported level of participation, $F(1, 31) = 3.558$, $p = .069$, enjoyment, $F(1, 31) = .639$, $p = .430$, interest, $F(1, 31) = .910$, $p = .347$, and lines typed, $F(1, 31) = .093$, $p = .911$. There were no differences in participants' participation, interest, and enjoyment levels, as well as lines typed whether the participant interacted with an attractive or unattractive chat-room member, or if the participant was a male or female.

Theta Power

EEG

Eight participants were excluded from the EEG analysis due to missing data or excessive noise during the EEG recording. Therefore, frontal EEG analyses were based on a total of 29 participants.

A one-way repeated measures ANOVA was used to determine whether the chat-room paradigm was successful in altering frontal theta power by using theta power as the dependent variable, and phase (inclusion, exclusion and re-inclusion) as a with-in subject variable. Results showed a non-significant, $F(2, 30) = 1.203$, $p = .180$, difference in theta power between phases. There were no differences in theta power between the inclusionary, exclusionary, and re-inclusionary phases of the experiment (see Figure 6).

Upon further analysis, a non-significant interaction effect was found between phase and the attractiveness manipulation, $F(2, 30) = 2.849$, $p = .055$ (see Figure 7).

Participants' exposed to the attractive chat-room members showed no difference in theta power from the inclusionary to the exclusionary phase, and from the exclusionary to the re-inclusionary phase. Subsequent t-tests revealed a non-significant difference in theta power when exposed to attractive chat-room members between the inclusion and exclusion phases, $t(11) = 2.054$, $p = .065$, the exclusion and re-inclusion phases, $t(11) = -.046$, $p = .964$, and the inclusion and re-inclusion phases, $t(11) = 1.669$, $p = .123$. These results reveal participants ostracized by the attractive chat-room members showed no differences in neural responses to participants ostracized by the unattractive chat-room members.

No significant differences in theta power were found when participants interacted with unattractive chat-room members between the inclusion and exclusion phases, $t(16) = .020$, $p = .985$, exclusion and re-inclusion phases, $t(16) = -.571$, $p = .576$, and inclusion and re-inclusion phases, $t(17) = -.556$, $p = .585$. Participants' exposed to the unattractive chat-room members showed a relatively stable theta power throughout all three phases of the experiment (see Figure 7).

Discussion

Ostracism generally refers to any type of exclusion of an individual or group from others (Williams & Sommer, 1997). Although the need for social interaction is critical for psychological well-being, little is known about the neural processes involved. According to Ralph Adolphs (2003), social nature defines what makes us human. In a world of constant technological advancements, it is important to understand how virtual communication relates to our desire to interact. By creating a realistic paradigm that mimics virtual communication, researchers can better understand how individuals' respond to cyber-ostracism. Self-report measures and analysis of lines typed within each phase of the experiment support the success of the virtual chat-room paradigm in eliciting social ostracism. The main hypothesis that frontal theta power would change between phases, specifically during the exclusionary phase was not supported, although revealed a possible trend leaning towards signifigance between theta power and phase, with inclusion showing the highest overall theta power and exclusion and re-inclusion showing lower degrees of theta power. Due to the preliminary nature of the experiment, it is possible future studies adopting a similar procedure will reveal significant results. Non-significant differences were also found for the attractiveness manipulation and biological sex, which future studies should take into consideration when investigating social cues' influence on social ostracism. A few of these non-significant differences include participants showing an increase in lines typed with the unattractive chat-room members, males showing an increase in self-reported participation with the unattractive chat-room members, as well as a relative decline in theta power from the inclusionary to the exclusionary phase, and from the exclusionary to the re-inclusionary phase while interacting with attractive chat-room members.

Success of Chat-room Paradigm

In contrast to previous studies using paradigms such as Ball Tossing, Cyberball, Life Alone, and Get Acquainted, this study utilized a realistic chat-room paradigm to create the experience of ostracism. Behavioral measures indicate that this paradigm was successful in eliciting feelings of ostracism by showing a significant decrease in lines typed, as well as a significant decrease in participation, enjoyment and interest during the exclusionary phase. These results have been replicated in previous studies such as Williams et al. (2002), and Gardner et al. (2000), that have shown ostracism through chat-room communication is sufficient to produce feelings of ostracism.

All participants indicated they had no previous knowledge or expectations about the current study. Regardless, previous literature has shown no differences in participants' responses to ostracism between those who have pre-existing knowledge that he or she will be ostracized and those who have none. Even when participants were given a prior rational explanation for exclusion, (e.g., they would be excluded due to technical difficulties), the anterior cingulate cortex (ACC) still became activated (Eisenberger, Lieberman, & Williams, 2003). This highlights individuals' sensitivity to social pain and its effectiveness in activating a neural response.

Theta Power

Theta activity is observed in the midfrontal region while performing mental tasks, especially during continuous concentration in the mental task (Asada, Fukuda, Tsunoda, Yamaguchi, & Tonoike, 1999). In a study utilizing magnetoencephalogram (MEG) and electroencephalogram (EEG), researchers found that during consecutive mental tasks, theta waves were seen within the medial prefrontal cortex (MPC) and anterior cingulate cortex (ACC) (Asada, Fukuda, Tsunoda, Yamaguchi, & Tonoike, 1999). This study not only supports the assumption that the F3, F4, and Fz sites correspond to the ventral medial prefrontal cortex and dorsal anterior cingulate cortex, but also supports the interaction between the two structures, highlighting the presence of a neural network between the two structures (Asada, Fukuda, Tsunoda, Yamaguchi, & Tonoike, 1999).

Theta oscillations have also been found to correlate with cognitive and affective processing (Kamarajan, Rangaswamy, Chorlian, Manz, Tang, Pandey, et al., 2008). In a previous study measuring theta oscillations during the processing of monetary loss, researchers observed increased theta activity in the presence of active task-related processing, indicating that a decrease (de-synchronization) in theta activity suggests weaker task-related processing in response to memory, creative thinking, intelligence, cognitive workload, face perception, stroop effect, and executive functioning (Kamarajan, Rangaswamy, Chorlian, Manz, Tang, Pandey, et al., 2008).

Previous literature has documented significant differences between inclusionary and exclusionary phases with respect to frontal theta power, by showing a decrease in neural synchrony during exclusion. A decrease in theta oscillations during the exclusionary phase is expected due to previous research demonstrating ostracism's detrimental effects affecting task-related processing. In a study measuring theta and alpha oscillations, researchers observed a decrease in theta power when participants became anxious or frustrated due to their inability to reach a meditative state (Aftanas & Golocheikine, 2001).

Although the current study failed to show any significant differences between phase and biological sex, the attractiveness manipulation revealed a non-significant, although leaning towards significant main effect. During the experiment, participants showed an overall decline in theta between the inclusionary and exclusionary phases, as well as the exclusionary and re-inclusionary phases when talking to an attractive chat-room member, compared to a relative stable theta power when talking to the unattractive chat-room members.

Attractiveness Manipulation

Participants significantly reported participating more with the unattractive chat-room members. These findings contradict previous literature's findings that attractive individuals are stereotypically rated more sociable, dominant, mentally healthy, intelligent, and socially skilled (Feingold, 1992). It is possible that the participant's obeyed these positive stereotypes to such an extent that they avoided interaction among the attractive chat-room members to avoid possible rejection. Males are more likely to interact with other males compared to attractive females for fear of rejection (Reis, Wheeler, Spiegel, Kernis, Nezlek, & Perri, 1982). Perhaps participants did not engage in conversation with the attractive chat-room members because they estimated their chance of acceptance was small, compared to a high perceived chance of acceptance with unattractive chat-room members. It is possible participants became anxious interacting with the attractive chat-room members, and thus compensated for this by avoiding interaction.

This type of behavior has been demonstrated in previous studies investigating people's preference for social interaction involving kind versus attractive individuals. Using an affiliation-under-stress paradigm, researchers found that during the low stress condition, males preferred interaction with the attractive women, but during the high stress condition, males preferred interaction with the kind women (Li, Halterman, Cason, Knight, & Maner, 2008). Regardless of stress level, women preferred interaction with kind, rather than attractive men (Li, Halterman, Cason, Knight, & Maner, 2008). Based on these results, it is possible participants became anxious or stressed when asked to interact with attractive chat-room members, and chose to avoid interaction in order to protect themselves from harm (ie. social ostracism). This type of behavior has been documented in several cyberball studies using high and low socially anxious individuals. Immediately following ostracism, high anxious individuals showed no differences in distress compared to controls (Zadro, Boland, & Richardson, 2006). It was not until participants finished several filler tasks, that high anxious individuals began to show a failure to return to non-distress levels (Zadro, Boland, & Richardson, 2006). This could perhaps explain why there was a relative decline in theta power throughout all phases of the experiment when participants' interacted with attractive chat-room members. Participants avoided interaction even within the re-inclusionary phases due to the stress of interacting with an attractive individual, as well as the detrimental effects of being excluded.

Sex Differences

When asked to report how left out of the chat-room participants felt during the exclusionary phase, males significantly reported higher feelings of ostracism. This contradicts previous assumptions that females respond and react to emotionally relevant stimuli to a greater degree than males (Hall & Mast, 2008). This could perhaps demonstrate the differences between face-to-face communication and cyber-communication. Although females excel in the detection of nonverbal social cues, as well as demonstrate greater accuracy in remembering and deciphering dynamic cues such as shrugging, smiling, and touching hair, these skills cannot be utilized in a virtual chat-room environment (Hall & Mast, 2008).

Males and females showed no difference in amount of lines typed within each phase of the experiment. These findings contradict previous literature documenting females' tendency to socially compensate in the presence of ostracism, and males' tendency to socially loaf (Williams & Sommer, 1997). Furthermore, males and females reported no significant difference in self-reported interest, enjoyment, and participation within each phase. Although this study failed to show any significant differences, previous studies have demonstrated differences in how different sexes perceive and cope with ostracism. In a similar study to Williams and Sommer (1997), researchers found females were more likely to contribute to a collective task with a same-sex partner that previously ostracized them compared to males (Bozin & Yoder, 2008). Following females normative guidelines as self-revealing, sociable, and more intimate in their relationships, females may work harder (compensate) in collective tasks after ostracism to alleviate social threat and re-establish their position within the group, while males actively loaf to save face and preserve their own normative guidelines (Bozin & Yoder, 2008).

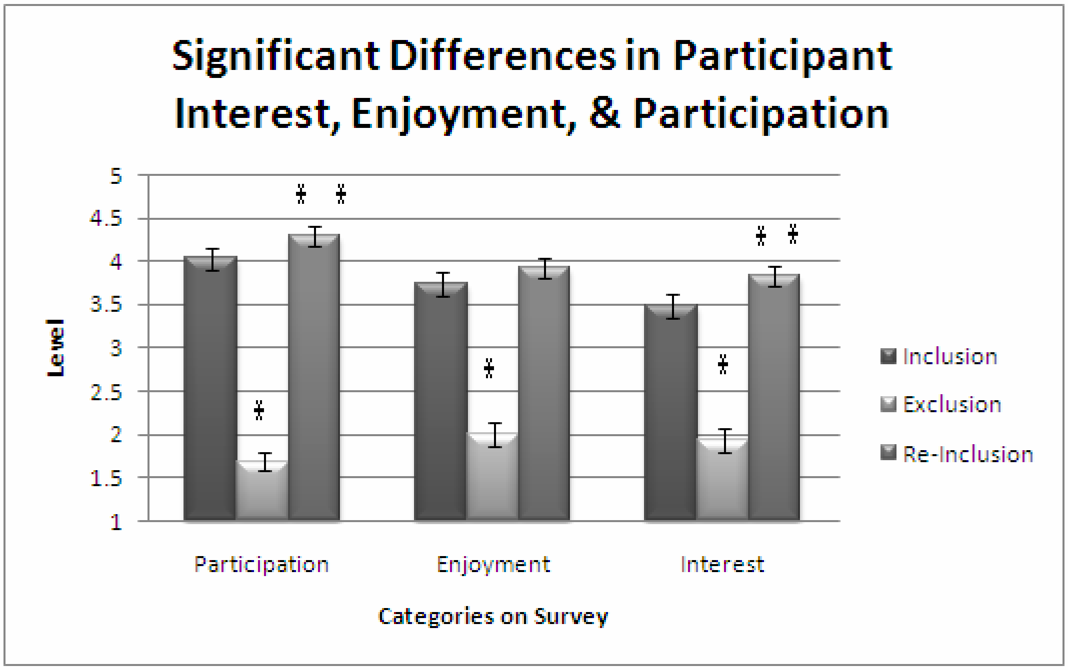
Limitations and Future Directions

Due to the preliminary nature of this on-going investigation, a small sample size was obtained. In addition to sample size, there was a relatively homogenous sample pool. The majority of participants were Caucasian, heterosexual, first-year students from the general psychology research experience program. Also, by having two independent variables (participants' sex and attractiveness manipulation), the number of participants within each cell was reduced, thus making it more difficult to achieve significant results. Future research directions should concentrate on increasing sample size and pool. Although the results of this study showed marginally significant and possible trends, it is important to increase sample size to more accurately determine the relationships between specific social cues and their effects on social ostracism.

This study successfully utilized a realistic chat-room paradigm to elicit feelings of social ostracism. Future research should take advantage of this paradigm, due to its effectiveness in collecting EEG data, as well as its relevance to today's society. Due to social interaction becoming virtualized, it is important to investigate whether this new form of communication not only fulfills our social needs, but whether there is a difference in reaction to ostracism with respect to face-to-face communication or virtual communication. In a study investigating the differences between social ostracism and cyber-ostracism, researchers found participants' self-esteem and self-control were more threatened during face to face communication compared to cyber-communication, highlighting differences between communication realms (Williams, Govan, Croker, Tynan, Cruickshank, & Lam, 2002). In addition, it is also important to investigate whether the social alarm system, involving the VMPFC and dACC, processes ostracism in a similar fashion to face-to face communication or whether it abandons its evolutionary roots for a more innovative way to process cyber-ostracism.

Implications/Applications

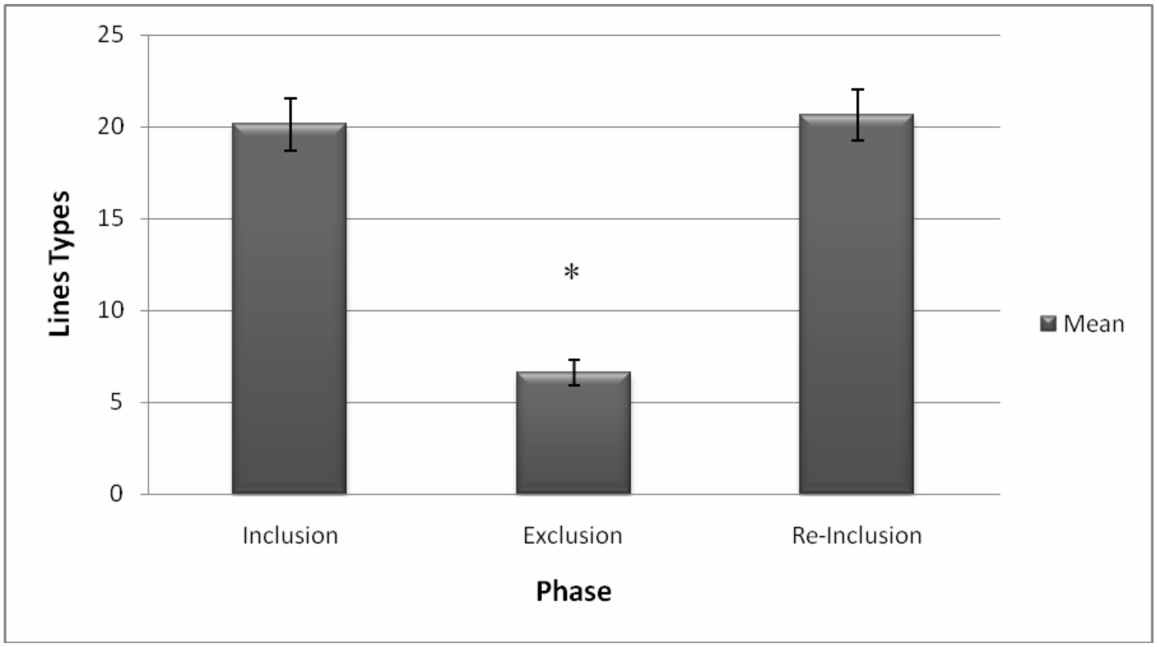
Understanding the influence specific social cues have on social ostracism and how this is processed neurologically between sexes is crucial for the formation of appropriate interventions. Despite the vast amount of previous literature demonstrating the psychological consequences of ostracism, unanswered questions still exist. By better understanding the influence specific social cues such as attractiveness, sexual preferences, and relationship status, have on individuals' responses to ostracism; clinicians can more accurately and effectively alleviate the negative consequences associated with social ostracism. In addition, due to rapid advancements in technology, social interaction has evolved into a more virtualized realm of communication. To date, there has been little research in the possible repercussions that could arise during virtual communication.



* Significant difference from inclusion and re-inclusion $p \leq .05$

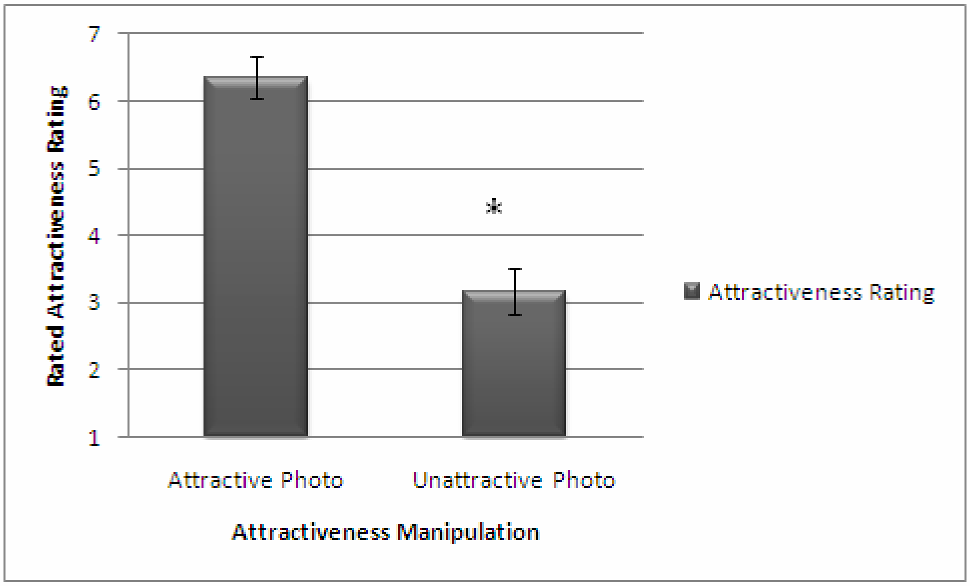
** Significant difference from inclusion $p \leq .05$

Figure 1: During the exclusionary phase, participants reported the lowest level of enjoyment, interest, and participation (p = .000, p = .000, p = .000 respectively). Error bars represent the standard error for each variable.



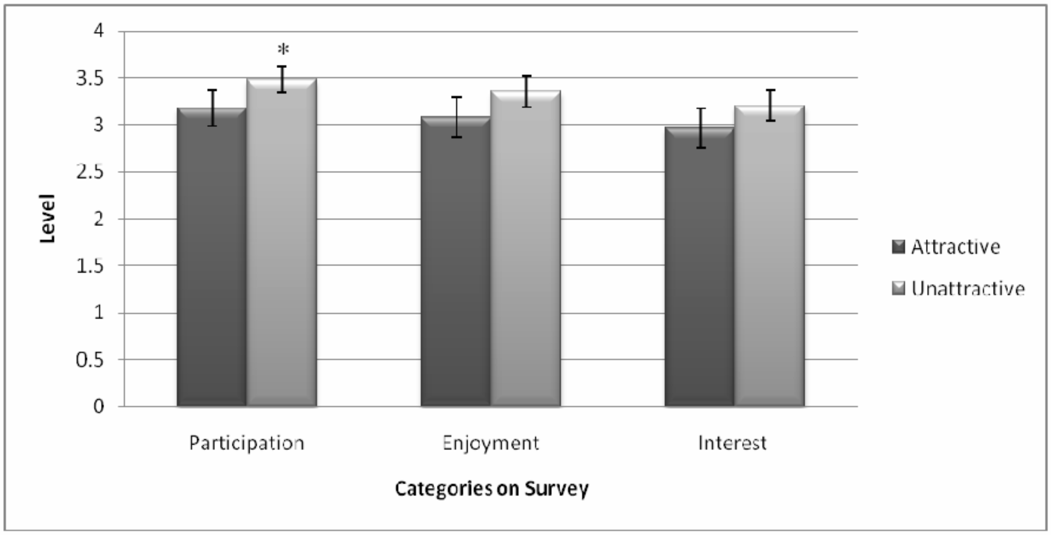
* Significantly different from inclusion and re-inclusion $p < .05$

Figure 2: During the exclusionary phase, participants typed fewer lines than during the inclusionary phases (p =.000). Error bars represent the standard error for each variable.



* Significant difference for participants' rating between the attractive and unattractive manipulation $p < .05$

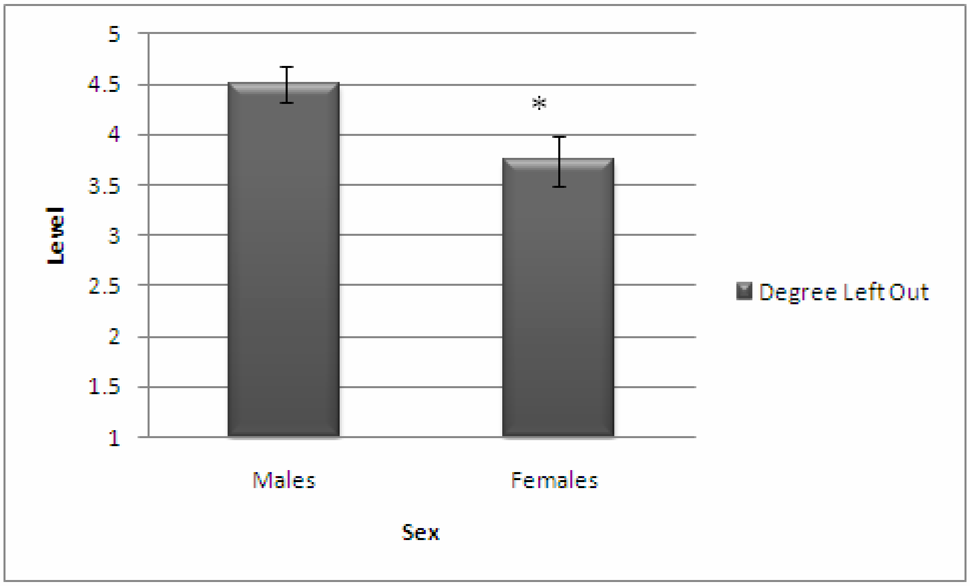
Figure 3: There was a significant difference between participants' rating for the attractive and unattractive chat-room members for the attractiveness manipulation ($p = .000$). Participants accurately rated the attractive chat-room members as attractive, and the unattractive chat-room members as unattractive.



* Significant difference between attractive and unattractive members in the chat-room

p < .05

Figure 4: During all phases of the experiment, participants significantly reported levels of participation, higher among unattractive members in the chat-room (*p* = .049). There were no significant differences in participant's self-reported enjoyment and interest (*p* = .177, *p* = .210 respectively) among the attractive and unattractive members in the chat-room. Error bars represent the standard error for each variable.



* Significant difference between males and females $p < .05$

Figure 5: During the exclusionary phase, males reported feeling more ostracized than females ($p = .025$). Error bars represent the standard error for each variable.

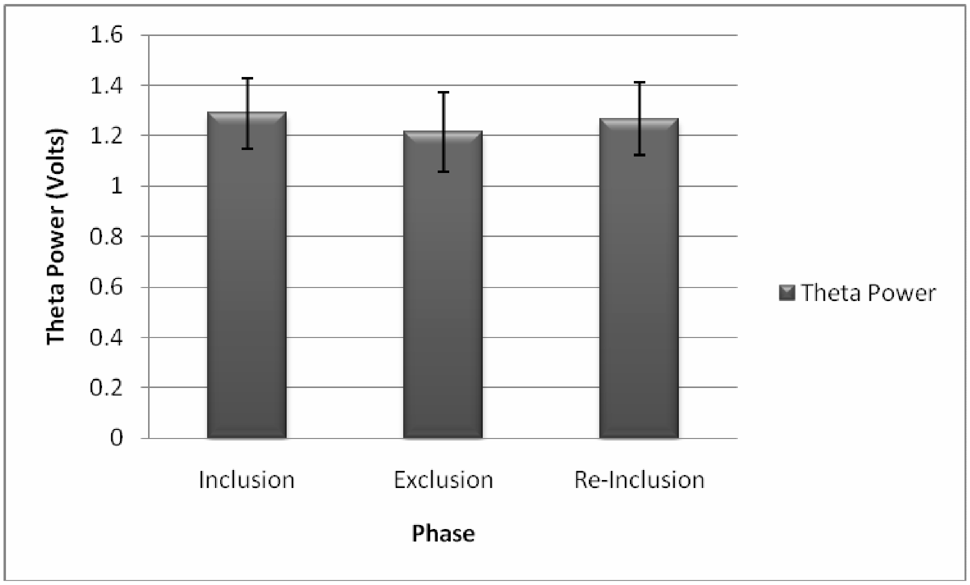


Figure 6: There were no significant differences in theta power between the inclusionary, exclusionary, and re-inclusionary phases of the experiment (p = .180). Error bars represent the standard error for each variable.

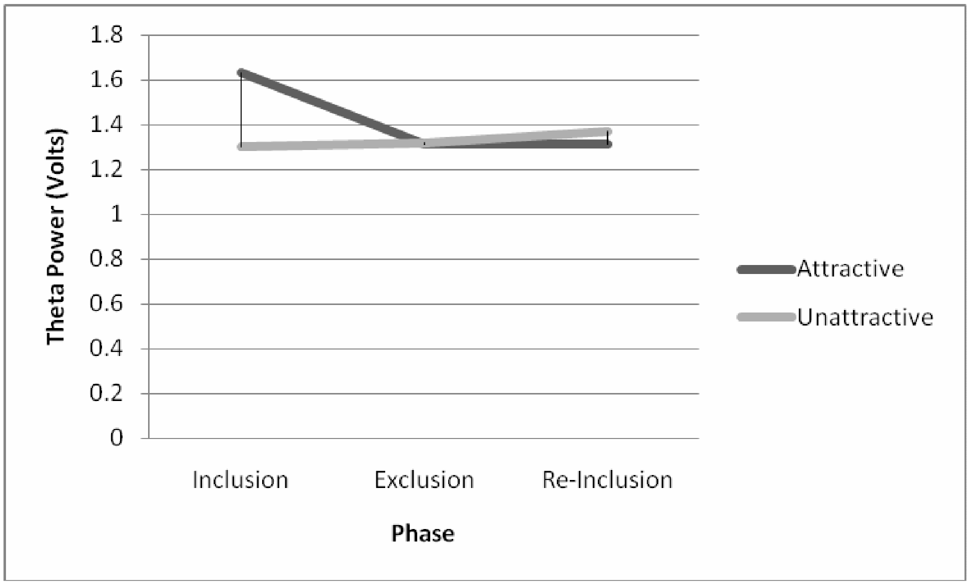


Figure 7: There were no significant differences in theta power between the inclusionary, exclusionary, and re-inclusionary phases of the experiment with respect to the attractiveness manipulation (p = .055).

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