STRESS REGULATION AND ITS IMPACT ON INHIBITORY GATING: CROSS-CULTURAL ANALYSIS

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A Thesis

Submitted to the Graduate College of Bowling Green
State University in partial fulfillment of
the requirements for the degree of

MASTER OF ARTS

August 2014

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ABSTRACT

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The purpose of this research study was to decipher the importance of understanding the role culture plays in perceptions, specifically pain perception and stress perceptions. Furthermore, this study examined how culture influences inhibitory gating (IG), a pre-attentional brain mechanism that plays role in filtering sensory perceptions. The significance of this research was that stress is an affective state experienced by most normal developing human beings, and like other affective regulations, it is important to understand to which extent culture impacts this regulation. Previous research on inhibitory gating focused on comparing clinical population such as those with schizophrenia, bipolar disorders, and autism spectrum disorders, and healthy adults. Abnormal inhibitory gating was found in this psychiatric clinical population. These psychiatric disorders are vastly different but they all have variations of stress in their diagnosis. Moreover, little is known about inhibitory gating differences in healthy adults. This study focused on examining inhibitory gating when healthy adults experienced stress stimuli. Furthermore, emotional regulation varies in each individual based on his/her experiences. Thus, the study also assessed cultural differences in inhibitory gating mediated by emotional change. Specifically, the cultural dimension of collectivism, known to value group harmony and shared experiences, and individualism, emphasis on independence and personal freedom, is used to examine culture. The participants in the study were from either an individualist background (Caucasian Americans) or collectivist background (Chinese). Inhibitory Gating was measured using the auditory evoked response 50 ms post-stimulus (P50) and used the cold-pressor test to induce emotional change. The prediction of the study was upheld as the cold-pressor test impaired gating in both groups. Moreover, the data showed that individualist background group had higher anxiety at the start of the experiment, which led to gating differences in both groups. The findings suggest that the samples diverge in the way that they experience stress and negative affect and this is reflected by differences in early brain processing of sensory information.

"We are the only animals that shape the environments that shape our brains"

-Bruce Wexler

This thesis is dedicated to the memory of my beloved Aabo (Father), Sahal Sheikh-Dahir, *Allah yerhamak* and his beloved sister Zeynab Sheikh-Dahir. It is your exceptional characters that I try to emulate in all that I do.

ACKNOWLEDGMENTS

First and far most: Alhamdulillah.

Thanks to my advisor Sara Abercrombie. You understood my interests and passions and supported me to seek what I needed to accomplish my thesis. Thank you for interpreting my rough ideas and sculpting them into a masterpiece of research design, for helping me understand my data, I sincerely thank you.

Thanks to my all-round mentor Howard “Casey” Cromwell by whose endurance, care, and patience provided me the opportunity to become a better scientist.

Thank you to Hyeyoung Bang for agreeing to be on my committee. You have provided nothing short of tactful encouragement and feedback.

Thanks to Rachel Atchley, whose intuitive support took the form that was most needed at the moment and ranged from logistics assistance to making sure I ate lunch when I forget.

Thanks to the most productive ERP research assistants – Brandon Schmid and Lisa Wiesner, for reliably and greatly contributing to this piece.

I am grateful to my MACIE and BAM Lab family for always being there to lend an ear and consistence source of intelligence. I am also grateful to my forever sister-friend, Fardowsa Abdi., for going above and beyond that call of just being a friend by always being there when I needed the most.

I know I would not have completed this thesis without my dear family’s support. Thanks to Mulki Osman, for providing emotional support through unexpected phone calls. Thanks to the Sahal Sisters: Rahma, you are so good to me and merciful, a person can ONLY wish for a sister like you. Ayan, thank you for listening to me ramble on and on about the progress of my study into the wee hours of the night and again in the dawn hours. You’re an awesome little sister!

Golden, you taught me to constantly challenge views and perspectives – a valuable lesson, thank you for being the supportive sister you are! Thank you to the rest of my family members, too many to list, but your constant support is appreciated. Last but definitely not the least, dearly hooyo: As the famous Abwaan Hadraawi once said:

> “Sidii awr haama wada dhusheedaan halabsanoo hah goortaa nama dhehdee waa noo sii hoorsatey, hooyadu waa lama huuraan”.

I credit you for ingraining in me the ways of logic which have become a very important part of me. Thank you for motivating me to keep reaching for excellence. Thank you for everything.

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CHAPTER I: INTRODUCTION

This study examines stress regulation and inhibitory gating in individuals from different cultures. Specifically, the study utilizes an event-related potential, an electroencephalography technique, to assess inhibitory gating and emotional inventories to examine emotional regulation. Drawing from cross-cultural studies and neuroscience data, this study provides evidence that inhibitory gating mechanism varies in different culture groups during maintenance of stress regulation. The findings lend support to the perspective of interplay of biology and culture in shaping the brain and mind.

Significance of Study

The literature pertaining to inhibitory gating research has been continuously investigated for over 30 years (Boutros et al., 2004). The significance of this research is that stress is experienced by most normal developing human beings and like other affective regulations, it is important to understand to which extent culture influences this regulation. Because the self, a representation of one's identity, of each individual person cultivates and matures in a specific cultural context, it is possible that stress develops in a culturally-specific way (Han and Northoff, 2009). Previous research from cognitive sciences has demonstrated evidence for cultural difference in the self and self-related processing (Markus and Kitayama, 1991), and these differences might be learned effects from different cultural frameworks. For example, as opposed to Western philosophy that highlights the distinctive dispositions to describe the self, East Asian philosophy places strong emphasis on human connections with each other in social contexts (Zhu and Han, 2008). In addition, previous data shows cross-cultural differences in neural substrates underlying how specific cultures process information related to the self (Knyazev et al. 2012). Therefore, a direct comparison of participants from individualistic culture (i.e. USA) and collectivist culture (i.e. East Asian countries) on inhibitory gating (IG) could highlight the culturally specific relationships between IG and stress regulation. Previous studies have correlated neural processes and cultural backgrounds using neuroimaging techniques, however, very few researchers have used electroencephalographic techniques to study cultural neuroscience. Due to the limitation of empirical research regarding electrophysiology cultural neuroscience, this study used event-related potential to investigate when a particular neural process occurs in different cultural brains.

Novelty of Research

This study examines inhibitory gating mechanism in healthy adults. P50 suppression, an operational measure of inhibitory gating, has been documented in clinical and healthy populations. It has been widely studied using psychiatric patients to examine cognitive and attentional dysfunction. Consistent empirical research has shown that P50 event-related potential component is a biomarker of understanding inhibitory mechanisms and gating functions in these populations. Stress has been the key mediating factor these populations. However, inhibitory gating research on healthy adults is limited. Moreover, the premise of cultural neuroscience is that humans have the same neural architecture but due to cultural experiences, changes in the brain structure are possible to occur over a period of time. Also, changes in neural architecture due to external environmental and personal experiences have been well documented in the neuroscience literature. This study examined inhibitory gating, a sensory neural mechanism, in different cultures. In this study, the cold-pressor task (CPT) was used to induce stress, an effective tool for inducing temporary stress and pain, in healthy individuals. The CPT is harmless and does not have any long-lasting impact on the individual (Johnson & Adler, 1993). The study compared the participants' baseline inhibitory gating functions and gating after the stress induction. According to prior research, there was a reason to expect inhibitory gating impairment after participants experienced stress stimuli (Johnson & Adler, 1993, Atchley & Cromwell, in press). The healthy population in this study were individuals from different cultural backgrounds. Specifically, Caucasian American and Chinese females' inhibitory gating functions were assessed. The hypothesis of the study was that the influence of emotion on inhibitory gating would vary dependent upon the cultural background of participants. Moreover, mood and anxiety inventories were implemented to further assess the affective functions after participants were exposed to stress stimuli.

From examining the literature of P50 gating suppression, no study has looked at inhibitory gating mechanism and cultural differences. In the literature review, the studies that examined P50 gating used both clinical and non-clinical populations to compare inhibitory gating profiles. P50 gating literature is established in such that we know the impairment of gating exists in most psychiatric disorders. However, it is also limited in examining the development of this sensory gating mechanism among different individuals. Moreover, P50 gating literature also consists of limited literature on the differences in P50 gating suppression in healthy adults (Patterson, et al. 2008). Because inhibitory gating might be useful in providing information during the diagnoses of these psychiatric disorders based on stress regulation and overall emotional implication, it is beneficial to study if inhibitory gating, mediated by emotional regulation, varies in different cultures. In this study, the effect of stress on inhibitory gating was replicated using methods from previous studies. Furthermore, P50 gating impairment in different cultural groups was investigated to see if there was a cultural-specific affect regulation. The study aimed to contribute to the field by examining cultural differences in a mechanism that could potentially be used as a clinical tool for diagnoses, treatment, and prevention for psychiatric disorders. Furthermore, this particular study enhances our understanding of the cultural brain, and widely assesses neural inhibitions in normal developing individuals.

Aims of the Study

This study aimed to examine general, big-picture questions about inhibitory gating mechanism and draw connections between emotional regulation and sensory processing. Importantly, the study is conducted to better understand inhibitory gating mechanism as an evolving system that potentially differs based on cultural experience. Moreover, this study contributes to the body of knowledge existing in cultural neuroscience literature by comparing sensory processing mechanism in different cultural groups.

Aim1: Stress effect on Inhibitory Gating

The first aim of this study was to examine the effect stress has on the effective inhibitory modulation of sensory input (i.e. inhibitory gating), assessed by the P50 paradigm, in healthy individuals. Johnson and Adler (1993) suggest diminished inhibitory gating function caused by transient distress and pain. In this study, baseline inhibitory gating function was recorded from participants before they were exposed to the physical stressor. Post-stress inhibitory gating function was recorded from participants after experiencing stress. Similar to Johnson and Adler's (1993) study, this study uses the cold – pressor task to induce physical stress and pain. The expected result was to see whether inhibitory gating impairment occurred after the stress manipulation.

Aim 2: Stress Effect on different cultural group's Inhibitory Gating

The second aim was to assess inhibitory gating in individuals from different cultural backgrounds when they experienced a transient and acute stressor. Stress, as most widely defined as the degree to which an individual perceives environmental conditions as challenging, threatening, and harmful, might be culture-dependent (Lazarus and folkman, 1984). Moreover, stress was found to influence inhibitory gating circuit in healthy individuals. It is befitting to examine if stress and emotional coping mechanisms, the volitional effort to regulate emotions due to an external stimuli, varies in different cultures. To my knowledge, this is the first study that incorporated culture in examining inhibitory gating mechanism.

Furthermore, culture is not a construct that is fixed or is a timeless value system; rather, it incorporates new forms and meanings. In previous research, anthropologists have found vastly diverse cultural practices that manifest and shape the way people behave and interact with one another (Shweder, 2003). These cultural manifestations have strong impact on how the self is fostered and maintained. Importantly, cultural practices potentially influence cognition and affective regulation (Kitayama and Mesquita, 2006). Following earlier contributions, the last couple of decades of research in cultural psychology examined a number of psychological tendencies related to collective and independence of the self, and provided and specified substantial evidence that these psychological tendencies show significant cultural variations (Markus and Kitayama, 1991, Kitayama et al., 2006). Importantly, this behavioral research on culture has recently integrated neuroscience measures such as functional magnetic resonance imaging (fMRI) and electroencephalography, providing initial evidence that cultural variation in behavioral responses is accompanied by corresponding differences in brain functions (Han and Northoff, 2008).

Thus, culture remains a multi-layered concept that shapes our understanding of the world through the influence of practices and social values. In this study, I examined the effects culture has on neural processes. Specifically, the focus is on the individualism and collectivism cultural framework (Hofstede, 1984). Individualism is correlated with a culture that emphasizes independence of the self in relation to the group while collectivism is defined as a culture that places importance on the group and values interdependency (Triandis 2001). The study was conducted to assess inhibitory gating functions in Caucasian American females and Chinese females. In this research study, I reason that stress response is grounded in culture and that individual's emotional perception is dependent upon culture, and therefore impacts neural process related to emotional regulation.

Research Questions

Research questions to be answered are 1) what are the effects of stress on inhibitory gating by examining the P50 amplitude suppression? And 2) are there cultural differences in inhibitory gating mechanism mediated by affective regulation?

Definition of Key Terms

There are important key terms and concepts that provide context to this study. It was necessary to define these terms in order to make the study easier to understand.

INHIBITORY GATING. It is characterized as an adaptive mechanism that serves protection for the brain because it is central to rapidly responding to new sensory information and to also disregarding irrelevant sensory stimuli (Boutros & Belger, 1999).

P50 COMPONENT. The P50 (positive component occurring 50 m sec after stimulus onset) response, the most reliable measure of inhibitory gating, is a component of event-related potential (Luck, 2005).

STRESS. Most widely defined as the degree to which an individual perceives environmental conditions as challenging, threatening, and harmful, might be culture-dependent (Lazarus and folkman, 1984).

CULTURE. Shared patterns of interactions and behaviors, values, and cognitive constructs, while continuously incorporating new forms and meanings (Schweder, 2003)

COLLECTIVISM. A cultural framework that focuses on the importance of group harmony by defining the self in relation with the group (Hofstede, 1984).

INDIVIDUALISM. A cultural framework that emphasizes personal freedom and independence in all aspects of the self (Hofstede, 1984)

CHAPTER II. LITERATURE REVIEW

Numerous studies have contributed to understanding the cultural variation in neural and psychological processes as means of examining the relationship of these processes and their growing properties. This chapter will describe prior research on cultural frameworks and an overview on the bidirectional relationship between culture and brain functions. The overview will include prior research pertaining to culture and the brain and the cross-cultural affective research.

Collectivism versus Individualism

Although humans have the same mental architecture, when they are exposed to different cultures for a long period of time, they become different people (Kitayama & Uskul, 2011). In order to empirically examine culture, some social scientists use the collectivism and individualism framework to examine cultural differences. The general understanding of individualism is a cultural framework that emphasizes personal freedom and independence in all aspects of the self. Collectivism, in contrast, focuses on the importance of group harmony by defining the self in relation with the group. Geert Hofstede (1984) developed the most widely known measure of individualism and collectivism. He used surveys of IBM employees to examine individuals with similar job positions in 53 countries so as to measure cultural differences. The study used cultural spectrum that had collectivism and individualism on a continuum. In the study, the US scored the highest in individualism, while East Asian countries, such as Japan, South Korea, North Korea, and China scored toward the lower end of the continuum, illustrating that these cultures are high in collectivism. In Hofstede's (1984) model, individualism and collectivism are differentiated in the following ways: (1) People in individualistic cultures tend to make decisions alone and independently, while people in a collectivistic cultures make decisions in the betterment of the group, while also making decisions with the in-group; (2) The more individualistic pronoun “I” is the center of people in individualistic cultures and the aggregate “we” is the focus of people in collectivistic cultures; (3) Additionally, “nuclear family structure” is the emphasized familial structure in individualistic cultures and “extended family or tribal structures” is the primary unit in collectivistic cultures.

Triandis (1994) suggested that there are other factors that distinguish between the cultural dimensions of collectivisms and individualism. The more complex the society is the more individualistic it becomes in comparison to a culture that is geared toward food-gathering nomads. In the case of the complexity of the society, the individual does not have to be loyal to the group and is force to make individual goals in order to survive. The second factor is the affluence of a culture; Triandis (1994) stated that the more prosperous a culture becomes, the more individualistic it becomes. In prosperous cultures, people gain financial and personal independence and begin to work for themselves rather than a group. The third factor that contributes to these cultural dimensions is heterogeneity, a culturally diverse society. Cultures that are homogenous or tightly close to each other in terms of language, religion, and customs, tend to form in-group relations and are thus considered collectivist culture. The Triandis’ study paints questionable picture of collectivist cultures such that these additional factors make the collectivist cultures underdeveloped and less prosperous. On the contrary, Japan, the most collectivist country in Hofsted’s study, was recently illustrate to be the world’s leader in science and technology and also the premier military power in space (Hofsted, 1984; Pekkanen and Kallender-Umezu, 2010). Therefore, these cultural distinctions are not completely dependent on the economic development of the country but rather are deeply ingrained values that manifest in self-identities and self-formation (Markus and Kitayama, 1991).

To further explore these constructs, Gudykunst (2003) stated that the division of individualism and collectivism define cultural conventions and rules relative to group identities and distinction between members of in-groups and out-groups. In-groups are described as groups that prompt importance to their members and groups for which individuals will make self-sacrifice. Out-groups are made up of individuals who do not associate with the in-groups. Gudykunst (2003) argued that the ‘in-group” identity is one of the main component that distinguishes collectivistic and individualistic cultures. Collectivist cultures associate themselves with wider family members and ethnic groups more than individualists. There are many in-groups in collectivist cultures such as large extended family, friends, work-group, and religious groups that potentially affect their decisions (Gudykunst, 2003).

These cultural dimensions are not exclusively tied to one person or to one culture. Eisenburg (1999) prompts us that although these dimensions of culture represent the attributes of most people in a specified culture, individuals will differ in the amount of individualism and collectivism they will represent within the cultural framework continuum. Thus, no society can be either solely individualistic or collectivistic. Triandis (1995) further clarifies that functional cultures have a mixture of each dimension. In more detail, individualist cultures are more individualistic in the continuum than collectivist. This means, although a culture can be described as an individualist culture, they could still have some values that are collectivistic in nature but majority of its values are individualistic in nature. This alternative view represents a polythetic construct rather than pure dichotomous constructs. Triandis (1995) reported that individualism and collectivism construct should be defined polythetically as it is done in other sciences. He used the example of the field of zoology where each phylum contains many combinations of characteristics and attributes, but only few attributes are characteristic of all the species within the particular phylum. For example, the defining attribute of the category "bird" from the Chordata phylum maybe 'feathers' while other broad attributes such as 'carnivorous' may be used to differentiate various species of birds. Similarly, the constructs of individualism and collectivism are identified by few defining attributes and each construct requires the additional scrutiny when applied to specific cultures. While each culture remains to hold both construct to a certain degree, specific cultures have more attributes that fall into either the individualism or the collectivism category.

Affective Implication: Collectivism versus Individualism

Research in cross-cultural psychology reported that affective states may have biological as well as socio-cultural component to it (Kitayama & Markus, 1994). To illustrate cultural-specific difference in emotion regulation, Markus and Kityama (1991)'s classical review represents the theory of independent and interdependent self-construal, which is the most influential work in the past decades in culture and psychology. According to the theory, individualistic cultures have independent self-construal, where an individual construes oneself as independent and makes meanings though one's own internal thoughts, feelings, and actions. Collectivist cultures have interdependent self-construal, where an individual construes oneself as contingent upon the connectedness of others in relationship. Markus and Kityama (1991) suggested that a defining attribute of the cultural dimension illustrates the 'self' as interdependent for collectivist cultures, and as independent for individualist cultures. In collectivist cultures, the self is conceived as a part of collective whereas in individualist cultures, the self is regarded as being independent of others. Furthermore, the researchers found that individuals from collectivist cultures (e.g. East Asian) viewed the self as a part of social web whereas those from individualist culture (e.g. European Americans) viewed the self as an isolated unit. These cultural dimensions, in essence, motivate behaviors and mold decisions. Markus and Kitayama (1991) further clarified that individualistic societies value the self as its own entity and decisions are made according to how it will effect the self. In contrast, collectivist societies value interdependent self where decisions are driven by the effects it will have on the group at large. Accordingly, Markus and Kitayama (1991) illustrated that European Americans are more likely to express ego-driven emotions out of protecting the "self" while non-westerners are more likely to experience "other-focused" emotions that stimulate group harmony.

Furthermore, it is important to inspect this dimension because of the immense differences that emerge between cultures when using individualism and collectivism cultural spectrum as measuring instruments (Eisenburg, 1999). It should not be assumed that an individual from a particular culture represents the ideal type of collectivist or individualist. On the contrary, individuals in different culture will sample collectivist and individualist cultural values, depending on the situation. However, collectivism and individualism are typically used to describe entire cultures (Triandis, 2001). These constructs represent as systems of meanings and practices in the context of which affective states are expected to vary (Mesquita, 2001). Although not all individuals in a given context experience affective states the same way, across people within a collectivist or individualist context, affective states are patterned in distinct way (Mesquita, 2001). Mesquita (2001) conducted self-reported interviews among indigenous Dutch group in the Netherlands that were characterized as individualist group and African Surinamese and Turkish group that were characterized as collectivist cultures. The researcher examined different components of emotion such as concerns and appraisal. He found cultural differences between collectivist and individualist cultures in each of the emotion components, in ways that were consistent with the respective cultural spectrum. Due to their interdependency, collectivist cultures tended to share their experiences with their groups. Furthermore, individuals' emotional responses to stresses have been a focus in affective research, with various indicators, such as physiological responses, emotional behavior and expression, and reported emotional incidents (Kitayama, Markus, & Kurokawa, 2000). In comparison with individualists, collectivists are likely to show higher level of emotional suppression (Matsumoto, 2006). These cultural differences in suppression may be associated with the interdependent versus independent principles of the self in collectivistic and individualistic cultures (Markus & Kitayama, 1991). According to this distinction, collectivist cultures are more likely to give priority to group outcomes over individual concerns. Furthermore, collectivist cultures value and emphasize group emotional states (Markus & Kitayama, 1991). Additionally, earlier studies found cultural differences in individuals' reported emotional states. People in individualistic cultures often reported higher level of subjective well-being and pleasant emotional experiences than people in collectivistic cultures (Kitayama, Markus, & Kurokawa, 2000). Moreover, Ronen and Seeman (2007) conducted a survey study examining effects of trauma related to stress on adolescents' subjective well-being and found that a greater sense of fear, a form of psychological stress, was associated to more negative emotions and fewer positive feelings. As such, it is befitting to study how stress is regulated in these cultures in order to add cultural-specific understanding of stress regulation. Subsequently, this study examines how culture influences a neural process that is largely defined to be correlated with stress and emotional regulation. While it is accurate that combining cultural factors and its bidirectional relation to brain mechanism is a recent examination, researchers in the social sciences have been examining cultural influence in biological mechanisms for a long time.

Culture and Biology

The concept of examining how culture and human biology interact is not new. On the contrary, researchers whose sole goal is to examine culture from different facets, anthropologists, have a division dedicated to interactions between culture and biology. This subfield is called biocultural anthropology, an attempt to understand how culture affects our biological capacities. Culture has become an important aspect of human history and social context. Biocultural anthropology examines how this complex and diversified cultural environment challenges and interacts with human biology (McElroy, 1990). Human biology is concerned with understanding the extent of human biological difference, along with assessing the mechanisms that generate and direct the difference thus relating it to health, disease, and social issues that concern people today. Contemporary human biology is more focused on the understanding biological mechanism to further examine the rise of abnormalities in these mechanisms (Kandel et al. 2013). However, the understanding of cultural influence on these mechanisms can illuminate the probable influences that arise from biological mechanism. In summary, culture does impact human biology in a sense that it shapes how these mechanisms manifest as social processes (Chiao & Bliziusky, 2010). Although the idea of incorporating biological mechanisms into cultural studies is not new, examining the bidirectional relationship on brain functions and culture represents an innovative approach to understanding the neurobiological diversity in individuals from different cultural backgrounds.

Brain and Culture: A Reciprocal Relationship

For a long time, “human culture” simply did not belong to the vocabulary of the field of neuroscience. There exists a limited knowledge and limited empirical studies on the role culture plays in neuroscience. Culture is a construct that carries complex definition and measuring such a construct raises questions. Due to this complexity in definition, it is difficult to gather tools that appropriately measure culture. The study of human culture (anthropology) has mainly focused on providing qualitative data on different cultures (Hendelson, 2004). In more recent years, there has been greater interest in revitalizing the importance of culture and its relationship with brain functions and several studies have provided the key interactions between culture studies and cognitive neuroscience. The facets of studying culture and its complimentary relationship in brain sciences offer exciting opportunities to examine and inform critical questions about human variations in different cultural contexts. Moreover, recent studies of the human brain have consistently established its capacity and plasticity for adaptation (Maguire et al. 2000). The argument for this is that learning not only changes our thoughts and perceptions about situations, but also can cause structural and functional changes in the brain (Hans & Northoff, 2008). Furthermore, just as we can learn from the field of anthropology and social psychology that cultural differences may lead to different perspectives and experiences, the field of neuroscience postulates that learning can more effectively occur through the maintenance of cultural practices.

Additionally, self-report measures of emotion regulation showed that East Asians were more likely to suppress their emotions than Caucasian Americans (Markus & Kitayama, 1999; Kim & Markus, 1999; and Matsumoto et al., 2008). In more recent electrophysiological data, Murata, Moser, and Kitayama (2013) used the ERP late positive potential component (LPP) to measure emotional processing in East Asians and European Americans. The researchers exposed both East Asian and European American participants to either neural or unpleasant pictures while instructing them to either suppress or attend expression of emotions. They found that East Asians showed significant decrease of LPP on the emotional expression condition whereas European Americans showed no attenuation of emotional processing when they tried to suppress their emotional expressions. This result is congruent with the Asian Confucian idea that emotions frequently prevent the importance of fostering social relations (Kitayama et al. 2006). Emotion regulation is highly correlated with stress regulation, or at least the verbal report of stress regulation (Raio et al. 2013). More closely related research done by Xu and colleagues (2009) suggests that empathetic responses to another person's distress, result of experiencing a stressor, are much stronger if the person is a member of the in-group than if he/she does not belong to the group. Although both cultures have in-groups, collectivist cultures have larger net of in-groups. Presumably, this leads to collectivist cultures experiencing emotions with larger in-groups than individualist cultures. Furthermore, prior research has demonstrated that culture shapes how we see and interpret the world around us. For example, psychology researchers have argued that culture can influence basic vision and attentional processes (Markus & Kitayama, 1991). The direction of empirical studies focused on the bidirectional relationship between culture and the brain address cultural variations in neural mechanisms (Gazzaniga, Ivry & Mangun, 2002).

Integration: Cultural Neuroscience

There is a bidirectional effect of the structure and function of the human brain and the environment (Chiao, 2009). The subfield that focuses on brain science and culture is called cultural neuroscience, which was coined by Joan Chiao, a professor of psychology. Cultural neuroscience attempts to integrate theories from anthropology, social psychology, neuroscience, and genetics to explore interactions with neural processes. Furthermore, cultural neuroscientists argue that social environment is shaped by culture and individuals' biological and psychological processes occur within cultural-specific contexts (Chiao et al. 2010). Adopting the Frame Line Test from Kitayama et al. (2003) where a vertical line was printed in a square frame, Hedden et al. 2008) conducted a cultural neuroimaging study examining neural activity in attentional task.

The researchers acquired FMRI data as European Americans and East Asians were asked to perform judgments that were either absolute or relative to the contextual information, such as the relationship between the perceived size of the line and the surrounding frame. Results from the study showed that European Americans showed greater activation during relative compared to absolute line judgments in frontal and parietal regions, areas typically associated with attentional processing. In contrast, the researchers found East Asians showed greater brain activations during absolute compared to relative judgments in the same regions. These findings suggest that perception of vertical line in a frame and its subsequent brain area activation is modulated by experience in a given cultural context. The participants required greater effort when engaged in non-preferred visual processing styles, which emphasized cultural difference in attentional related tasks. Importantly, cultural variations in neural response on the structural level suggest that there could be different brain circuitry in play for simple tasks related to perceptual regulation. Findings like this suggest that different cultures engage different areas of the brain to execute similar tasks. This is a powerful suggestion as neuroscientists continue to understand and investigate mechanisms involving neural processes.

Although majority of neuroscience literature reporting research on different cultures has been conducted using human neuroimaging techniques (e.g. FMRI), recent studies have examined the effects of culture using electrophysiological techniques to better understand the cultural dimension of collectivism and individualism (Lewis et al. 2008; Ishii et al. 2010; and Goto et al. 2013) Neuroimaging FMRI is a technique used to extract brain activation images representing activated brain sites while electrophysiological technique ERP is used to acquire data representing electrical activation in the brain at given time (Herzmann et al. 2012). Lewis and colleagues (2008) measured the event-related potential (ERP) of the positive peak occurring around 300 msec (P300), which are thought to index attention to infrequent events, in East Asian American and European American participants. They found that East Asian Americans showed greater P300 amplitudes in response to contextually discrepant stimuli compared to European Americans. A second ERP study examined the N400 component, which is a reflection of the integration of word's meaning into the context (Ishii et al. 2010). Ishii and colleagues examined Japanese female participants who listened to words that did not match the spoken vocal tone (e.g., the word "happy" verbalized in a sad tone of voice) and words that matched the spoken vocal tone. The Japanese participants showed greater N400 ERP activation, which has been shown to be a reliable neurobiological marker of the detection of semantic incongruity (Ishii et al. 2010). The research findings were limited to Japanese participants and thus were unclear whether the same result would be obtained in people of different culture where self is thought to be relatively independent and separate from other people (e.g. European Americans). As a result, Goto et al. (2013) studied European Americans and Asian Americans' N400 ERP response to multiple emotional facial expressions (happy versus sad) and affective scenes (positive versus negative). The visual stimuli were congruent (e.g., happy face with positive scene) or incongruent (e.g., happy face with negative scene). They found that Asian Americans showed a greater N400 to incongruent than to the congruent trials, but they found no incongruity effect among European American participants. One interpretation of these findings is that East Asians regard the image elements as more tightly bound together into the whole context whereas European Americans treat each visual element in a picture more as separate objects. Another interpretation is that the structural properties of language modulate experiences and influence behavior. In a cross-linguistic study, Bick and Colleagues (2011) demonstrated that language processing in the brain is not universal and thus poses challenge to empirically isolate language in experiments involving visual stimuli recognition.

Altogether, these cultural neuroscience studies demonstrated that the ways culture impact neural responses to social information provide a complex representation. For example, Kitayama et al. (2003) observed that Japanese participants were more accurate at producing lines of correct length when asked to attend to their relative size as opposed to their absolute size whereas European American participants were more accurate at drawing lines of correct length when asked to attend to their absolute size. Furthermore, Hedden and colleagues (2008) examined the same task using an FMRI technique and their findings suggest cultural difference in neural responses to the extent that distinct brain regions were recruited to execute the absolute and relative line-judgment tasks in relation to the participant's culture. By examining Hedden and colleagues (2008) research data, one can observe that similar pattern of neural activation may arise in response to different stimuli across cultures based on the cultural practices and meaning of the particular stimuli (e.g., effortful attention). Prior research has also shown that language plays significant role in assigning practices and meanings (Burnland, 1989). An East Asian person saying "yes" or nodding their head doesn't necessarily translate to a European American responding the same way (Burnland, 1989). Ambady, Koo, Lee, & Rosenthal (1996) proposed that in many individualistic cultures, language contains greater verbal content while in collectivist cultures; the proportion of information conveyed by verbal content is relatively small. As a result, European Americans attend primarily to verbal content while East Asians pay closer attention to vocal tone and other contextual information (Ishii, Reyes, & Kitayama, 2003). Furthermore, it is often through language socialization that cultural practices and meanings are instilled into new members of a cultural group (Heath, 1990). However, because language is an intricate part of culture, it is difficult to empirically separate from any research findings pertaining to cultural differences. These research areas in combining cultural patterns and neural process can lead to significant findings, and thus, lead to future research applications. The current study is aimed to contribute to the limited electrophysiological data involving culture and neural processes. Specifically, inhibitory gating, a sensory filtration mechanism, is examined in different cultures.

Inhibitory Gating

Inhibitory gating can be thought of as a door that opens to "gate-in" important sensory information while "gate-out" irrelevant sensory information (Cromwell et al. 2008). Gating-in is a response reflecting preferential treatment to new stimuli in the environment whereas gating-out is considered by filtering out repeated and redundant stimuli in the environment. Inhibitory gating is characterized as an adaptive mechanism that serves protection for the brain because it is central to rapidly responding to new sensory information and to also disregarding irrelevant sensory stimuli (Boutros & Belger, 1999). Majority of the literature on inhibitory gating has been examined in the auditory modality using the pair-click paradigm. Successful P50 gating mechanism is important to maintaining normal mental health. Impairment in inhibitory gating can lead to an abundance of irrelevant stimuli into the cortex (McGhie & Chapman, 1961). This mechanism has been widely studied because several clinical populations are reliably impaired on this measure (Adler et al., 1982, Cabranes et al. 2012, Kemner et al. 2002). For instance, it is recognized that individuals with schizophrenia fail to filter sensory information appropriately. When measured in a typical P50 pair-click paradigm, evoked response is greater to the second click in individuals with schizophrenia compared to healthy individuals (Olincy et al., 2000). Studies of this nature have been highly replicated and the findings have been consistent (Clementz, Geyer, & Braff, 1998). Although schizophrenia is the clinical group that has received the most attention, many other clinical populations have been found to have inhibitory gating deficits, such as individuals with post-traumatic stress disorder (Neylan et al., 1999) and bipolar disorder (Schluze et al., 2007). Furthermore, these impairments are linked to behavioral disorders and psychotic symptoms (McGhie & Chapman, 1961). It is not yet fully understood how the neural mechanisms underlying inhibitory gating contribute to the pathology of disorders, or whether similar mechanisms are involved in different clinical populations. Although we know inhibitory gating is impaired in certain clinical groups, it is still a question the specific functions related to inhibitory gating (Lijffijt, Lane, et al., 2009). Moreover, prior research has shown that healthy adults had P50 sensory filtering scores within one standard deviation of the scores of schizophrenia patients (Patterson et al. 2008). An interesting question that remains to be examined is the cultural variations related to inhibitory gating mechanism, in relation to psychological processes such as emotion regulation. Early sensory processing is complex and it is self-evident that if people perceive the world differently, they will also react to it differently (Javitt, 2009). This study explored the possible relationship between culture and inhibitory gating mechanism.

Stress Regulation and Inhibitory Gating

Impairment in inhibitory gating, the process for filtering sensory information in the brain, have been significantly found in schizophrenic patients (Adler et al. 1982). Other psychological disorders such as obsessive compulsive disorder, post-traumatic stress disorder and drug addiction have sensory filtering problems that could be described as loss of sensory "gating" (Adler et al., 2001). Each of these diverse disorders has been examined using one component, known as the P50 suppression or sensory inhibitory gating (IG). Stress has been shown to play role in inhibitory gating impairment (Cromwell et al. 2005). There have not been many studies regarding the effect stress has on inhibitory gating. Johnson and Adler (1993) found that mild physical discomfort yields transient weakening of P50 inhibitory gating for up to 30 minutes following the cold-pressor test in human participants. Cromwell, Anstrom, Azarov, & Woodward (2005) found stress causes deficit in inhibitory gating in animal models (rodents). Cromwell and colleagues (2005) also illustrated that mildly stressed rats showed weaker IG in the amygdala, an areas of the brain thought to involve fear and emotional processing. Follow-up study by Cromwell, Klein, and Mears (2007) illustrated that acute stress, through injection, showed strengthened inhibitory gating responses to tone pairs, whereas chronic stress induced by 24 hours of food deprivation showed weakened inhibitory gating responses in the rat striatum, a region involved in reward processing. Using mental arithmetic technique, White, Kanazawa, and Yee (2005) found that this psychological stress weakens inhibitory gating and increases electrodermal response and heart rate measures of stress. These diverse findings illustrate that inhibitory gating is processed in diverse areas of brain and can subsequently impact a lot of the brain processes, and that stress is contingent factor in inhibitory gating. Yee and White (2001) further indicate that stress in combination with anxiety provide disruption to inhibitory gating. The cold-pressor task, which induces physical stress and pain by having a participant insert one hand in ice water, can also impair gating for about half an hour (Johnson and Adler, 1993). In this study, the cold-pressor task induces temporary pain and stresses the participant. Stress as negative feelings and reactions can serve as an adaptive function because each individual may experience and perceive stress relatively different (Selye, 1982).

Stress and Culture

Research focused on stress regulation has focused on body's reaction to stressors and the cognitive processes that evaluate the event or situation as a stressor (Pearlin, 1982). However, stress responses have shown that people undergoing the same stressful events are not affected the same way. Pearlin (1982) observed that individual's stress experience is primarily social in nature. The ways people deal with situations are generally learned from the groups to which they belong. Furthermore, the researcher suggested that although there are individual differences, coping strategies are largely derived from the social environment. Culture and society may shape what events are perceived as stressful, what coping strategies are acceptable to use in a particular society, and what institutional mechanisms individuals may turn to for support (O'connor & Shimizu, 2002). Moreover, Merton (1968) illustrated that society can elicit stress by promoting values that conflict with the structures in which they exist. Merton (1968) further argued that the system of values in the United States promotes attainment of monetary and honorable success among more people than could be accommodated by the opportunity structures available. As a consequence, many of those individuals who internalize these culturally valued goals may experience more stress on the individual level. In contrast, societies that place importance on group cohesion such China may experience stress on a group level rather than on an individual level (O'connor & Shimizu, 2002). Studies focused on cultural differences that may exist in stress reactions and responses are needed to examine how various social and cultural structures influence the individual's experience of stress. Due to the limited studies in stress and cultural framework, this study aims to investigate the effect of stress in individuals from different cultures.

China and the U.S.A

Previous studies showed that individualistic values are more central in the U.S. and collectivistic values are present in China (Hofstede, 1984; Triandis, 1994; and Chung & Mallory, 1999). Furthermore, in Triandis and colleagues' (1990) study, Chinese cultures scored higher on collectivism and lower on individualism. Leung and Bond (1984) also found that Chinese subjects were more oriented toward enhancing in-group harmony, a key feature in collectivistic societies. One of the widely studied differences between Chinese culture and Caucasian American culture is self-construal construct or how individuals think about themselves in relation to others (Markus & Kitayama, 1991). In more detail, cultural practices and values shape social behaviors and one of those ways is how an individual represents themselves in relation to others. This determines the relationship one has with others and further shapes social behaviors (Heine & Singer. 2008). A study conducted by Zhu and colleagues (2007) indicated evidence that neural substrates of self-evaluation are modulated by cultural characteristics of collectivism and individualism. The researchers asked Chinese and Caucasian (majority being Caucasian Americans) participants to choose whether a particular trait adjective described themselves (self condition), their mother (mother condition), or an unrelated politician (other condition). The researchers used neuroimaging technique to observe changes in the activation of the medial prefrontal cortex (MPFC), an area that is thought to be engaged in representation of self-knowledge such as individual's own personality traits. The results showed that in the Chinese participants, there was no difference in brain activity within the MPFC during processing of self and processing of the close other (i.e. mother). This was an indication that Chinese participants used the MPFC to denote both themselves and a close other (i.e. mother). In the Caucasian participants who are more independent, the MPFC was activated only in the self- evaluation condition. There were no difference in the unrelated other condition between the two groups. The self is important to our social interactions and interpersonal relations thus the results from this study showed that culture may effect representations at the neural level. In summary, the United States is typically categorized as an individualistic culture whereas China is typically labeled as a collectivistic culture (Adler, Brahm, & Graham, 1992; Markus & Kitayama, 1991). Therefore, the dimension of individualism and collectivism serves as a useful theoretical framework for examining cultural differences in brain mechanisms (Chiao, 2009). This study uses stress-induced pain model to evaluate cultural difference in stress regulation, therefore, it is important to illustrate previous literature on cross-cultural pain perceptions.

Cross-Cultural Pain Perceptions

Pain as an unpleasant sensory and emotional problem is a major world health issue and is not well understood (IASP, 2004). Pain is also a primary reason why people seek medical attention and often the perception of pain can vary within cultures (IASP, 2004). Additionally, pain is inherently a subjective experience, and often people cannot prove their level of suffering. To date, most measures of pain experience rely on subjective patient perception. Because of this, there is a room for perceiver bias and room for the impact of culture on pain perception.

In human cultures, biological substrates that are important to a person's survival gain cultural significance (Richarson & Boyd, 2001). Pain regulation is a vital biological process that a person must maintain in order to survive. Also, pain perception is a universal phenomenon for those who are physiologically normal. Even though this phenomenon is experienced across societies, an individual's culture is what dictates how pain regulation is perceived and manifested (Knox et al. 1977). The role of culture in human physiological activities is important and cannot be disregarded. Consuming food is a vital physiological need but certain cultural events can directly go against these vital needs to observe a significant cultural pattern, such as a Muslim fasting on the month of Ramadan. Groups of various cultures may assume differing outlooks towards these various types of pain. From previous example, fasting from food can induce pain for those who have not observed fasting before. There can be physiological symptoms such as reporting tiredness and other stress-inducing effects. However, for those who fasted before and are also *wanting* to fast, their attitudes could fall onto the pain acceptance route and even pain expectancy route. This denotes that experience and cultural patterns shape our physiological perceptions. Wolff and Langley (1968) demonstrate through laboratory pain studies that cultural variations exist in response to painful stimuli. Streltzer and Wade (1981) studied differences in postoperative pain regulation in individuals who were of Caucasian, Chinese, Japanese, Filipino, and Hawaiian culture. These patients were undertaking elective cholecystectomy. They discovered that the Caucasian and Hawaiian patients received more medication than the rest of the groups who were undergoing the same procedure. These patients reported feeling more pain and thus needing additional medication to manage the pain. Other studies that looked at factors impacting patients with chronic back pain found that when compared with patients from New Zealand, American patients reported greater emotional disruptions and behavioral manifestations (Carron et al. (1985). The American patients reported need for more medications and thus used more drugs. They also reported greater impairments in social activities, intimate relationships, and vocational activities. Furthermore, Brena et al. (1990) discovered that Japanese patients with lower back pain were less likely to complain about psychosocial and vocational domain impairments, while American patients were more likely to experience impairments in those areas. A follow up study by Sanders et al. (1992) found reliable results. Sanders et al. (1992) discussed that individuals from heterogonous cultures were more likely to reports painful stimuli that those from homogenous cultures. They found that reporting personal painful perceptions in homogeneous cultures were less acceptable than more diverse, pluralistic societies.

In another laboratory-induced pain study, Sternbach and Tursky (1965) studied the role of interethnic variations in relation to pain perception in response to transcutaneous electrical stimulation. In this study, they found that Protestants of British background and Irish-Americans tended to report lower expressions of their pain, whereas Italian Americans and Jewish Americans reported greater expressions of their pain. In another study by Clark and Clark (1980) used statistical decision model to compare ratings to electrical stimuli in Buddhist Nepalese and Westerners. The higher pain thresholds of the Nepalese were found to be entirely due to more stoical pain report criterion. They did not find significant difference between the groups in discriminating sensory perception.

In most cultures, the response to painful stimuli lies on the continuum of pathos stoicism (Wolff, 1985). The diversity of response has occasioned comments from a variety of scholars including anthropologists, medical clinicians, and laboratory pain researchers (Zatzick & Dimsdale, 1990). As studying pain in naturalistic environment poses a challenge to clinicians and social scientists, researchers have turn to inducing pain in laboratories. Furthermore, due to human research regulations, the methods of inducing pain in laboratory went from having multiple ways to measure pain to few, appropriate and safe methods. This way, researchers can control for variables and can direct causal effect. In this study, the cold – pressor task, an effective laboratory task used to induce temporary pain, is used to investigate cultures that vary in nature, collectivist and individual culture. Unfortunately, as one can understand, the laboratory models are still under-developed and will need extensive research to improve its effectiveness.

Pain Measures

There are conceptual and methodological strains inherently present in laboratory-induced pain studies, however the alternative of not having a controlled setting is harder to measure in the natural environment. An important point to this study is to understand the relationship of pain tolerance and pain threshold. Threshold is a verbal account of pain whereas tolerance is a request for termination or withdrawal from the stimulus. Furthermore, among researchers, greater debate persists as how pain threshold and tolerance relate to pain perception, in laboratory-induced pain stimuli. Although Gelfand (1956) suggested that there is little correlation between pain tolerance and pain threshold, Clark and Bindra (1956) established a high correlation between the two pain measures. Harris and Rollman (1983) compared pain threshold and tolerance levels using three different methods of pain induction: cold-pressor, electrical stimulation, and cutaneous pressure. Multivariate analysis of subject response applied across the various stressors demonstrated that while related, threshold and tolerance measures might measure aspects of the pain experience. These results support most pain researchers' conclusion that pain threshold is more loaded towards physiological variables whereas pain tolerance is loaded toward psychological variables (Wolff, 1986). To illustrate which measure is more appropriate for cross-cultural pain studies, a combination of both measures is needed in order to get the "bigger" picture of study under investigation. Recent study found a relationship between Inhibitory gating (IG) and laboratory-induced stressor (Atchely & Cromwell, in press). Atchely and Cromwell (in press) found that participants showed inhibitory gating deficit when they implemented preparatory information, scripts that regulated the forthcoming stressor, in addition to the stress manipulation using the cold – pressor task (CPT). One of the aims of the current study was understand stress regulation in different culture groups and the CPT was used to induce stress to measure cultural pain difference.

Current Study

In summary, the literature review introduced Hofstede's (1984) dimension of individualism and collectivism, which is used to distinguish cultural groups in this study. Furthermore, cultural neuroscience literature was introduced to provide bidirectional relationship between culture and neural processes. Particularly, previous studies involving early sensory mechanism, inhibitory gating, was presented to illustrate the gap in the literature. The goal of this study is to provide additional evidence on how this mechanism functions in healthy adults. It also investigated possible link between cultural background and inhibitory mechanism. In more detail, the goal of the present study was to investigate the relationship between auditory P50 inhibitory gating and cultural differences using stress stimuli. This study utilized ERP technique to investigate cultural impact on inhibitory gating. In order to evaluate for cultural differences, Chinese participants were examined to represent collectivist cultures and Caucasian Americans (US) participants represented individualistic cultures. The participants consisted of females because there is known gender difference in empathic neural responses between genders (Han et al., 2008). Drawing from the very limited prior research on cultural difference on cognitive neuroscience, the anticipated results were that participants from a collectivist culture (i.e. Chinese) would respond less to the stress stimuli than participants from an individualistic culture (i.e. Caucasian Americans). On the basis of the emotional self-report questionnaires, I predicted the response nature during post-stress would depend on the culture of the participant. The sheds light on the role culture mitigates person's stress and emotional regulation. In addition to the limitation of the literature available, the study highlights stress regulation and how pre-attentional sensory filtration differs in cultural groups. Moreover, the study uses collectivist culture and individualist culture to establish cultural differences. Collectivism is a cultural framework that places emphasis on group harmony while individualism is one that places importance on independence of the self.

CHAPTER III: METHODS

The overarching goal of this study was to deepen the understanding of cultural variability in inhibitory gating mediated by stress regulation. This chapter provides participants' information along with criteria used to properly screen participants. Moreover, inhibitory gating measurement tools and a description of the materials used in the study is also included in this chapter.

Participants

The study consisted of 10 Caucasian American female and 9 Chinese female participants. The majority of participants in this study were enrolled in an introductory psychology course and the remaining participants were recruited using flyers. Participation in this study was limited to females who come from either individualistic culture background or collectivist culture background. The following criteria were used to screen participants: between 18-30 years old, no current psychological diagnoses, no history of neurological disease, no serious medical conditions, no circulatory problems, and normal hearing. As a precautionary measure, participants who demonstrated serious illness unrelated to the screening criteria did not qualify to participate since the experiment involved physical stress. Participants were verbally asked to report if they had serious illness that was not mentioned in the screening form. Participants agreed to refrain from drinking alcohol or taking non-prescription drugs for 24 hours prior to their appointments. Participants who are also smokers agreed to refrain from nicotine usage for at least 30 minutes prior to testing as well. Moreover, evidence suggests that inhibitory gating mechanisms take time to develop; therefore participants were required to be at least 18 years old (Freedman et al., 1987). Because of the exploratory nature of the study, data were collected from females in order to control for any cross-gender difference that could potentially arise.

Materials

EEG Equipment and Stress Model

The ERP setup was composed of a Biopac MP150 unit, one Biopac ERS100C amplifier, and Biopac CAP100C electrode array for EEG measurement Activity (BIOPAC Systems, Inc., Goleta, Ca). EEG was recorded from the Cz, the central brain region (Yee and White, 2001). Two reference electrodes was placed on the earlobes and linked to the cap. Another reference electrode located on the cap, near the forehead, was also recorded to minimize noise. Data was recorded using AcqKnowledge 4.2 software (BIOPAC Systems, Inc., Goleta, Ca) and two Dell computers. One computer contained the E-prime software tool and the other computer had the AcqKnowledge software. The pair-clicks were presented electronically using E-prime 2.0 (Psychology Software Tools, Pittsburgh, PA). E-prime is a software tool use to present stimuli under precise timing. The pair-clicks were calibrated at 80 dB SPL and were also verified by a sound-level meter (Dolu et al., 2001). The pair-click lasted between 6 to 7 minutes. Participants received the clicks binaurally through noise-cancelling Sennheiser headphones.

The cold pressor test was performed by submerging the participant's left hand into cold water with temperature maintained at 32-34°. There was screen separating the water from the ice so participants will not directly be in contact with the ice. The participant was instructed to keep still and quiet. The experimenter stood behind the participant to avoid any unnecessary distractions. The participant was observed for pain or discomfort sensation and the test was terminated if the participant complained of great discomfort, otherwise they were required to keep their hand in ice water for 120 seconds. A stopwatch was used to time the test and the time was appropriately recorded for the particular participant.

EEG and ERP Technique

Electroencephalogram (EEG) is a recording of electric activity made from the scalp (De Waard, 1996). EEG electric signals are commonly classified into four bands: up to 4Hz. (Delta waves), 4 to 8 Hz (Theta waves), 8 to 13 Hz (Alpha waves), and more than 13 Hz (Beta waves). In its natural form, EEG is a highly coarse measure of brain activity (Luck, 2005). In the EEG outputs, there are varieties of brain activities, making it harder to decipher the neural processes that interest the investigator. A more accurate and controlled way to collect EEG activity is to use a technique that averages the waveforms that would separate the specific neural processes of interest. This technique is called event-related potential (ERP). ERPs are electrical potentials that are time locked to events and are associated with specific event in the environment (Luck, 2005). ERPs consist of a variety of components that measure specific neural processes that carry different temporal information along with the direction of the waveform, positive or negative.

P50 ERP Component

Research in P50 component using paired-clicks has been widely examined in the literature. The P50 (positive component occurring 50 m sec after stimulus onset) response, the most reliable measure of inhibitory gating, is a component of event-related potential. In a typical P50 paradigm two identical stimuli are presented with 500ms inter stimulus intervals (ISI) and with an inter-trial interval (ITI) of 10s. Each of these stimuli generates an EEG waveform. In normal individuals, the positive component that is elicited at approximately 50 ms, the P50 response, after the presentation of the second stimulus is generally found to be reduced compared to the P50 amplitude elicited by the first stimulus. The proposed study will utilize the P50 component responses to compare the responses of participants from the two cultures, collectivist and individualistic. Inhibitory gating is best measured by a ratio of the P50 amplitudes of S2 and

S1, or it is by the difference between the amplitudes of S2 and S1. However, traditionally, it is measured by dividing the S2 amplitude by S1 amplitude obtain a ratio – P50 ratio (White, Kanazawa, and Yee, 2005). There were two inhibitory gating trials conducted in this study and participants experienced stress stimuli between the trials.

Pair-Click Paradigm

Event-related potentials occurring approximately 50ms after click presentation (P50) provide a consistent mid-latency measure of inhibitory gating (Yee and White, 2001). P50 gating was assessed by comparing participants' P50 responses to initial clicks (the conditioning stimulus) and secondary clicks (the test stimulus). In greater detail, the initial click was followed by a second click at the 500ms mark. Click pairs were presented every 10 seconds. Participants listened to 49 pairs of clicks which they were allowed a short break to stretch between baseline gating and post-stress gating recordings (Yee and White, 2001). The inhibitory gating trials lasted between 6 to 7 minutes. In order to maintain consistency across participants, they were instructed to keep their eyes closed or to maintain gaze at a cross sign that appeared in the computer in front of them.

Positive and Negative Affective Scale (PANAS)

Participants in both groups were presented with the PANAS inventory before and after the collection of the electrophysiology data. The positive and negative affective scale (PANAS) is an emotional questionnaire that measures the affective well –being of an individual. The PANAS inventory consisted of 20 items and was developed to measure affective states of adults. The items on the scale are rated on 5-point scale ranging from 1 = *very slightly or not all* to 5) *extremely* to specify the extent to which the participant has felt this particular affective state at the current moment. The negative and positive affective terms were randomly distributed throughout the inventory. The test was validated with a sample of undergraduate students (Watson et al 1988). It comprises of two mood scales, one evaluating positive affect and the other measuring negative affect. Watson and colleagues (1988) stated Cronbach's alpha coefficients for the reliability of the measures were .86 for the positive affective terms and .87 for the negative affective items. The main focus was the positive and negative affect of the scale to examine whether participants experienced stress and relates to negative emotions after experiencing the cold-pressor task. In order to obtain an overall affective state of the participant, the sum of the 10-items that were positive affective terms and sum of the10-items that described negative affective states were calculated for each person.

State Anxiety Inventory (SAI)

Administration of the State anxiety inventory (SAI) was used to measure current anxiety symptoms of the participant (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). Spielberger and colleagues (1983) developed the SAI consisted of 20-items self-report measures. The SAI scale measures how participants feel at the moment (e.g. "I feel calm"; "I feel anxious"). The SAI have been found to contain two factors to measure anxiety, which Spielberger and colleagues labeled *anxiety absent* and *anxiety present* (Spielberger et al., 1983). The test showed high reliability (average αs > .89). The SAI questionnaire is useful in detecting current anxiety in clinical settings and to distinguish it from depressive symptoms (Spielberger et al. 1983). In this study, the SAI questionnaire was used to detect the presence of anxiety before and after the electrophysiological data.

Procedure

Upon arrival in the laboratory, a pre-screening form was read to participants to ensure they met the study criteria. After obtaining informed consent, the participants completed a mood questionnaire and an anxiety questionnaire. Participants were then prepared for the collection of electroencephalogram (EEG) data. The participants were seated in a comfortable armchair in front of a computer monitor. Testing took place in a room with sound attenuation. On average, the experiment lasted 60 minutes. For the EEG preparation, participants who have hair were required to comb and part their hair down the middle in order to fit the EEG cap and to prepare areas where the electrodes will be placed. Furthermore, participants were asked to remove any form of jewelry. Alcohol swab and Nuprep (Weaver and Company, Denver, CO) was used to clean the earlobes. The reference ear electrodes (Electro-Cap Systems, Eaton, OH) were filled with Ten20, a dense conductive gel (Weaver and Company, Denver, CO) and were placed on the earlobes. EEGs were recorded by the 16-electrode Cap (Electro-Cap Systems, Eaton, OH). The reference electrode located near the forehead was exfoliated using NuPep to reduce impedance and was subsequently filled with conductive gel. Conductive gel (Electro-Cap Systems, Eaton, OH) was inserted into the Cz site on the scalp. The EEG cap had two straps that snapped onto a chest band, which was used to hold the cap in place. The impedance for the cap and ear elctrodes was checked using ChekTrode; the average impedance for the participants was 10Kohms (M = 5 KΩ).

Participants were instructed to sit still, and were told to either close their eyes to decrease any movements or to keep their focus on a cross fixation point that appeared on the computer screen in front of them. They were also instructed to relax the muscles around their face and neck and to sit in a comfortable position. These instructions were given because any kind of movement and anxiety-induced physiological symptoms does create artifacts and thus makes the EEG readouts harder to interpret. After the first inhibitory gating trial, participants received a short break to rest their eyes and stretch. Next, participants were told to place their left hand, up to their wrist, in the ice water bath (32-34°F) for 120 seconds. The cold-pressor task is effective for inducing temporary pain; however, the task is harmless and does not have any long-lasting effects on the individual (Johnson & Adler, 1993). The experimenter reminded participants verbally that they were allowed to displace their hand at any time during the experiment if the cold-pressor task became uncomfortable. After the cold-pressor task, participants immediately began a second inhibitory gating trial that was identical to the first. The instructions were similar to the first inhibitory gating trial. Participants then filled out a second SAI and PANAS to assess their anxiety and mood after the experiment was over. At the end of the experiment, participants were debriefed and compensated for their time with either course credit or $10 cash incentive.

Data Analysis

Data were analyzed offline with AcqKnowledge software (BioPac Systems, Inc., Goleta, Ca). ERPs were extracted for paired-click tones in order to measure the P50 component. In more detail, EEG data was amplified and band-pass filtered at 1.0 to 100 Hz during data acquisition. The sampling rate was 1,000 Hz. The characteristic of P50 frequency is approximately 40 Hz; therefore the bandpass digital filter was set to 10-50 Hz and respectfully applied to the Cz channel (Zhang et al., 2012). This allowed the component to be identified more easily. All detected artifacts were corrected for by subtracting the appropriate voltages (Luck, 2005). P50 was measured at Cz site and the data was manually collected by identifying the highest positive peak between 30-90 msec range after the stimulus onset (Zhang et al., 2012). The data for the first stimulus was collected followed by the second stimulus. The P50 suppression ratio (P50 T/C ratio) was calculated as P50 amplitude to stimulus 2 divided by P50 amplitude to stimulus 1, expressed as percent and termed here the T/C ratio. A small P50 T/C ratio represented a large inhibitory capacity and thus, good inhibitory gating ability. Inhibitory gating is a necessary brain function because the failure to inhibit an influx of extraneous or distracting information may lead to processing inappropriate stimuli, which may result in perceptual or attentional deficits (Cromwell et al. 2008). Data collectors were blinded to participants' group assignments during analysis. The group association was added to the data after all the EEG analysis were complete.

Statistical Analysis

In the following analyses, data from all participants were included in the statistical analysis. All analyses used P50 amplitudes recorded from the Cz electrode site (Davies et al., 2009). The Statistical Package of Social Science (SPSS) was used for all data analysis. A repeated measure of ANCOVA was used to assess P50 test/condition ratio. Additional ANOVAs and t-tests were used to analyze the P50 amplitude stimuli and the emotional questionnaires.

CHAPTER IV: RESULTS

This chapter provides an overview of the results obtained from 19 participants (10 female Caucasian Americans and female Chinese). The results include the electrophysiology data acquired using the ERP paired-click paradigm design. Specifically, a comparison of the pre – stress and post – stress P50 T/C ratio for individualist and collectivist cultures are provided along with the P50 T/C ratio difference between the two cultural backgrounds. Moreover, results from the two identical clicks (S1 and S2) are provided in respect to each culture and the difference between the two cultures.

EEG Data Results

Most studies that use the P50 paired-click paradigm to assess inhibitory gating only evaluate Cz, the central scalp electrode. This study assessed the P50 paired-click paradigm using ANCOVAs by analyzing P50 T/C ratio for between collectivist and individualist group before experiencing stress and after stress induction while using the stress manipulation (cold-pressor task) duration and anxiety measure as covariates. ANOVAs or t-tests were used for the other measures.

P50 T/C Ratio

The cold-pressor task was used to induce stress to examine inhibitory gating mechanism in both groups. Moreover, the post-stress P50 T/C ratio is the reflection of the inhibitory gating trial obtained after participants experienced the cold-pressor task. Repeated t-tests were conducted in both groups to determine whether there were significant mean differences between baseline P50 T/C ratios and post-stress P50 T/C ratios. Participants in the collectivist culture group showed significantly greater P50 T/C ratio on post-stress inhibitory gating test compared to their baseline inhibitory gating test, $t(9) = 5.996$, $p = .001$. Similarly, there was also significant greater post –stress P50 T/C ratio than baseline P50 T/C ratio in individualistic culture participants, $t(9) = -5.610$, $p < .001$), as shown in Table 3. This illustrates that both groups showed inhibitory gating impairment after experiencing the cold-pressor task. However, there was a significant cold pressor duration difference between the cultures. The results indicated that participants in the collectivist group held their hands in the water significantly less time (M = 35 secs, SD = 32.26) than participants from the individualistic culture (M = 104 secs, SD = 28.50), $t(17) = -4.93$, $p > .001$). Next, to measure anxiety differences (SAI), a repeated measures of ANOVA, culture as the between subjects factor, presence of anxiety - before and after stress exposure, as within subject factor was conducted. Results revealed significant interaction between culture and presence of anxiety ($F(1, 17)$ – 65.14, $p < .001$). This result is due to individualist culture group reporting increased presence of anxiety at the start of the experiment (M = 29.60, SEM = 1.49) compared to the collectivist culture group (M = 16. 55; SEM = 1.13), as shown in figure 1**.**

Due to this significant difference in the stress manipulation and state anxiety, Pearson's correlation was conducted to examine if there was a relationship between these variables and pre – stress P50 T/C ratios (see Table 1 below). Although cold – pressor task duration and pre – stress P50 T/C ratio were not significantly correlated, $r(17) = .413$, $p > .05$), traditionally, a correlation above $r = .30$ is included in further statistical analysis. Moreover, pre – stress presence of anxiety was significantly and positively correlated with pre – stress P50 T/C ratio, $r(17) = .697$, $p < .05$). Similarly, pre – stress absence of anxiety was significantly and negatively correlated with pre – stress P50 T/C ratio, $r(17) = -.591$, $p < .05$. Taken together, individualistic culture participants reported higher level of anxiety and also kept their hand in the stress task more than collectivist culture.

Next, a follow up analysis was conducted to examine inhibitory gating difference when state anxiety and cold –pressor duration were considered between the two groups. To assess the difference, a repeated measure of analysis of covariance (ANCOVA) was employed to measure stress (pre-stress, post – stress induction), as within subject factors, culture as between subject factors, and cold– pressor duration and SAI as covariates (see Table 2 below). There was no significant main effect for stress, $F(1, 14) = .329$, $p > 0.05$. There was no significant interaction effect between culture and stress, $F(1, 14) = .016$, $p > 0.05$. Similarly, there was no significant interaction between stress and the cold-pressor task duration, $F(1, 14) = .216$, $p > 0.05$). Moreover, there was no significant interaction between stress and pre – stress presence of anxiety, $F(1, 17) = 2.91$, $p > 0.05$. The qualitative difference in post-stress inhibitory gating was due to the difference in pre-stress anxiety and cold-pressor task duration. As shown in figure 1, the two cultures showed the same inhibitory gating trend when pre-stress anxiety reports and CPT duration are included in the analysis.

Stimulus 1 & Stimulus 2

The capability of inhibitory gating is measured by the ratio of the P50 amplitudes of S1 and S2. The first stimuli also known as the conditioning click (S1) was presented to the participants to compare it to the second stimulus also known as the test click (S2). S1 and S2 are the pair-click paradigm described in detail in the methods sections. Since S1 and S2 are the components that make up the P50 ratio, analysis comparing the stimuli, stress, and cultural differences were examined. To assess stimuli difference, a three-way ANOVA test comparing between stimuli (S1 and S2), culture (individualist and collectivist culture), and stress induction (pre- and post-stress) was conducted. The test revealed a main effect for stimuli ($F(1, 17) = 175.3$, $p < 0.001$) and a significant interaction between stimuli and stress ($F(1, 17) = 51.56$, $p <$

0.01). There were no significant between group effects, see table 3 for descriptive statistics on stimuli amplitudes. Individuals in both groups had higher P50 amplitude of S2 and decrease in S1 after experiencing the stress stimuli, which led to P50 gating impairment.

PANAS Data Results

The PANAS was distributed to participants to assess affective states before and after the collection of the EEG data. To examine negative affective state difference, a repeated measure ANOVA, with culture as a between subjects factor, and scores on PANAS– before and after stress exposure, as the within subject factor was conducted. In order to check and see if the data met the assumption of normality, Q-Q plots for the PANAS scores were examined. ANOVA tests are robust to violations of this assumption (Mertler & Vannatta, 2009), the assumption was assumed met. The results found no main effect of culture ($F(1, 17) = .511$, $p > .05$) and no main effect of pre- and post-stress affective state ($F(1, 17) = .569$, $p > .05$). The participants in both cultural groups reported about the same affective states before and after experiencing stress. The PANAS questionnaire did not reveal interesting data supporting the aims of the study. The means are graphed in figure 5.

Table 1

Correlation for SAI, CPT Duration, and P50 T/C ratios

Factors		Cold –Pressor Task Duration	Pre-Stress Absence Anxiety	Pre-Stress Presence Anxiety	Pre-Stress P50 T/C Ratio	Post-Stress P50 T/C Ratio
Cold-Pressor Task Duration	Pearson Correlation Sig. (2-tailed)		-.497 .030	.675 .002	.083 .736	.413 .079
Pre-Stress Presence Anxiety	Pearson Correlation Sig. (2-tailed)	.675 .002	-.870 .000		-.032 .898	.697 .001
Post-Stress P50 T/C Ratio	Pearson Correlation Sig. (2-tailed)	.413 .079	-.591 .008	.697 .001	-.167 .495	

Bold indicates significant correlation at the 0.05 level (2-tailed)

Table 2

Repeated Measure ANCOVA: P50 Gating Ratios and Anxiety Reports

Source	SS	df	MS	F	p
Stress	10.86	1	10.86	.329	.576
Stress*CPT	7.12	1	7.12	.216	.650
Stress*Pre-Stress Presence of Anxiety	4.94	1	4.94	.150	.705
Stress*Pre-Stress Absence of Anxiety	95.97	1	95.97	2.91	.110
Stress*Culture	.536	1	.536	.016	.900
Error	108.0	54	2.0		

Table 3

Mean T/C Ratio (%) and Stimuli Amplitude (in µV) for each of the 2 groups. Standard Deviations are shown in parenthesis

Condition	Mean P50 T/C Ratio	Amplitude Conditioning Stimulus	Amplitude Test Stimulus
Pre-Stress Inhibitory Gating			
Individualist Culture	84.55 (5.83)	.030 (.093)	.028 (.090)
Collectivist Culture	84.12 (4.42)	.043 (.130)	.038 (.120)
Pre-Stress Inhibitory Gating			
Individualist Culture	101.49 (5.50)	.073 (.232)	.074 (.235)
Collectivist Culture	94.96 (5.11)	.074 (.224)	.078 (.235)

Figure 1

Inhibitory Gating Mechanism and Culture: Includes CPT duration and SAI as Covariates

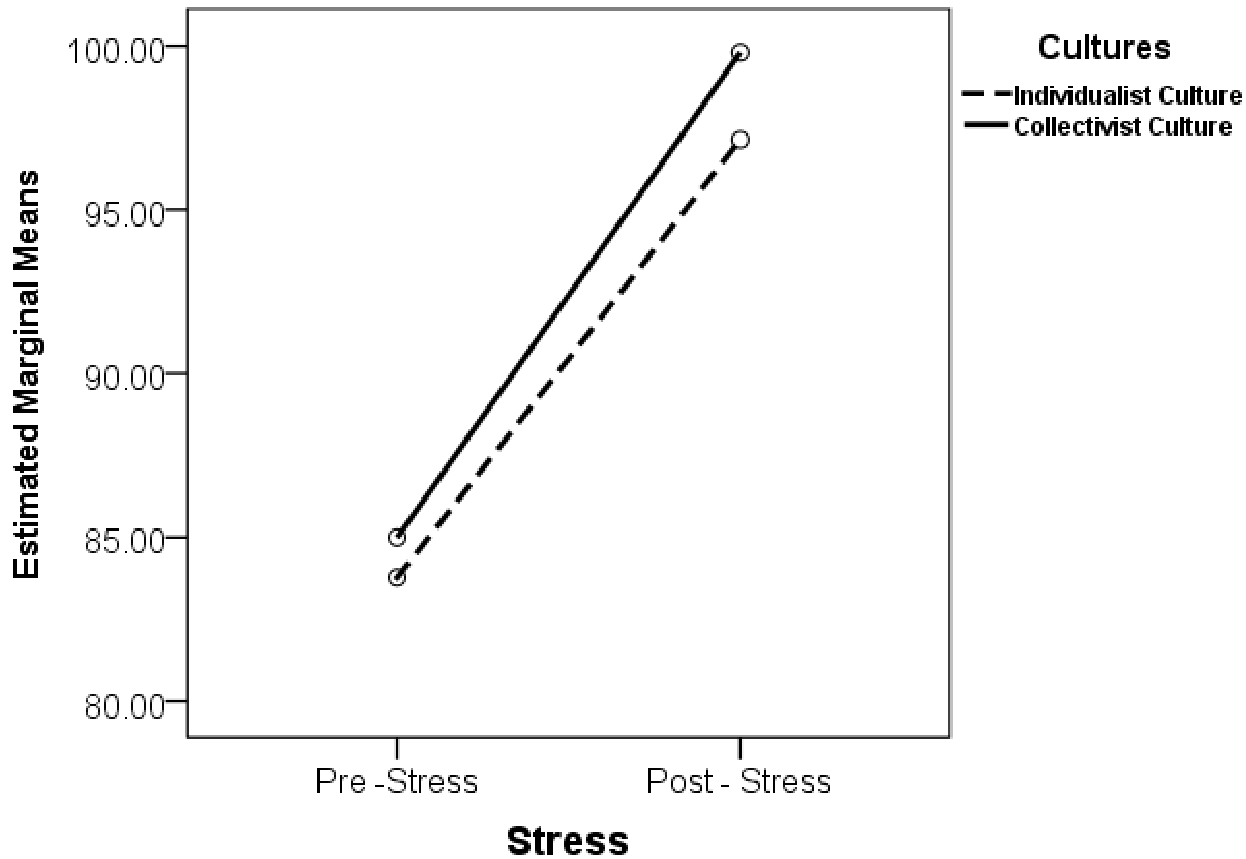


Figure 2

<u>Presence of Anxiety measured by SAI</u>

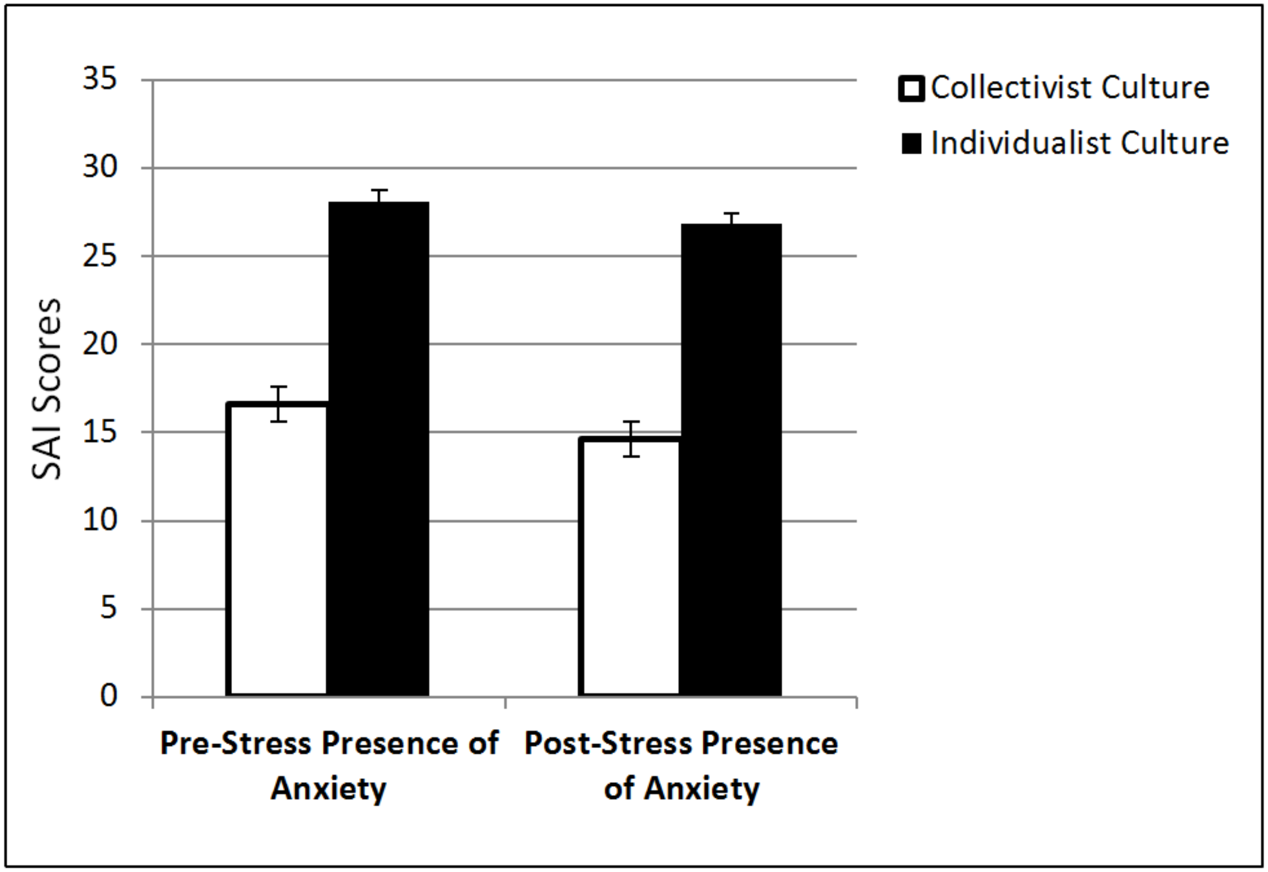


Figure 3

<u>Stimulus 1 & Stimulus 2 Mean Graph</u>

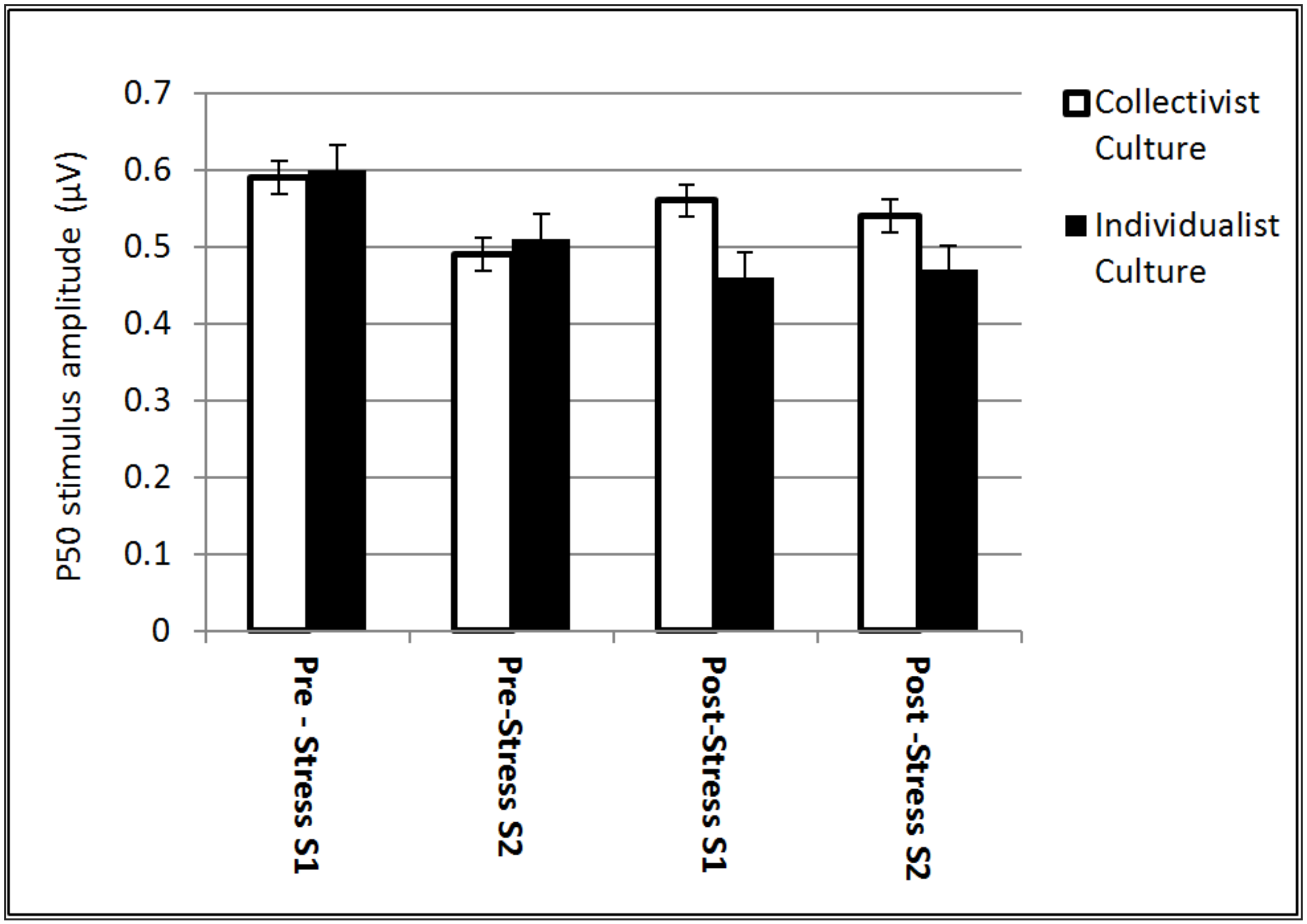
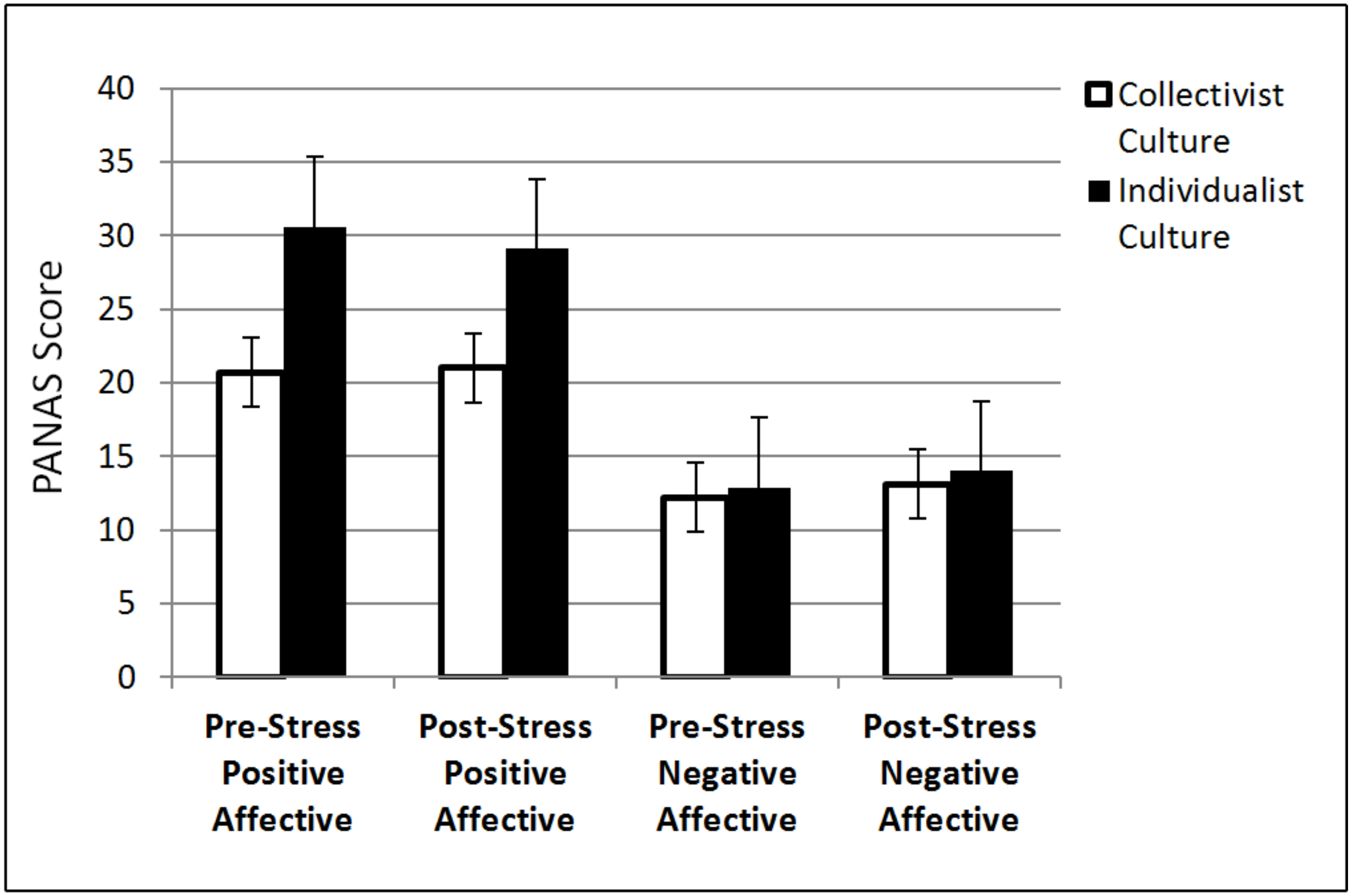


Figure 4

Positive and Negative Affective Scale Reports



CHAPTER V: DISCUSSION

Overview

In respect to the hypothesis of the study, the results indicated that: the cold – pressor was effective in inducing stress and produced inhibitory gating impairment in participants from cultural backgrounds. Caucasian American participants kept their hand in the ice-water longer than the Chinese participants. Furthermore, Caucasian American participants reported higher anxiety levels before and after the collection of the EEG data. This significant difference in the pre-stress anxiety reporting and difference in the cold –pressor task duration explain the difference in post-stress inhibitory gating test. However, the negative affective states measured by the PANAS questionnaire did not differ in pre –stress and post-stress responses in both groups. The findings suggest that both groups had impaired gating but the Caucasian American participants showed greater impairment because of their pre-stress presence of anxiety and stress stimuli response. Moreover, this study concludes that participants in both cultures may have similar inhibitory gating mechanism but differ in their level of anxiety.

Specific aim 1: Stress on Inhibitory Gating

Two groups of healthy participants experienced the cold pressor task (CPT) to see if the task revealed inhibitory gating impairment. P50 ERP potential was recorded before and after the cold – pressor task to examine a change in the amplitude of the P50 ERP. In both groups, a significant increase in P50 T/C ratio was observed after participants experienced the stress-inducing task. Similar to previous studies, the findings conclude that a change in the P50 T/C ratio was due to the effect of the cold pressor task and thus stress impairs inhibitory gating (Atchley & Cromwell, in press; Woods et al. 2012; & Johnson and Adler, 1993). Currently, the mechanisms that might govern stress regulation and its perpetual effect on this early sensory processing mechanism remain unclear.

In more detail, the P50 T/C ratio is used to reliably discriminate impaired and normal function inhibitory gating circuit. Relying on the early work by Freedman and colleagues (1983), this study assessed inhibitory gating at the central brain region (Cz), where it has been reported to show the most robust P50 suppression. Participants' P50 gating was collected at baseline (i.e. before the cold-pressor induction) and post-stress (i.e after cold-pressor induction). P50 suppression is traditionally quantified by computing a ratio of evoked potentials by using auditory paired clicks (de Wilde O, Bour L, Dingemans P, Koelman J, & Linszen D, 2007). In inhibitory gating paired-click paradigm, the first click is called the Conditioning(C) click because it essentially conditions the brain to be prepared for additional incoming sensory stimuli. Subsequently, the second click is called the Test (T) click because it tests whether the brain prepared for previous incoming stimuli. Although, the results did not reveal meaningful difference between the stimuli, the P50 T/C ratio provided significant information regarding the inhibitory gating function. As expected, both groups showed normal baseline inhibitory gating, by examining the P50 T/C ratio. However, participants in both groups showed inhibitory gating impairment in their post-stress inhibitory gating trial. This suggests that stress plays an important role in a person's ability to filter out redundant sensory information. In order to alleviate stress and re-store the ability to gate sensory input, future research will need to include stress management and stress regulation in sensory gating research.

Specific aim 2: Culture and Inhibitory Gating

The stress induction was effective in reducing the P50 gating in both groups, however, individualist culture participants showed higher P50 T/C ratio due to a presence of anxiety at the start of the experiment. This significant presence of anxiety influenced the inhibitory gating mechanism after participants experienced the stress stimuli. Moreover, individualist culture participants held their hands in the cold-pressor task, which created greater anxiety as observed from their post-stress anxiety results. Therefore, the observed P50 gating deficit in the Caucasian American participants is presumably due to higher levels of anxiety, in addition to the stress manipulation. There might be cultural-specific presentations of anxiety. Few studies illustrate that within collectivist cultures, strict social norms intended to ensure group harmony may induce social anxiety due to feared negative consequences if those norms are violated (Heinrichs et al. 2006; Schreier et al. 2011). On the contrary, research from cross-cultural epidemiological studies show that collectivist culture populations (i.e. East Asian cultures) consistently report lower prevalence of negative affect, such as anxiety and mood disorders (e.g. major depressive disorder and bipolar disorder) relative to individualist culture populations (Weissman et al. 1996; Kessler & Ustun 2008).

There have not been studies that attempted to reconcile the discrepancy in cross-cultural studies regarding anxiety differences. However, one postulation is that reporting the presence of anxiety is related to the emotional expression of individuals. Uchida and colleagues (2009) proposed that collectivist culture contexts provide a conjoint model; emotions develop from multiple sources and involve evaluating the relationship between the self and others. Furthermore, in the individualist culture context, disjoint model is demonstrated through emotions stemming from individual experiences and primarily internal. Their research suggests that when Caucasian Americans are asked about emotions, they are more likely to have self-focused responses “I feel happy” whereas as Japanese typical reaction would reflect emotions between the self and others “I would like to share my happiness with others.” Therefore, Uchida and colleagues (2009) argue that emotion, assessed in relational context, are more prevalent in collectivist culture than individualist cultures. Thus, it is possible that participants in the collectivist culture reported feeling less anxious because of this relational aspect of emotion.

In one of the classic studies of inhibitory gating, Waldo and Freedman (1986) had participants perform a mental arithmetic task while listening to paired-clicks to induce stress. They found that the arithmetic task did not change the P50 suppression ratio. In their analysis, there were few people in their sample that showed reduction in P50 suppression. The researchers suggested that it could be due to an increase in anxiety. This automatic suppression of gating represents the ability to regulate the amount of information an individual receives and thereby facilitating the ability to organize and efficiently process information (Waldo and Freedman, 1986). The current study suggests that presence of anxiety disrupts this process and thus influences the individual's ability to organize and process information. Moreover, it is concluded that individual's culture background is needed in order to adequately examine effects of stress and anxiety on inhibitory gating.

Previous research has focused on inhibitory gating involving individuals with psychiatric disorders, there have been research that conducted differences in P50 gating in healthy adults. Patterson and colleagues (2008) observed P50 gating differences in healthy adults, noting some participants' P50 gating scores falling within the range of those observed in individuals with psychiatric disorders. Relatively little is known, however, about the functional significances of impaired inhibitory gating. Many of studies in inhibitory gating show the involvement of psychological variable. Although limited, this study provided possible differences in sensory filtering system associated with anxiety difference that could potentially be rooted in cultural and experiential differences.

Furthermore, the difference in inhibitory gating impairment could be due to the stress perception in both cultures. Numerous studies have suggested that difference in cultural practices lead to perceptual difference (Chua et al, 2005 & Nisbett & Miyamoto, 2006). The suggestions in the studies proposed that social structure effected perception and regulations. In an interdependent social structure, one would place importance on relationships and view the environment in a holistic matter whereas an independent social structure would require the individual to place emphasis on personal goals and view the environment in a more detailed matter. Societies that have more interdependent social structure, such as an Eastern Asian society, attend more to the context of the environment and thus experience perceptions in a holistic matter (Nisbett & Miyamoto, 2006). However, societies that have more independent social structure, such as the USA, place importance on saliency and interpret the environment through those lenses (Nisbett et al. 2001). This study focused on emotional regulation, specifically stress regulation, and one of the goals was to see how a temporary pain and stress perception effects neural inhibition. Stress regulation has not been widely studied in a cross-cultural research. However, in the early work of field anthropology, stress has been examined in terms of the identification of highly stressed groups, understanding of the relative importance of specific stressors on certain groups, and identification of cultural phenomena that are either stress producing or stress reducing (Brown, 1981). Additionally, Flinn (2006) suggested that human species must have proper stress regulation that is best fitted for their cultural and environmental context. The researcher's view suggests that, from an evolutionary perspective, humans evolved to cope with the growing complexity of the social and cultural environment. According to this line of interpretation, stress regulation is adapted based on cultural environment.

To further tie Hofsted's cultural dimensions of collectivism and individualism, the cross-cultural stress and pain perception studies indicated that homogeneous, closely knitted (collectivistic in nature) cultures tend to have lower reports of pain perceptions. These well-studied cultural traits describe the relative value placed on the individual in relation to the group. One explanation is that collectivist cultures are already equipped with this sharing mechanism and thus deal with painful and stressful stimuli and other perceptions better. Another explanation could be that individualistic cultures report painful stimuli because they are better at reporting their emotional expressions. From previous research, culture shapes the amount of emotions people express to others. As culture is a multi- faceted construct (Bond & Tedeschi, 2001), it is important to understand and measure what it is about culture that can account for cultural differences in emotional expression. For example, Matsumoto, Takeuchi, Andayani, Kouznetsova, and Krupp (1998) found cultural differences in the importance of different display rules for emotional expression. Their analyses revealed that the constructs of individualism and collectivism at the individual level mostly mediated these cultural differences across types of emotions and social experiences.

Current Study Implications

The relatively limited research examining culture and brain function relationship prompted this study. The study examined cultural influences on pre-attentional sensory filtration process and emotional regulation. Inhibitory gating measured by the P50 ERP ratio has usually been studied in schizophrenics and other psychiatric disorders, and no attention has been given to cultural difference effects in gating mechanism. It was hypothesized that individuals with individualist culture background would show greater P50 deficits in comparison to individuals from collectivist cultures when expose to a stress stimuli. Moreover, it was hypothesized that greater emotional suppression would be present in collectivist culture participants after the stress induction compare to participants from individualistic perspective. The findings suggested P50 gating differences after stress stimulation was due to individualist culture group reporting elevated anxiety levels at the start of the experiment than collectivist culture group. Due to this anxiety and stress stimuli duration difference, there was a greater P50 gating deficit in individualist culture participants. The affective state inventory showed no meaningful difference between the cultural groups. Taken together, results from this study suggest that reductions in P50 amplitude to the second of the paired auditory stimuli may reflect cultural differences due to emotional regulation difference. Furthermore, additional exploration would be useful to assess where the cultural differences lie in the inhibitory gating circuit. Moreover, if the inhibitory gating circuit is in fact dependent on stress and affective regulation, cultural variations will need to be included in future research. Additionally, there is evidence illustrating the distinction between individualism and collectivism in convincing that the theoretical constructs have aided cross-cultural research (Hui & Triandis, 1986). However, the rise of globalization and technological development has facilitated an increase in virtual as well as actual interaction between collectivist and individualist countries. Therefore, there is need for sub-categories within the constructs that would appropriately predict cultural differences in future research. Along with changes in societies, culture will vary in degrees of collectivism and individualism. Thus, the theoretical framework of collectivism and individualism will change along with modification in cultural values and the influence of the ongoing globalization.

In general, there is limited research on electrophysiology studies focused on culture and brain functions. This study attempted to illustrate culture, as an agent that facilitates significant change in brain functions. Bruce Wexler, a professor of Psychiatry at Yale University, argues that this bidirectional influence culture and the environment have on the brain yields neuroplasticity, the quality of neural structures to change. These neural structures change primarily through the interconnections of the basic nerve cells that establish the structures (Han & and Poppel, 2011). These changes occur due to a proliferation in neuronal activation and an increase in pathways where these neurons communicate; “neurons that fire together, wire together”. In this study, although inhibitory gating difference was not evident in both cultures, it is possible that at different times the basic nerve cells that constitute these structural adaptations change due to cultural and environmental influence. Thus far, molecular structure and mechanistic differences due to culture has not been well established. This is partly due to the fact that research on culture and brain function is at its infancy and thus poses many questions that have yet to be answered. However, the field’s early stage also highlights its exceptional potential in answering the ancient question of nature and nurture as joint factors of human behaviors, and how these influences arise. Whether through electrophysiological or neuroimaging studies, the field of cultural neuroscience features the importance of understanding human culture as a key factor in psychological and biological processes.

Limitations and Future Directions

There are several limitations of the current study that need to be acknowledged. One of the limitations for this study was that the Chinese cultural background participants were tested in an individualistic country (USA) and in English. In order to increase the validity of the results, Chinese students who recently arrived in the United States (< 3 months) were recruited for the study. Additionally, participants were told to abstain from alcohol and smoking prior to arriving in the laboratory, participants’ drinking and smoking habits were not included in the experiment model. Furthermore, majority of the participants were recruited from introductory to psychology courses and were required to participate in a study to learn about the research process. Due to this requirement, participants recruited through introductory to psychology courses, which mostly represented the Caucasian American group, may have come in to the laboratory with higher anxiety than those who voluntarily wanted to participate in the experiment. In addition, majority of the Chinese participants were graduate students and were proficient in the English language whereas all the Caucasian American participants were undergraduate students. Other methodological limitations in the study relate to the acquisition and analysis of the ERP data. The P50 wave is rather small wave that is susceptible to attenuation from excess noise in the EEG recordings (Luck, 2005). One way this study improved the detection of the P50 wave was to increase the size of the waveforms. Another way to improve P50 wave detection would have been to increase the number of trials to improve signal to noise ratio (Luck, 2005). The time required to collect significant number of trials was beyond what was practical for this study.

Although both groups showed inhibitory gating impairment after the stress stimuli, the Chinese participants held their hand in the task significantly less time than the Caucasian participants. A qualitative response from the participants was that in most Asian countries, ice – water is not favorably regarded. Additionally, Mony and colleagues (2013) reported in their perception of sweetness study that most Asian individuals prefer room temperature or hot water with their meals whereas North American individuals prefer cold or ice –beverages. Therefore, there might be a cross-cultural CPT difference, which might account for the significant duration difference. Future studies would need to use different stress manipulation to assess cross-cultural stress regulation and inhibitory gating. Furthermore, P50 ERP component may not be the only measurement of inhibitory gating. It has been found that schizophrenics have reduced amplitudes for the N100 and P200 ERP components, and have considerably longer latencies for the P50 and N100 ERP components (Boutros, Korzyukov, Oliwa, Feingold, & Campbell, et al, 2004). In connection with cultural differences in inhibitory gating, future research needs to assess these later stages of inhibitory gating.

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APPENDIX A. SCREENING CRITERIA

Screening Letter

EXPERIMENT INSTRUCTIONS: Inform the participants that their responses to these screening questions are confidential. The responses that are marked with the asterisk act as grounds for disqualification.

1. Are you a female that is between 18 and 30 years old? ___Yes ___No*
2. Are you currently diagnosed with a mental disorder? ___ Yes* ___No
3. Have you ever been diagnosed with a neurological disorder? ___Yes* ___No
4. Are you currently receiving treatment for any medical condition? ___Yes* ___No
5. Do you have Reynaud's disease or any other vascular diseases?
6. Do you have any hearing problems? ___Yes* ___No
7. Do you have any non-removable metal objects around your face and ears? ___Yes* ___No
8. Would you be willing to abstain from non-prescription drugs for 24 hours prior to the experiment?

   ___Yes ___No*
9. Would you b willing to abstain from nicotine for 30 minutes prior to the experiment? ___Yes

   ___No*
10. Would you be willing to abstain from alcohol for 24 hours prior to the experiment? ___Yes ___No*

NOTE: This letter will be read to the participants as soon as they enter the experiment room. The asterisks are for the researcher to mark, if the participant gives the answers with the asterisks they will be treated as grounds for disqualification. The participants will not see the asterisks on the paper. In order to protect the participant and keep out unnecessary admittance of medical conditions, the researcher will read the following statement to the participants:

"Thank you for coming to participate in this study. During this experiment, you will submerge your hand in cold water and there are certain medical conditions that might be exacerbated by participating in the cold pressor task. Therefore, we will have to exclude participants who had history of cardiovascular disorders including hypertension, history of fainting or seizures, history of frostbite, open cut or sore on hand to be immersed, fracture of limb to be immersed, and Reynaud's disorder or any other vascular diseases. We want to conduct a safe experiment and not cause any harm to participants. If you meet any of the medical conditions listed, please let me know so we can terminate the experiment."

If the participant passes this screening process, proceed to the consent form.

APPENDIX B. POSITIVE AND NEGATIVE AFFECTIVE SCALE

PANAS

This scale consists of a number of words that describe different feelings and emotions.
For each item indicate to what extent you feel this way at the present moment.
Write a number from 1 to 5 on the line next to each item.

very slightly or not at all	a little	moderately	quite a bit	extremely
1	**2**	**3**	**4**	**5**

1. ______ interested	8. ______ distressed	15. ______ excited
2. ______ upset	9. ______ strong	16. ______ guilty
3. ______ scared	10. ______ hostile	17. ______ enthusiastic
4. ______ proud	11. ______ irritable	18. ______ alert
5. ______ ashamed	12. ______ inspired	19. ______ nervous
6. ______ determined	13. ______ attentive	20. ______ jittery
7. ______ active	14. ______ afraid	

Source: Watson, Clark & Tellegen, 1988.

APPENDIX C. STATE ANXIETY INVENTORY

SAI

INSTRUCTIONS: A number of statements that people have used to describe themselves are given on the following pages. Read each statement and then select the appropriate one to indicate how you feel right now, that is, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

1. I feel calm.

- ☐ Not at all
- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

2. I feel secure.

- ☐ Not at all
- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

3. I am tense.

- ☐ Not at all
- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

4. I am regretful.

- ☐ Not at all
- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

5. I am at ease.

- ☐ Not at all
- ☐ Somewhat

- [ ] Moderately so
- [ ] Very much so

6. I feel upset.

- [ ] Not at all
- [ ] Somewhat
- [ ] Moderately so
- [ ] Very much so

7. I am presently worrying over possible misfortunes.

- [ ] Not at all
- [ ] Somewhat
- [ ] Moderately so
- [ ] Very much so

8. I feel rested.

- [ ] Not at all
- [ ] Somewhat
- [ ] Moderately so
- [ ] Very much so

9. I feel anxious.

- [ ] Not at all
- [ ] Somewhat
- [ ] Moderately so
- [ ] Very much so

10. I feel comfortable.

- [ ] Not at all
- [ ] Somewhat
- [ ] Moderately so
- [ ] Very much so

11. I feel self-confident.

- [ ] Not at all

- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

12. I feel nervous.

- ☐ Not at all
- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

13. I am jittery.

- ☐ Not at all
- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

14. I feel "high strung".

- ☐ Not at all
- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

15. I feel relaxed.

- ☐ Not at all
- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

16. I feel content.

- ☐ Not at all
- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

17. I am worried.

- ☐ Not at all
- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

18. I feel overexcited and rattled.

- ☐ Not at all
- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

19. I feel joyful.

- ☐ Not at all
- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

20. I feel pleasant.

- ☐ Not at all
- ☐ Somewhat
- ☐ Moderately so
- ☐ Very much so

APPENDIX D. CONSENT FORM

BGSU®

BOWLING GREEN STATE UNIVERSITY

School of Educational Foundations, Leadership and Policy & Department of Psychology

Title of the Experiment: Stress Regulation and its effect on Inhibitory Gating: Cross-Cultural Analysis

Principal Investigator: Naima Dahir
School of Education Foundations, Leadership and Policy
Email: ndahir@bgsu.edu
Phone: (614) 599 - 5663

I am conducting a research to understand more about inhibitory gating, which is a pre-attentional brain mechanism that measures the sensory stimuli in the brain. Inhibitory gating is the brain's response to sensory information as measured by electroencephalograph (EEG). In order to participate in this experiment, you must meet the following criteria:

1. Be between ages 18 and 30.
2. Not currently diagnosed with mental disorders and never diagnosed with neurological disease.
3. Not currently receiving treatment for any medical condition.
4. Normal hearing.
5. Able to remove any metal objects worn around the ears or on the face.
6. Willing to abstain from:
    a. Non-prescription drugs for 24 hours prior to the experiment.
    b. Nicotine for 30 minutes prior to the experiment.
    c. Alcohol for 24 hours prior to the experiment.

If you agree to participate in this experiment keeping the outlined criteria in mind, the following will take place:

At the start of the experiment, I will ask you to review the criteria for the study to ensure you have met them. If you are able to participate in the study, you will take surveys that question you about your current mood and general characteristics. After the survey, you will wear an electrode cap on your head, two electrodes will be placed on each of your earlobes, two electrodes will be placed around your right eye, and one electrode will be placed on your forehead. During the experiment, you will wear noise-canceling headphones; listen to clicks for about 6-7 minutes. You will sit in a comfortable position with your eyes closed during the clicks. Next, you will be informed about the cold-water task and you will place your left hand in the water for about 30 seconds. Next, you will be asked to listen to set of clicks for another 6-7 minutes. Finally, the electrodes will be removed from your face and your ears. The EEG cap will also be removed. At the end of the experiment, you will take the questionnaires again based on your experience with the above procedures. This experience should last about an hour.

You will earn course credit or receive cash incentive for your participation in this experiment. You will receive 0.25 SONA credit or $2.50 for every 15 minutes you participate. The total experiment is worth 1 SONA credit and the total cash incentive is $10. If you withdraw from the experiment without completing it, the course credit and the cash incentive will be rounded up to the nearest ¼ hour increment. The researcher will ask whether the participant chooses to receive a SONA credit or cash incentive; the participants will be rewarded according to their choice.

Your participation for this experiment will be held to the highest confidence. When you come in to participate in the experiment, I will assign you a number that I will use to represent you throughout the experiment. Your participation files will be stored in a password protected computer. Only approved researchers will have access to these files to maintain confidentiality. The only form that will have your name is this consent form and I will store it in a locked cabinet.

Participation in this study is entirely voluntary. You can refuse to participate or withdraw it at any time. By participating in this study, your academic records and your affiliated relationships with the university will not be impacted in any way. The experiment will be terminated without your consent if I observe equipment damage or any other unforeseen technical circumstances. If I have to terminate the experiment, you will still receive course credit or cash incentive.

The risk of participating in this experiment is not greater those experience in daily life. The ice water might be uncomfortable, but you are free to withdraw your hand at anytime. However, participants with vascular diseases (e.g. Raynaud's disease) might be exacerbated by participating in the cold pressor task and therefore will be excluded from the experiment. There will always be an experimenter to address any concerns you may have. There are no direct personal benefits to you by participating in this study, but this experiment will help us understand how culture shapes the human brain and its impact on inhibitory gating.

If you have any questions regarding this form, please ask the experimenter before proceeding. If you also like more information about this particular study, feel free to contact Naima Dahir by using the information provided at the top of this form. You may contact the project Advisor: Dr. Sara Abercrombie, at (419) 372 – 3412 or sabercr@bgsu.edu. If you have questions regarding the conduct of this study or concerns regarding your rights as a research participant, you may contact the chair of the Human Subject Review Board at Bowling Green State University at (419) 372 – 7716 or hsrb@bgsu.edu.

I have had the study explained to me, and my questions have been answered to my satisfaction. Based on the information I have been given, I agree to participate in this study.

______________________________ __________________________

Participant Signature Date

BGSU HSRB - APPROVED FOR USE
IRBNet ID # 456140
EFFECTIVE 03/24/2014
EXPIRES 06/29/2014

APPENDIX E. HSRB APPROVAL LETTER

BGSU®
BOWLING GREEN STATE UNIVERSITY
Office of Research Compliance

DATE:	July 29, 2013
TO:	Naima Dahir, M.A.
FROM:	Bowling Green State University Human Subjects Review Board
PROJECT TITLE:	[456140-3] Stress Regulation and its impact on Inhibitory Gating: Cross-Cultural Analysis
SUBMISSION TYPE:	Revision
ACTION:	APPROVED
APPROVAL DATE:	July 26, 2013
EXPIRATION DATE:	June 29, 2014
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category # 7

Thank you for your submission of Revision materials for this project. The Bowling Green State University Human Subjects Review Board has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

The final approved version of the consent document(s) is available as a published Board Document in the Review Details page. You must use the approved version of the consent document when obtaining consent from participants. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that you are responsible to conduct the study as approved by the HSRB. If you seek to make any changes in your project activities or procedures, those modifications must be approved by this committee prior to initiation. Please use the modification request form for this procedure.

You have been approved to enroll *40* participants. If you wish to enroll additional participants you must seek approval from the HSRB.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. All NON-COMPLIANCE issues or COMPLAINTS regarding this project must also be reported promptly to this office.

This approval expires on June 29, 2014. You will receive a continuing review notice before your project expires. If you wish to continue your work after the expiration date, your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date.

Good luck with your work. If you have any questions, please contact the Office of Research Compliance at 419-372-7716 or hsrb@bgsu.edu. Please include your project title and reference number in all correspondence regarding this project.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Bowling Green State University Human Subjects Review Board's records.