Master's Thesis of Education

The Relation between Depression and Empathic Reactivity According to Changes in Mu Rhythm

- An EEG Study -

우울과 공감적 반응성 간의 관계: EEG에서 뮤 리듬의 변화를 중심으로

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Abstract

The results regarding the relation between depression and empathic reactivity greatly vary despite numerous researches. The present study aims to deepen the understanding of and identify the correlation between depression and empathic reactivity through the measurement of mu rhythm.

A total of 40 participants were divided into two groups - non-depressed (here forward referred to as the healthy group) and subclinically depressed (here forward referred to as the depressed group). Those who scored between 0-15 points in the CES-D questionnaire were placed in the healthy group, while those who scored 16-24 points were placed in the depressed group. Each group consisted of 20 participants. Of the 40, the data of 2 participants in the depressed group were removed due to data loss in the recording process. All participants satisfied the participation conditions, which included normal or corrected-to-normal vision, normal hearing, no history of mental illness, no intake of medicine that may affect neural activity, and right-handedness. Participants took the CES-D for group assignment and participated in the EEG experiment for the measurement of mu suppression. Participants were presented with pictures that showed painful situations and were instructed to either increase or decrease their level of empathic reactivity when viewing the pictures, according to the condition. Research findings showed that there was a significant interaction effect between group and condition. Furthermore, the healthy group showed a significant difference in mu suppression between the two conditions, with a stronger mu suppression in the increase condition. The depressed group, however, did not show a significant difference between the two conditions.

Such results support past research in that top-down processing of depressed individuals’ cognitive empathy does not properly mediate empathic reactivity, leaving them not distinguishing between oneself and the other when empathizing. The current study also provides theoretical contributions by clearing up the contradicting results between depression and empathy through using an objective method of measuring neural reactivity, therefore confirming an important factor related to subclinical depression. The results provide an insight into the differing mechanism of those with a subclinical level of depression and suggests a pathway of intervention into depression. Limitations and future directions are further discussed.

Keyword : Depression, Subclinical Depression, Empathy, Mu Rhythm, EEG, Neural Reactivity
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1. Introduction

1.1 Introduction

In 2020, South Korea ranked 1st in depression prevalence rate amongst OECD countries (OECD, 2020). Depression is a sustained depressed state of mood, including loss of interest in daily activities, restlessness, tire, insomnia or hypersomnia, and reduction in cognition or attention (First, 2013). If not treated properly, it can lead to detrimental outcomes such as suicide (Jeon et al., 2010). The majority of those who commit suicide have shown to have a relation with depression (WHO, 2009), which makes it even more important that we understand various factors that are related to depression.

Depression takes a significant effect in different aspects of life including social relationships, low quality of relationships, and a low level of social support (Hirshfeld et al., 2000; Bosc, 2000; Stefos et al., 1996). It is related to a defect in the processing of cognitive and affective stimulants (Marazziti et al., 2010). When depressed, individuals pay more attention to negative information while having trouble focusing on positive stimuli (Disner et al., 2011; Suslow et al., 2001) and even show a bias in interpretation, judging facial expressions to be less happy or sadder than non-depressed individuals (Bourke et al., 2010). Such bias is reflected in brain activation as well. The amygdala and right DLPFC (dorsolateral prefrontal cortex) are hyperactivated for a longer period when processing affective stimuli, while the left DLPFC is hypoactivated (Disner et al., 2011). Such activation reflects a flaw in top-down processing and overactivation of bottom-up processing, the same factors that affect the process of empathizing.

Empathy is an essential factor regarding prosocial behavior (Decety et al., 2016; Yan et al., 2017) and effective interpersonal interaction (Shamay-Tsoory, 2011; Li et al., 2017). As much as it is a vital element for humans as social beings (Decety & Lamm, 2006;

Kim & Kim, 2017), empathy affects core aspects in life such as friendship and happiness (Ford & Aberdain, 2015; Wang et al., 2014). Various definitions of empathy have been introduced due to its complex characteristics. It is most commonly understood as "the ability to put oneself into the mental shoes of another person to understand his or her emotions and feelings" (Goldman, 1993). However, due to the broadness of description, scholars continued to define empathy in various ways to explain its complex nature in a simple way. Bernhard & Singer (2012) defined empathy as "sharing and inference of emotional or sensory experiences of others", inferring an affective and cognitive, motor aspect to empathy, while Ickes (1997) described empathy as "a complex form of psychological inference in which observation, memory, knowledge, and reasoning are combined to yield insights into the thoughts and feelings of others" and created a more wholesome definition. Despite the numerous definitions of empathy, all definitions included the experiencing of another individual's emotions over one's own and understanding the emotion while maintaining differentiation between oneself and the other (Decety & Lamm, 2006). A low level of empathy is found to result in antisocial behavior and low self-esteem (Jolliffe & Farrington, 2011; Jung, 2014) while excessive empathy leads to social anxiety, introvertedness, and an inability of self-control in empathic interaction (Carmel & Glick, 1996; Iange & Cough, 2011; Riggio & Taylor, 2000).

Empathy has two main components: affective and cognitive empathy (Guadagni et al., 2014; Dziobek et al., 2018). Affective empathy is the ability to fathom the emotions of another though connecting sympathetically (Smith, 2006) without necessitating understanding of the situation causing such emotion (Rankin et al., 2005). Cognitive empathy is the ability to fathom another' s emotional state or feelings, perspective, and situation (Ickes et al., 2000; Marazziti et al., 2010). Affective empathy is a trait considered to be influenced greater by genetic variance than cognitive empathy (Melchers et al., 2016) and advances during the early years (Bubandt & Willersley, 2015), which explains its bottom-up process (Shamay-

Tsoory, 2011; Decety, 2011). Cogntive empathy, on the other hand, is an ability that advances with age and social experience even into late adulthood (Bubandt & Willersley, 2015).

Batson (2009) introduced two main ways of empathizing with different outcomes. The first is imagining the emotional reaction of the other individual in a given situation. This type of empathy leads to prosocial behavior and provision of help. The second is imagining one' s own emotional reaction of the other individual' s situation. This type of empathy lacks discerning between oneself and the other, which is a necessary part of empathy (Decety & Lamm, 2006). It leads to the re-experience of pain in one' s past (Batson, 2009), causing an increase in emotional stress. The distinction between the two types of empathizing stresses the importance of differentiation. The process by which differentiation happens is by proper regulation through top-down processing (Thoma et al., 2011). Just as how babies start crying once they see someone else crying (Roth-Hanania et al., 2011), affective empathy does not require any additional information other than the emotion that the individual is feeling. This reaction is associated with the amygdala, hypothalamus, and somatosensory cortex regions in the brain (Decety, 2011). Cognitive empathy, which is a top-down process, takes its role in downregulating the bottom-up processing of emotion and discerning between oneself and another individual, leaving oneself to experience less emotional stress (Decety et al., 2010). Therefore, a low level of cognitive empathy would cause a greater experience of distress, leading to the possibility of depression (Thoma et al., 2011; Melillo et al., 2014).

Depression and empathy are significantly correlated (Romani-Sponchiado et al., 2019). The components of empathy each show a differing relation with depression. Cognitive empathy is seen to be negatively correlated to depression (Schreiter et al., 2013; Bennik et al., 2019; Zhang et al., 2021), aligning with how depressed individuals show a decrease in the frontal lobe functions - executive function, goal-directed actions, behavior and cognition (aan het Rot et al., 2009; Price & Drevets, 2012; Fuster, 2002). Cognitive empathy also shows a significant correlation with the frontal lobe, especially in perspective taking - an important trait in cognitive empathy (Gallese et al., 2004; Zaki et al., 2009; Singer, 2006), which shows an inevitable negative correlation between the two factors. Affective empathy, on the other hand, is positively correlated with depression (Melillo et al., 2014; Choi et al., 2018; Borges et al., 2021). This positive correlation is explained by the hyperactivation of affective empathy due to the lack of top-down processing increasing according to the severity of depression. When empathizing affectively with pain, the neural circuit which indicates a strong desire to free oneself from the painful experience is activated when simply observing another individual in a painful situation (Decety & Lamm, 2006). In other words, the pain is experienced as if it is one's own emotion. However, due to the decrease in cognitive empathy during depression or depressive episodes, the pain experience is maintained at a high intensity on a personal level.

Previous research, however, has two major limitations. First, much research has been done regarding the relation between empathy and depression, but no study has been done on the relation between empathy and subclinical depression. As much as subclinical depression is a major risk factor of depression (Kessler et al., 1997; Cuijpers & Smit, 2004), research on the effects and symptoms of subclinical depression must be done. Until now, most research focused on depression, instead of a preventive factor of depression. Preventing a degeneration into a severe level of depression is a vital process. This study will therefore focus on the subclinical population and its relation to empathy. Second, almost all research done on empathy has been done through questionnaires (Batson et al., 1987; Bryant, 1987; Davis, 1983; Cusi et al., 2011; Gadassi et al., 2011; Thoma et al., 2011; Schreiter et al., 2013; Melillo et al., 2014; Choi et al., 2018). Questionnaires, however, have a humane limitation of the participant's awareness of self-presentation (Fan & Han, 2008). Therefore, by using EEG data to analyze empathic reactivity, this study will provide an objective outcome in the relation between empathy and subclinical depression.

1.2.1 Research Objective

As much as empathy is related to prosocial behavior, moral reasoning, and aggression inhibition (Eisenberg et al., 2006) and takes on an effect in various aspects of our lives (Ford & Aberdain, 2015; Wang et al., 2014), it is essential to understand factors which either effect or have a significant correlation with empathy. Depression is one factor related to empathy that we must also focus on. South Korea is the country with the highest rate of depression amongst OECD nations (Lee, 2021). One of the biggest risk factors of depression is subclinical depression (Kessler et al., 1997; Cuijpers & Smit, 2004). Subclinical depression is an important factor related to abilities of decision making, attention to emotion, alexithymia, and social functioning (Heo et al., 2021; Troup et al., 2017; Kessler et al., 1997). Subclinically depressed individuals also show flaws in social functioning (Kessler et al., 1997; Hirschfeld et al., 2000). A low affective state leads to limited social support and connectivity, and negative relations (Steptoe et al., 2008). This is due to the lack of ability to properly process social signals (van Baaren et al., 2006), which is similar to depression. Likewise, the discovery and treatment of depression is important, but prevention of degeneration to depression is just as vital, which is why this study will focus on a subclinical population.

Past research on empathy, however, has been done mainly through questionnaires or other self-report measures such as diaries (Batson et al., 1987; Bryant, 1987; Davis, 1983; Cusi et al., 2011; Gadassi et al., 2011; Thoma et al., 2011; Schreiter et al., 2013; Melillo et al., 2014; Choi et al., 2018). Despite the meaningful results of past research, there is a fundamental flaw with self-report measures in that it includes influence of social desirability and intention to present a positive image of oneself (Fan & Han, 2008). This limitation led to the measuring empathy through neurological methods. The mu rhythm of the EEG has been used to measure neural responses of empathy in recent studies (Li et al., 2017; Moore et al., 2012; Woodruff et al., 2011; Hoenen et al., 2013), showing significant correlations between empathy and emotions of differing valences. Likewise, this study will be using EEG to record neurological data as an objective measure of empathy, especially when compared to self-reported questionnaires.

1.2 Research Questions and Hypotheses

The research questions are as follows:

1) Is there an interaction effect between group and condition?
    1-1) Does the healthy group show a difference between the two conditions?
    1-2) Does the subclinically depressive group show a difference between the two conditions?

The hypotheses are as follows:

1) There will be an interaction effect between group and condition.
    1-1) The healthy group will show a significant difference between the two conditions.
    1-2) The subclinically depressive group will not show a significant difference between the two conditions.

2. Literature Review

2.1 Depression

Depression is a state of persisting depressive mood, loss of interest in daily activities, restlessness, tire, insomnia or hypersomnia, and reduction in cognition or attention (First, 2013). It is an emotional disorder which shows symptoms of anxiety, feelings helplessness and worthlessness, gloomy moods, and self-judgment of failure (Battle, 1978). Long durations of such a state lead to effects in various aspects such as occupation or social relationships and ultimately resulting in pain or harm in other aspects of life (Hirschfeld et al., 2000; Kessler et al., 2003). A lack of expectations for future experiences is also a characteristic of depressed individuals (Macleod & Byrne, 1996), which can be explained through the significant correlation between depression and negative predictions of the future (Andersen & Limpert, 2001). Depression is diagnosed through the Diagnostic and Statistical Manual-5th edition manual, which checks for at least four out of the listed nine symptoms to last for a minimum of two weeks, including subjective reports of a depressed mood, a decrease in interest or pleasure in the majority of daily activities, significant change in weight or appetite, difficulty with sleeping, a low level of energy, feelings of unworthiness or improper guilt, effects in cognitive abilities such as concentration or decision-making, and negative thoughts involving death or the planning of death (American Psychiatric Association, 2022).

Around 5% of adults are affected by depression around the world (World Health Organization, 2021). More specifically, around 7.1% of adults in America suffered from depression in 2017 (National Institute of Mental Health, 2017), while, in South Korea, the number of patients dealing with depression increased by 35.1% within a matter of 4 years - from 2017 to 2021 (Health Insurance Review &

Assessment Service, 2022). As much as depression is co-existent with other medical illnesses, from eating disorders and substance abuse to physical illnesses such as strokes, heart attacks, HIV, cancer, diabetes, and more, it is seen to contribute greatly to the overall burden of disease worldwide (World Health Organization, 2017).

For such reasons, it is judged to be vital that depression is to be understood properly and treated accurately in order to prevent intensification of the disorder.

2.1.1 Affective and Cognitive Processing in Depression

Depression shows a significant correlation with the processing of affective and cognitive stimuli (Marazziti et al., 2010). Individuals with depression show a tendency to focus on and remember more negative information compared to positive or neutral information, and even interpret positive and neutral information as less happy or sadder than non-depressed individuals (Disner et al., 2011; Bourke et al., 2010). In a study where participants judged the emotion of facial expressions, individuals with depression judged more facial expressions to be sad than the healthy participants (Hale III, 1998; Geerts & Bouhyus, 1998), while depressed participants of a face-in-the-crowd task, where an individual has to find faces of certain emotions in a crowd, took significantly longer in finding faces of positive emotions than non-depressed individuals (Suslow et al., 2001).

Such bias toward negative emotions and stimuli, however, is not solely affective; it is proven to be associated with executive dysfunction (Uekermann et al., 2008). Bias in the processing of affective stimuli is related to a stronger and longer lasting activation of the amygdala and right DLPFC (dorsolateral prefrontal cortex), along with under-activation of the left DLPFC, while bias in thoughts show association with hyperactivity of the amygdala, hippocampus, MPFC (medial prefrontal cortex), rostral ACC, and subgenual cingulate (Disner et al., 2011). Overall, such bias towards negative emotions and stimuli in depression shows an increased activation in the bottom-up processing of the stimuli and a decrease in the top-down processing (Disner et al., 2011). Such findings indicate that when depressed, one experiences the emotion in much stronger intensity, and processes the provided stimuli much less cognitively, leaving the strongly received affective response to reside rather than be processed. Likewise, in regards to cognitive processing, depression is significantly correlated with a decrease in executive function, memory, attentional function abilities, and a decrease in Theory of Mind (Lee et al., 2005; Szily & Keri, 2009; Marazziti et al., 2010), leading to an overall decline of cognitive abilities compared to those without depression.

2.1.2 Depression and Empathy

Depression is a factor significantly correlated with empathy (Romani-Sponchiado et al., 2019), especially when the level of empathy is either very high or very low (Tully et al., 2016). There were mixed outcomes regarding the valence of the correlation, but this becomes clearer once the two components of empathy are treated independently (Yan et al., 2020).

Depression shows a positive correlation with affective empathy and a negative correlation with cognitive empathy. Depressed patients show a higher level of affective empathy, especially in personal distress (Melillo et al., 2014; Thoma et al., 2011; Choi et al., 2018; Borges et al., 2021) and a lower level of cognitive empathy (Schreiter et al., 2013; Bennik et al., 2019; Zhang et al., 2021), especially in perspective taking (Cusi et al., 2011; Melillo et al., 2014). The positive and negative correlations with each component of empathy align with the top-down processing and bottom-up processing of empathy. When experiencing pain directly, the neural regions which indicate motivational and affective processing of a strong urge to end or escape a painful experience - the anterior medial cingulate cortex (ACC), anterior insula, cerebellum, right dorsal ACC, and somatosensory cortex - are activated (Decety &

Lamm, 2006). Studies show that the same neural circuit is activated when simply observing another individual experiencing pain (Lloyd & Roberts, 2004; Singer et al., 2004; Decety & Lamm, 2006), which would indicate a form of empathic situation. However, depression affects the functioning of the frontal lobe (aan het Rot et al., 2009; Price & Drevets, 2012) which is mainly associated with executive functions, goal-directed actions, cognition, and behavior (Fuster, 2002). The frontal lobe is also related to cognitive empathy and especially to perspective taking (Gallese et al., 2004; Zaki et al., 2009; Singer, 2006), leading to the conclusion that the change in function of the frontal lobe during depression is also associated with functioning of cognitive empathy (Schreiter et al., 2013). This results in a lack of inhibition of excessive bottom-up processing of pain during the top-down processing of empathy. Such limitation causes the depressed individual to experience excessive empathic reaction as if the pain is one's own.

Studies on the relation between empathy and depression are mostly done through filling out self-reported questionnaires (Bryant, 1987; Davis, 1983; Cusi et al., 2011; Gadassi et al., 2011; Thoma et al., 2011; Schreiter et al., 2013; Melillo et al., 2014; Choi et al., 2018). However, the results of studies done through questionnaires may not be fully reliable; the inclination of social desirability and concerns with self-representation take an effect on the questionnaires' results (Fan & Han, 2008). Also, each study used different questionnaires to measure empathy or depression. The Interpersonal Reactivity Index, Toronto Empathy Questionnaire and Empathy Questionnaire were used to measure empathy, while the Center for Epidemiologic Studies Depression Scale, Hamilton Rating Scale for Depression, Beck Depression Inventory, Depression Anxiety Stress Scale, Patient-Reported Outcomes Measurement Information System, Quick Inventory of Depressive Symptomatology, and more were used to measure depression. Therefore, this study will focus on gathering objective data for objective assessments of the relationship between empathy and depression.

2.2 Empathy

2.2.1 The Definition of Empathy

Due to its various factors and characteristics, empathy has been defined in various ways throughout the past. Early on, a debate on the definition of empathy focused mainly on whether empathy was a factor of recognition or experience of emotion (Chlopan et al., 1985; Jolliffe & Farrington, 2004), which later resulted in including both aspects. Goldman (1993) defined empathy as “the ability to put oneself into the mental shoes of another person to understand his or her emotions and feelings” and Bernhardt & Singer (2012) stated that is the “sharing and inference of emotional or sensory experiences of others”. The initial definition focused more on the cognitive aspects while the latter focused more on the affective aspect. Ickes (1997) combined the two definitions and further included the factors necessary in which to bring about empathy, stating that empathy is “a complex form of psychological inference in which observation, memory, knowledge, and reasoning are combined to yield insights into the thoughts and feelings of others”. Others included taking the perspective of another over one’s own (Hoffman, 1982; Batson et al., 1997). Through comprehensively gathering various definitions and bringing them to a consensus, the main overlapping definitions of empathy included sharing the experience of another’s emotion over one’s own and understanding the emotion while maintaining a sense of differentiation, meaning that one knows the emotion is simply an emotional response towards the observed individual, not one’s own. Under consideration, empathy is ultimately defined as the ability of which one comprehends, relates to, and infers another’s affective experiences and thoughts rather that one’s own while differentiating between oneself and the other (Decety & Lamm, 2006).

2.2.2 Affective and Cognitive Empathy

Empathy is mainly divided into two components: affective and cognitive empathy (Eisenberg & Eggum, 2009; Guadagni et al., 2014; Dziobek et al., 2018). Affective empathy is the ability to comprehend another's emotions through sympathetic participation (Smith, 2006) without requiring the context of the situation (Rankin et al., 2005). It refers to the sensing of another's emotion and creating an automatic, indirect affective response (Eisenberg & Strayer, 1987). The process of affective empathy is a bottom-up process (Shamay-Tsoory, 2011; Decety, 2011), meaning that it is automatic, instinctive, and reflexive in nature. It does not require understanding or comprehension of the source of another's emotion, feeling, or state (Roth-Hanania et al., 2011). It rapidly advances during the early years (Bubandt & Willersley, 2015) with a 52-57% genetic variance (Melchers et al., 2016) and decreases over time (Zhou et al., 2002; Chen et al., 2014). Cognitive empathy, on the other hand, is a component that gradually develops with age and social interaction (Bubandt & Willersley, 2015) and showed less of a genetic variance (Melchers et al., 2016). Cognitive empathy is the ability to comprehend the state of another's emotion and/or feelings, stance, and condition (Ickes et al., 2000; Marazziti et al., 2010; Yan et al., 2020). Contrary to affective empathy, cognitive empathy is a top-down process (Xu et al., 2009) in which the resulting empathy is influenced by the cognitive aspects an individual is consciously aware of. Through cognitive empathy, one can anticipate another's behavior and have the ability to beguile another into one's own advantage, catch lies, and tell whether one is independent of reality (Baron-Cohen, 2004).

Scholars have attempted to find and add additional components of empathy. Blair (2005) added a third component of motor empathy, which refers to the mirror neurons' role in the empathetic process (will be explained later in 2.2.1). Affective empathy is also divided into two components, which includes responding to the physical expression of another's emotion and to contextual information that works as an affective stimulus. On the other hand, Dziobek et al.

(2018) categorized affective empathy into direct and indirect factors. Direct affective empathy refers to the emotions or feelings of the individual who is observing someone else in an emotional situation (e.g., I am happy that the individual received an award for his/her hard work). Indirect affective empathy includes the physiological reactions of the individual observing someone else in an emotional situation (e.g., My hands were sweaty when I saw the person nervously giving a presentation). Kim & Kim (2017) created an empathy scale fit for the Korean population. Along with affective and cognitive empathy, a third component of 'attitude' has been included in the empathy scale to reflect the Korean group culture. Attitude composes of two subcomponents: sincerity and attentiveness. Sincerity, which aligns with the 'congruence' subcomponent under affective empathy in the empathy scale for social workers created by King & Holosko(2012), refers to the sincere and open-minded, non-judgmental attitude of the observer. The second component, attentiveness, describes how much the observer involves oneself in the communication and attentively reacts to the other through nods, eye contact, and other additional interactive qualities.

As explained, many scholars have and are continuously attempting to discover, include, and categorize additional aspects of empathy. However, most of the new components or categorizations mentioned are already included in the domain of affective and cognitive empathy. Motor empathy, rather than being an individual factor of empathy, can be categorized under the neural aspect of affective and cognitive empathy; it describes the partial neural reaction that simultaneously occurs with affective empathy. The categorization of affective empathy by Blair (2005) emphasizes the factor as to which the observer empathizes to, but the latter overlaps with cognitive empathy. Direct and indirect empathy divides the empathetic reaction to the affective or physiological reaction, similar to motor empathy. The different standards line up with the varying definitions of empathy. Excluding the newly introduced attitude factor that takes on a cultural background, which indicates that it is yet to be inferred to as a universal factor of empathy, the same conclusion can be made for the categorizations as has been for the definition of empathy; the most widely accepted and proven domains of empathy are affective and cognitive empathy (Yan et al., 2020), which is what I will be focusing on throughout this study.

2.2.3 Roles and Neural Bases

2.2.3.1 Methods of Empathy

There are two main methods of empathizing: imagining the reaction of the other in an emotional situation and imagining one's own reaction if in place of the same situation as the other (Batson, 2009). The initial method is one that leads to emotional concern and prosocial behavior and help. while the latter brings about emotional pain. The latter results in a negative outcome due to the fact that in such empathic situations, the differentiation by the observer between oneself and the observed does not take place, resulting in the experience of pain to be one's own experience (Batson et al., 1997)- an experience stronger than when it is not one's own. This results in a re-experiencing of past emotional pain (Batson, 2009) leading to a high level of emotional stress.

This difference is supported on a neurological basis. Jackson et al., (2006) presented photos in which people's hands or feet were in painful or nonpainful situations. The participants were instructed to either imagine the presented photos to be their situation - self-perspective - or another individual's situation - other-perspective. In both situations, the neural circuits regarding pain processing - mainly the parietal operculum, the ACC, and the anterior insula - were activated. In the self-perspective condition, however, the neural areas which process a direct pain experience - posterior ACC, insula proper, and somatosensory cortex - were also activated due to the intensity of pain processing. Such studies prove that using the empathic method of putting oneself in another's place results in a more direct experience of pain despite not actually experiencing it oneself.

2.2.3.2 Top-down and Bottom-up Processing in Empathy

Affective empathy, in its nature, is a bottom-up processing which is a reaction, usually of the same emotion, to another' s emotion without the need for a plausible reason to the emotion or understanding of the situation, well represented by babies who begin to cry when seeing someone else cry (Roth-Hanania et al., 2011). It involves the neural response of the amygdala, hypothalamus, and orbitofrontal cortex (Decety, 2011). Cognitive empathy, which is a top-down processing of the other's emotion, is one that mediates the empathic response. It takes part in differentiating and adopting another's perspective, resulting in the activation of the frontopolar cortex, ventromedial prefrontal cortex, medial prefrontal cortex, and other areas related to adopting another's perspective (Ruby & Decety, 2004).

The inability of differentiation between oneself and another is influenced by the top-down processing of cognitive empathy (Thoma et al., 2011). When presented with a different situation or contextual information of the other– the other cognitive aspect of empathy –, empathic reactions change regarding the level of intensity experienced (Xu et al., 2009). In the case of physicians, who are regularly exposed to an environment of people dealing with pain, the top-down processing aspect of empathy has shown to down-regulate bottom-up processing of pain (Decety et al., 2010) so that the physicians would not constantly empathize with their clients' pains, which would lead to a constant state of pain experience and processing. As such, an absence of top-down processing would result in excessive empathic reactions (Decety et al., 2016), which, when dealing with negative emotions and pain, holds the possibility of leading to depression (Melillo et al., 2014; Thoma et al., 2011).

Affective and cognitive empathy are found at different time points in terms of neural reaction. There were continuous attempts to capture affective and cognitive empathic reaction. In Fan & Han (2007)'s research, reaction toward painful stimuli compared to neutral stimuli was spotted 140 ms in the frontal area after painful stimuli was visually presented. This reaction showed a significant correlation with perceived pain of the target within the stimuli and self-unpleasantness. A late empathic response was also spotted in central-parietal regions after 380 ms, which was contextually understood as the top-down attention toward the stimuli. Decety et al. (2010) implemented a more complex experimental design for their research in order to more accurately test empathic reaction. Test results showed an N110 differentiation between the two conditions of pain and no-pain in the frontal lobe. Late P3 was also spotted over the centro-parietal regions. Such results indicate that affective empathic reaction toward pain occurs around 100 ms after the painful stimuli is provided, while a later empathic reaction at around 400 ms is interpreted to indicated top-down processing, or cognitive processing of empathy.

3. Methodology

3.1 Electroencephalogram (EEG)

The electroencephalogram (EEG) is an electrophysiological method of recording the electrical activities of the brain (Luck, 2014). Information processing results in neurons firing synapses which cause electrical currents. Although the electrical current of a single synapse may be unnoticeable, a single nerve cell creates several trillion synapses, which leads to the addition of all the small currents to become a voltage significant enough to be detected in the skull area through electrodes that are placed on the scalp. Through catching neural reactions and measuring reactivity toward specific sensory, cognitive, motor, and affective stimuli through electrical brainwaves, neural behavior is used to identify the different functions of the brain.

There are several benefits to using the EEG compared to other methods to measure neural responses. First, the EEG catches neural reactivity within milliseconds, which greatly increases temporal resolution incomparable to other neuroimaging methods such as the fMRI. Such temporal resolution allows for an appraisal of instantaneous neural reactivity despite the constant presence of various stimuli (Luck, 2014). Second, the equipment is also easily accessible and inexpensive, especially when compared to neuroimaging equipment, making it more approachable for use and assessment. Use of expensive equipment that are immotile make it hard to approach, limiting the capability of carrying out more researches. Finally, the EEG is non-invasive and safe for anyone to undergo. An electrolytic gel, which is harmless to the body, is injected between the scalp and the electrodes in order to get a better recording of instantaneous neural electrical responses.

3.2 Mu Suppression

Mu rhythm is an oscillation with a frequency of 8~13 Hz located near the somatosensory cortex (Gastaut, 1952; Niedermeyer & da Silva, 2005) and showed relations with stronger blood flow in the somatosensory cortex (Ritter et al., 2009). The electrical signals which make up the mu rhythm are known to collectively "idle", which results in a collective higher power of mu rhythm when at rest (Pfurtsheller et al., 1996). Any sensorimotor activity, such as touch or movement, causes desynchronization in the collective mu rhythm, which is called mu suppression (Muthukumaraswamy, & Johnson 2004). Desynchronization in the mu rhythm also happens during imagination and observation of movements and touch, indicating vicarious sensorimotor activity (Babiloni et al., 2002; Pineda, 2005; Yang et al., 2009; Hoenen et al., 2015).

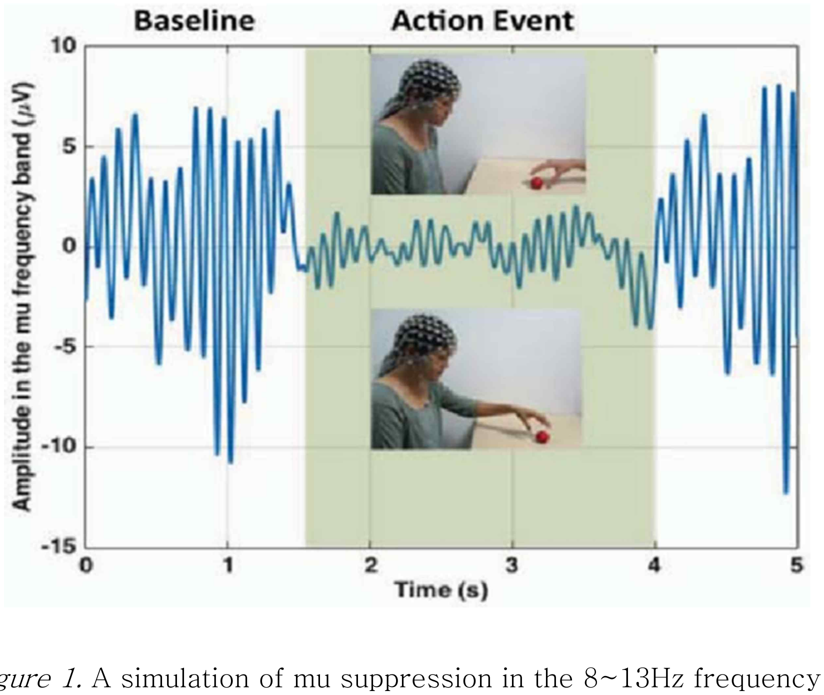

Figure 1. A simulation of mu suppression in the 8~13Hz frequency band. The participant is showing an identical neural reactivity in terms of mu suppression during action observation and execution. The idle mu rhythm is recorded at baseline for comparison with the action event, at which mu

suppression can be seen for both situations (Fox et al., 2016)

Mu suppression has been found to be a significant assessment method of empathy for pain. When empathizing, the automatic and simultaneous occurrence of somatic and motor mimicry take place (Iacobani, 2009; Lamm et al., 2011; Sonnby-Borgström et al., 2003; Varcin et al., 2010). Empathy, as a vicarious neural activation that takes place due to emotional stimuli of an individual’s situation or experience (Choi, 2021), reproduces the subjective discomfort (i.e., affective-motivational components) and the situation regarding pain occurrence (i.e., sensory-discriminative aspects) during simple observation (Botvinick et al., 2005; Decety et al., 2008; Decety & Michalska, 2010). This is also known as emotional contagion, where the observer naturally follows and synchronizes with the facial expression, voice, position, or behavior, and ultimately the emotional experience of the target (Hatfield et al., 1993). Mu suppression, therefore, is an adequate assessment method of neural responses during observation of a target experiencing pain (Cheng et al., 2008).

3.3 Time Frequency Analysis

Time Frequency Analysis (TFA) is a method to analyze neural oscillations in EEG data. The neural oscillations are analyzed by frequency (the speed at which the neural data is oscillating), power (also called amplitude, referring to the strength level of the oscillation), and phase (the position along the sine wave at a given time point). Neural oscillations in EEG data are seen to be a sum of sine wave of different frequencies (Cohen, 2014). The sine waves are categorized into a group of frequencies, of which the following are the most commonly analyzed through TFA: delta (2~4Hz), theta (4~8Hz), alpha (8~12Hz), beta (15~30Hz), and gamma (30~150Hz) waves. In order to see a difference in rhythmic activity at each frequency, the oscillation is separated and analyzed by frequency. The difference contains significant meaning in terms of functional processing of cognitive, emotional, social, motor, linguistic, and more areas, depending on the provided task during EEG recording. Through separating the overlapping sine waves in a single oscillation in the EEG data, the data becomes analyzable and interpretable.

After gathering appropriate EEG data, pre-processing the data through filters, and extracting data in time segments according to the time window of interest, the data is processed through methods such as convolution, Fourier Transform, or Morlet Wavelets so that the EEG data is now presented in spectrograms (Figure 2). The spectrogram displays the change in the power of frequency over time. The spectrograms of each experimental condition are averaged together in order to test for statistical significance.

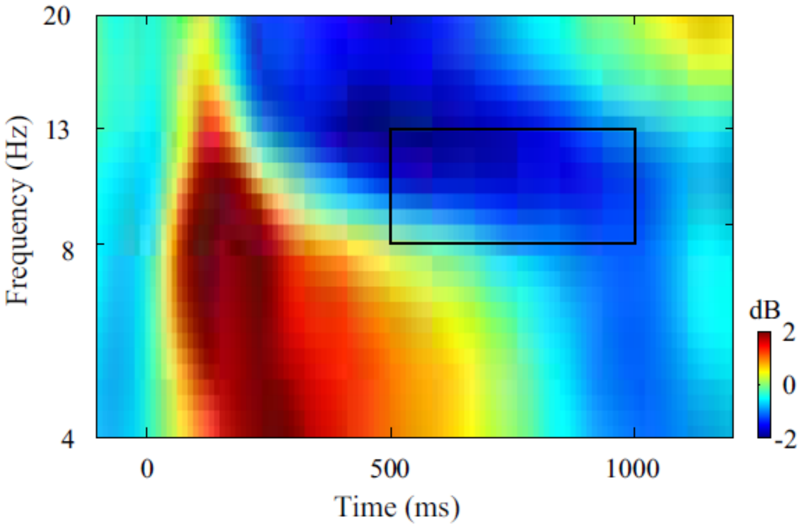

Figure 2. A simulation of a time-frequency image. The frequency of all 64 channel recordings of all subjects. The black rectangle represents the window for mu rhythm at 8~13Hz. The blue color, indicating a lower power during the time window of interest, is a representation of mu suppression. (Li et al., 2017)

4. Experiment

4.1 Participants

The study consisted of two groups – healthy and subclinically depressed participants (here forward referred to as the depressed group), each consisting of 20 participants. Participants in the healthy group included those who scored between 0~15 points on the CES-D, while the latter included those who scored between 16~24 points, which is indicative of subclinical depression. All participants were right-handed with normal or corrected-to-normal vision and normal hearing. They had no record of any mental illness and were not taking any prescribed medication to prevent any factor that could affect the results of the study. In case of participants who participated in an EEG study in the past, it was made sure that they did not have any abnormal or extraordinary reaction in the process of the experiment. Due to data loss in the process of data recording, the data of two participants in the depressed group were removed. This resulted in the data processing of a total of 18 participants in the depressed group and 20 participants in the healthy group.

4.2 General Procedures

The present study was carried out after receiving approval by the Seoul National University Institutional Review Board (SNUIRB; No. 2209_002-005). The experiment took a maximum of 90 minutes for each participant. The procedure is as shown in Table 1.

Table 1. *General Procedure of Experiment*

Step	Procedure	Preparation	Elapsed Time
1	Recruitment	Exclusion Criteria & Schedule	-
2	Agreement Form & CES-D	Agreement Form; CES-D	15
3	Preparation for EEG	EEG equipment	30~40
4	Explanation of EEG Experiment	Computer - Explanation	4
5	Practice Session	Computer – Experiment (Practice)	1
6	EEG Experiment	Computer – Experiment	20
7	Wrap-Up	Toiletries, Towel, Hair Dryer	10

① Recruitment

The recruitment of participants was done online. An online form included a brief explanation of the study, a list of the exclusion criteria, and the researcher's contact information for participation. Once participants checked that they have no relevance to any exclusion criteria, participants contacted the researcher to show their willingness for participation. Through the phone, the researcher explained the study briefly, double-checked the exclusion criteria, described the experimental process, and set a date as to when the participant will be coming to the research laboratory for participation.

② Agreement Form and CES-D

Once the participants visited the laboratory, they were first taken through the information sheet and signed the informed consent. They then took the CES-D and participated in the EEG experiment.

③ Preparation for EEG

Participants entered and stayed in an electromagnetically shielded room to remove any neurologic response to factors unrelated to the experiment. Prior to the experiment, an elastic cap of the 10-20 international system was secured on the participant's head and electrolytic gel was injected in each of the 32 electrodes, the ground electrode, and HEOG and VEOG electrodes for clean data collection. The gel was applied until all electrodes were stably picking up neural responses.

④ Explanation of EEG Experiment

Once all preparation was complete, the participant was informed of the two conditions: INCREASE and DECREASE. In the INCREASE condition, participants were informed to empathize with the target's pain, thinking as much as possible from the target's point of view. In the DECREASE condition, participants were instructed to minimize empathy towards the target's pain, thinking that the target had no relation to oneself. All participants were informed not to close their eyes or look away in order to decrease any emotional response. Through this procedure, the results showed how much top-down processing is applied in each condition.

⑤ Practice Session

To minimize any confusion during the experiment, participants first completed a practice session. Additional questions were answered before the start of the official experiment. Lastly, participants were told that photos would be presented at the end of each block to check whether they focused throughout the session to encourage focus from start to finish.

⑥ EEG Experiment

Each block first provided an explanation for the upcoming condition (increase or decrease). Then a fixation cross appeared for 4000ms in the middle of the screen. Afterward, a picture of the target’s hand or foot experiencing pain, or a control picture appeared for 4000ms. A black screen was presented for 500~1500ms as an intertrial interval. To encourage focus throughout the sessions, participants were asked how much they empathized with the target after each photo. The paradigm is as shown in Figure 3. A total of 62 trials were in each block, and the trials were randomized. 8 sets were created to randomize between photos, condition, and presentation order. A brief break was provided between the two blocks when participants could stretch and prepare for the second block. Once ready, participants pressed the space button to start the second block.

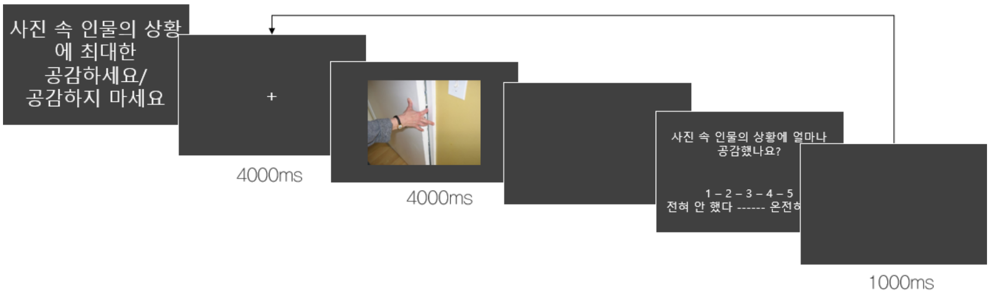

Figure 3. The paradigm of EEG experiment. Participants were told to either empathize or not empathize with the target within the picture. After the instruction, the fixation cross was presented for 4000ms, followed by the picture for 4000ms. Then a blank screen was presented along with a self-evaluation of empathy toward the picture. This process was repeated 62 times for each block, with a total of 2 blocks (one for each condition).

⑦ Wrap-Up

Once finished with the full experiment, participants were provided with shampoo, conditioner, face wash, towel, hair dryer, and a sink to wash the electrolytic gel out of their hair before leaving the laboratory. Participants were later compensated with 30,000 KRW for participation.

4.3 Assessment Tools

4.3.1 Picture Stimuli

Photos Jackson & Decety (2005) were used as picture stimuli during EEG data acquisition. Photos were either of a hand or foot about to experience mechanical, thermal, and pressure pain, or were control photos where there was no sign of any pain to be experienced in the same situation, as shown in Figure 4. The photos were validated through an assessment of pain on a 7-point Likert scale by 33 adults (19 male; 14 female). In the case of painful photos, 62 photos that rated 4 points or above were used in the experiment. 62 control photos that rated less 3 points or lower were used, resulting in a total of 124 photos. Matching photos were intentionally grouped into separate sessions so they would not be presented in the same session. The photos were then randomized in the trials to ensure valid outcomes.

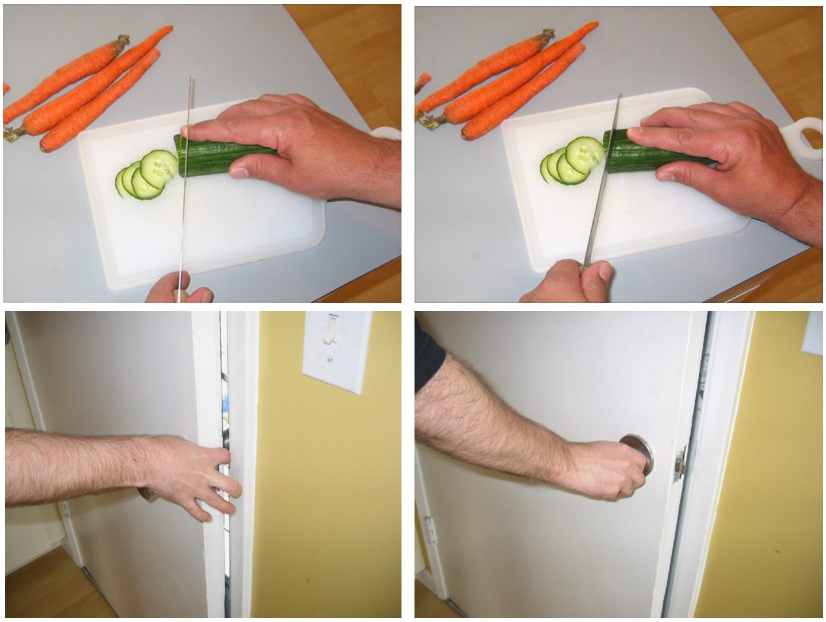

Figure 4. Four photos taken and used by Jackson & Decety (2005) that were used in the present study. Photos on the left - photos categorized as painful – show situations in which someone's right hand is or is about to experience pain. Photos of the right, however, show a similar situation in which no pain is experienced. The two photos on the top were separated so they would not be shown in the same session (same condition). Likewise, the two photos on the bottom were categorized under different conditions.

4.3.2 Center for Epidemiologic Studies Depression Scale (CES-D) - Korean Version

The CES-D was first created by Radloff (1977) in order provide a self-report depression scale to advance research regarding depressive symptoms in a non-clinical population. Jeon et al. (2001) translated and validated the Korean version. The scale is a 4-point Likert scale (1=barely; 2=sometimes; 3=often; 4=almost all the time) self-report measure of 20 questions. 0~15 points indicate no depression, while 16~24 points indicate a subclinical level of depression. 25 points or more indicate a clinical level of depression, requiring clinical attention. The Cronbach's α is .91. The Cronbach's α in this study was .677.

Due to the focus on subclinical depression for this study, all participants who scored 25 points or higher were excluded from the study. Participants who scored between 0~15 points were assigned to the healthy group, while those who scored between 16~24 points were assigned to the subclinically depressed group. Both groups were given the same assessments and stimuli, which were compared to validate any difference in neural reaction.

4.4 EEG Data Acquisition

EEG data was recorded through 32 electrodes placed on the scalp following the 10-20 international system. Three electrodes were placed – one under the left eye and two on both left and right temples - to control for bipolar vertical and horizontal electro-oculograms (VEOG; HEOG). An additional ground electrode was placed between electrodes Fp1 and Fp2, located on the middle area of the forehead. The Cz electrode was used as the reference electrode. Once the cap was secured onto the participant, electrolytic gel was injected between the scalp and electrodes to ensure better recording of the electrical signals. The impedance was set to be below 20 kΩ. The actiChamp amplifier was used to amplify EEG, and BrainVision Recorder was used for recording. The data was recorded at a sampling rate of 500 Hz.

4.5 EEG Data Preprocessing and Time Frequency Analysis

Data preprocessing and main analysis was conducted through Brain Vision Analyzer 2.2 with a band-pass filter of 0.5~40 Hz. Then ocular correction (correction for eye blinks and movements) was done through Independent Component Analysis. After segmenting the data by the 8000ms epochs according to the stimulus onset (-

4000~4000ms), baseline correction was done to the mean value of the signal at -200~0ms (prior to the stimulus onset).

Then, Time Frequency Analysis was done through complex Morlet wavelet transformation between 5~30 Hz in logarithmic steps of 25 steps with a Morlet parameter of 5. Suppression was then calculated as the power after the stimulus onset compared to the baseline. The Cz, C3, and C4 electrodes are the main focus for detecting mu suppression (Pfurtscheller et al., 1996; Ritter et al., 2009). The difference between the conditional reactivities were taken for statistical analysis.

4.6 Statistical Analysis

Statistical analysis was done using the SPSS Statistics 25. Independent two sample t-test was used to compare the CES-D results and homogeneity of the two groups. After confirming homogeneity between the two groups, a 2x2 mixed design ANOVA was then performed to compare mu suppression between the two groups (healthy x depressed) and two conditions (increase x decrease) for each of the electrodes (C3, Cz, C4). Whenever necessary, the Greenhouse-Geisser epsilon values were used to correct the degrees of freedom.

5. Results

5.1 Behavioral Results

The CES-D results of the two groups were first compared. The two groups' CES-D results were tested to show that there is a significant difference between the two groups regarding level of depression (p=.000) as shown in Table 1 (includes the descriptive statistics). The homogeneity of the two groups were also tested with sex and age. As a result, the two groups did not show any significant difference regarding sex (p=.712) and age(p=.241). Therefore, the two groups were seen to be homogenous. The t-test results and descriptive statistics are listed in Table 2.

Table 2. *Independent two sample t-test and descriptive statistics (mean values and standard deviations) of CES-D results for both groups*

Group	N	Mean	SD	t	p
Healthy	20	7.05	4.071	-11.846*	.000
Depressed	18	21.00	3.049		

*p <.05

Table 3. *Independent two sample t-test and descriptive statistics (mean values and standard deviations) of homogeneity test between the two groups*

	Group	N	M	SD	t	p
Sex	Healthy	20	1.55	.510	-372	.712
	Depressed	18	1.61	.502		
Age	Healthy	20	24.00	2.218	-1.203	.241
	Depressed	18	25.50	4.890		

*p <.05

5.2 EEG Results

The 2x2 mixed design ANOVA results showed that there was a significant interaction effect between group and condition ($F(1, 36) = 7.229$, $p = .011$, $\eta 2 = .167$) at location C4.

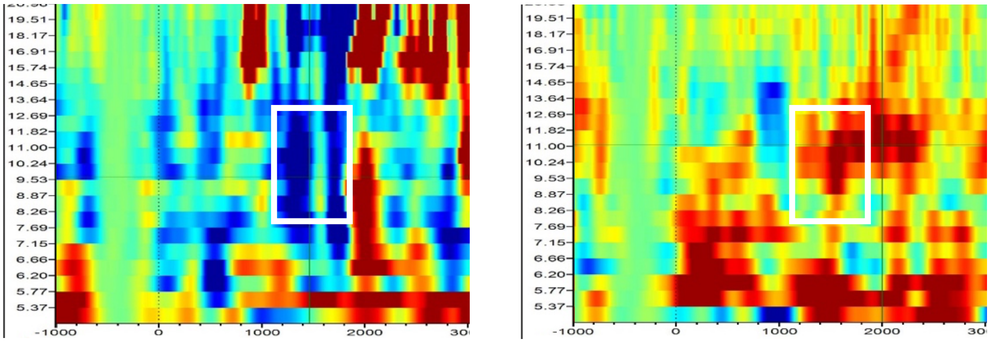

Figure 5. Mu suppression indices for the healthy group (left) and the depressed group (right). The graph shows the time and frequency range that is analyzed. Time 0 indicates the onset of the picture stimuli. First, the difference between the painful picture reactivity and control picture reactivity were taken for each group. Then, the difference of the two conditions were taken to show the mu suppression indices shown in the

figures above. The white box indicates the location of mu suppression occurrence. Blue indicates suppression.

Further pairwise comparison revealed that there was a significantly stronger mu suppression in the increase condition compared to the decrease condition regarding the healthy group ($p=.018$). However, there was no significant difference between the two conditions for the depressed group($p=.187$) as shown in Table 3 and Figure 4.

No main effect of condition ($F(1,36) = .545$, $p = .465$, $\eta 2 = .015$) or group ($F(1,36) = 1.554$, $p = .221$, $\eta 2 = .041$) was found to be significant.

Table 4. *Pairwise comparison between the two conditions of each group*

Group	Condition	M	Difference	SE	p
Healthy	Increase - Decrease	-1479.020 5328.383	-6797.40*	2730.478	.018
Depressed	Increase - Decrease	738.287 -3131.001	3869.288	2878.177	.187

*p <.05

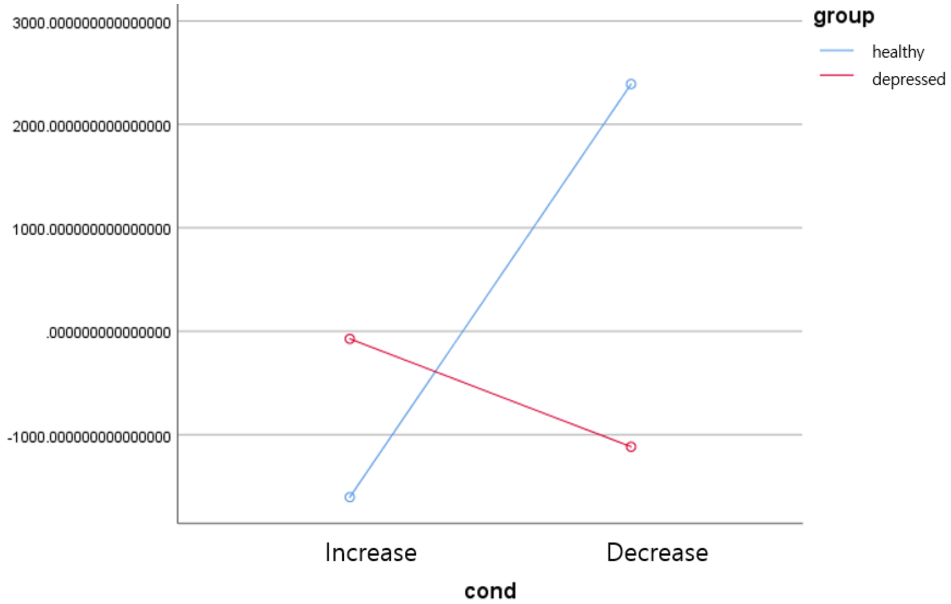

Figure 6. The pairwise comparison of the two groups presented as a graph. The healthy group (blue line) showed a significant difference between the two conditions, while the depressed group (red line) did not show a significant difference between the two conditions.

6. Discussion

6.1 Summary and Interpretation of the Results

There has been much research done in the relation between depression and empathy (Gadassi et al., 2011; Cusi et al., 2011; Melillo et al., 2014; Choi et al., 2018; Zhang et al., 2021), but the results were inconsistent due to the nature of self-report questionnaires (Fan & Han, 2008). In this study, the relation between subclinical depression and empathy was measured through a more objective measurement tool, the EEG mu rhythm. Upon Batson (2009)'s two methods of empathizing and the changes in cognitive and affective processing according to depression, I hypothesized that there will be an interaction effect between the two groups (healthy and depressed) and the two conditions (increase and decrease). More specifically, I hypothesized that the healthy group will show a significant difference between the increase and decrease conditions, while the depressed group will not show a significant difference between the two conditions. This was due to the theory that when depressed, cognitive empathy will not be able to fulfill its duties in regulating empathy, resulting in an equal amount of empathy despite the differing situations.

The research findings revealed that there was a significant interaction effect between groups and conditions, as hypothesized. As for the healthy group, there was a significant difference in neural reactivity between the two conditions. When trying to increase empathy, the participants showed a significantly greater mu suppression compared to when trying to decrease empathy (i.e., increase > decrease). This indicates that those who are not depressed have the ability to control their level of empathic reaction towards another, clearly differentiating between oneself and the person within the picture (Batson, 2009). Furthermore, participants in the subclinically depressed group showed no significant difference between the two conditions (increase = decrease) despite being instructed to react differently. These results indicate that those who are suffering from a subclinical level of depression do not have the ability to control their method or level of empathic reaction towards another, despite being told to consciously control oneself. Both groups' results were as hypothesized.

As to how only the C4 area brought significant results, it has been shown in past research that reactions to negative emotions occurs in the right hemisphere (Davidson, 1984). Accordingly, as pain is seen to be an unpleasant, negative emotion (Mokhtari et al., 2019), the results of the present study regarding significant differences only in the right hemisphere in reaction to pain aligns with previous findings.

Altogether, the results can be interpreted as follows: as hypothesized, participants in the healthy group were able to willingly mediate their level of empathy according to the given situation; the top-down processing of cognitive empathy created the distinction between oneself and the target in the picture (Ickes et al., 2011; Blair, 2005), controlling the level of empathic reaction when consciously putting in the effort. However, also as hypothesized, participants in the subclinically depressed group were not able to mediate empathy according to the situation. This can be seen as the result of their lack of distinction between oneself and another, a distinct trait in those who suffer from depression (Dernt et al., 2012; O'Connor et al., 2002; Schneider et al., 2012). They can be theorized to have experienced the pain of the target in the picture as their own (Batson, 1991) due to the lack of control over cognitive empathy (Decety et al., 2016). The inability to make changes in empathic reactions despite voluntary efforts can be seen as an important trait of those who are experiencing depression that affect not only their current state but also their relationships.

6.2 Theoretical Contributions and Practical Implications

The current study provides several theoretical contributions and practical implications. First, it cleared the correlational relationship between depression and empathy. The correlation between depression and empathy has been researched over a long period of time, but the researches provided contradicting results and suggested various reasons for such differences. However, the majority of those researches were done through self-report questionnaires, which accompanies limitations such as social desirability (Fan & Han, 2008). Therefore, an objective method of neural responses was used to measure empathy. Through past research, it has been proven that mu suppression is a valid measurement index of empathy (Cheng et al., 2008b). The results of the present study provide an insight into the empathic mechanism of those with a subclinical level of depression and suggests a pathway of intervention into depression.

Second, the current study found an important factor related to subclinical depression. Not much research has been done on subclinical depression despite it being a vital risk factor of depression (Kessler et al., 1997; Cuijpers & Smit, 2004), which can lead to detrimental outcomes such as suicide (Jeon et al., 2010). The results showed that empathy is a factor that is compromised on a subclinical level of depression, suggesting an important factor to be understood and intervened in counseling.

Third, Choi (2020) stated that empathy should be treated as "a flexible skill which can be grown with sufficient motivation". However, it is proven through the current study that despite such motivation, there are factors that affect voluntary mediation of empathy. Depression, even on a subclinical level, is a factor that prevents the ability of voluntary mediation of empathy. Knowledge of such effects allows a counselor to better understand the client on an integrated level, leading to proper and more accurate, effective interventions.

6.3 Limitations and Future Directions

The present study carries a few limitations and offers future directions that align with it. First, it the accurate definition of empathy is as used in the current study. However, the word 'empathy' in Korean is used to mean sympathy, pity and compassion (Kim, 2015). Despite the significant results presented in the current study, there may have been confusion when the participants were directed to empathize with the target in the picture due to such a gap in definition. In future studies, using more accurate wording than just 'empathy' when providing instructions may create more accurate results through a more uniform understanding.

Second, mu suppression was used as the index for empathic response based on preceding research (Cheng et al., 2008b; Perry, 2010; Moore et al., 2012; Hoenen, 2013; Sashenka et al., 2013; Li et al., 2017; Choi, 2020). Despite such data to support mu suppression as an index for empathy, it is never fully certain as to whether mu suppression was solely a response of empathy. Adding additional neural indices of empathy and using additional methods of measurement may make up for such limitations.

Third, the empathic response of those with clinical depression was not included in the current study. Comparing a healthy group, subclinically depressive group, and a clinically depressive group would provide a more integrated understanding of the difference in empathy according to severity of depression.

Lastly, only empathy toward pain was used to measure empathy. Checking the neural empathic response to various positive and negative emotions in future research would provide a more well-rounded understanding regarding empathic response.

7. Overall Conclusion

The current study focused using EEG to prove the correlation between depression and empathy. The main hypothesis was that there would be a significant interaction effect between the two groups (non-depressed and depressed) and the two conditions (increase and decrease). More specifically, it was hypothesized that the participants of the non-depressed group would show a significant difference between the two conditions, while participants of the depressed group would not show a significant difference between the conditions. This was based on the theory that those who are depressed are not able to distinguish between their emotions and others' emotions, resulting in an empathic response where they would be overwhelmed by the target's emotion. The two groups differed in levels of depression (non-depressed vs subclinically depressed) and were given two conditions – either to increase or decrease empathy toward the target in the picture. The neural response of mu suppression was used to measure empathic response.

Research findings reveal that those without depression were able to control their level of empathy according to the condition; they showed a higher level of mu suppression in the increase condition, and a lower level of mu suppression in the decrease condition. Those with a subclinical level of depression, however, were not able to provide a significant difference between increasing and decreasing empathic response despite the differing conditions. This proves that depression, even on a subclinical level, is a factor that prevents voluntary mediation of empathy.

The results of the current study suggest that empathy is compromised from a subclinical level of depression. As much as empathy is an important factor in social functioning and relations (Eslinger, 1998; Bosc, 2000; Baron-Cohen & Wheelwright, 2004), it is important to have a proper understanding of such changes in accordance with depression. Depression is a vital factor in South Korea's society (Lee, 2021), which is why a deeper understanding is essential. Through proper understanding of the society and each individual, counselors will be able to better understand their clients and carry out more valid approaches that benefit the clients.

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Appendix A: Center for Epidemiologic Studies Depression Scale (CES-D)

아래에 적혀 있는 각 문항을 잘 읽은 후, 오늘을 포함하여 지난 일주일 동안 당신이 느끼고 행동한 것을 가장 잘 나타내는 숫자에 표시해주시기 바랍니다.

극히 드물다 (1주 중 1일 이하)	가끔 있었다 (1주 중 1~2일간)	자주 있었다 (1주 중 3~4일간)	거의 대부분 그랬다 (1주 중 5일 이상)

0 -------------- 1 -------------- 2 -------------- 3

문 항		해당하는 정도			
1.	평소에는 아무렇지 않던 일들이 귀찮게 느껴졌다.	0	1	2	3
2.	먹고 싶지 않았다; 입맛이 없었다.	0	1	2	3
3.	가족이나 친구가 도와주더라도 울적한 기분을 떨쳐 버릴 수 없었다.	0	1	2	3
4.	다른 사람들만큼 능력이 있다고 느꼈다.	0	1	2	3
5.	무슨 일을 하든 정신을 집중하기가 힘들었다.	0	1	2	3
6.	우울했다.	0	1	2	3
7.	하는 일마다 힘들게 느껴졌다.	0	1	2	3
8.	미래에 대하여 희망적으로 느꼈다.	0	1	2	3
9.	내 인생은 실패작이라는 생각이 들었다.	0	1	2	3
10.	두려움을 느꼈다.	0	1	2	3

11. 잠을 설쳤다; 잠을 잘 이루지 못했다.	0	1	2	3
12. 행복했다.	0	1	2	3
13. 평소보다 말을 적게 했다; 말수가 줄었다.	0	1	2	3
14. 세상에 홀로 있는 듯한 외로움을 느꼈다.	0	1	2	3
15. 사람들이 나에게 차갑게 대하는 것 같았다.	0	1	2	3
16. 생활이 즐거웠다.	0	1	2	3
17. 갑자기 울음이 나왔다.	0	1	2	3
18. 슬픔을 느꼈다.	0	1	2	3
19. 사람들이 나를 싫어하는 것 같았다.	0	1	2	3
20. 도무지 무엇을 시작할 기운이 나지 않았다.	0	1	2	3

Appendix B: Consent Form

연구참여자용 설명문

연구 과제명 : 우울과 대인관계 반응성의 관계: EEG를 중심으로
연구책임자명 : 김진주 (서울대학교 교육학과, 석사과정)

이 연구는 준임상적 수준의 우울이 대인관계 반응성과 어떤 관계 양상을 보이는지 알아보는 데 목적을 두고 있습니다. 준임상적 수준의 우울여부 및 수준에 따라 대인관계 반응성 양상이 어떻게 달라지는지 알아보려고 하며, 이를 위해 연구 참여자의 자기보고식 검사수행과 뇌전도 (electroencephalogram, EEG) 데이터를 수집하고자 합니다. 귀하는 만 18세 이상, 65세 미만 성인으로 이 연구에 참여하도록 권유 받았습니다. 본 연구의 수행 및 안내를 맡은 연구책임자는 서울대학교 사범대학 교육학과 소속의 김진주 연구원(010-****-****)이며, 본 연구는 자발적으로 참여 의사를 밝히신 분에 한하여 수행될 것입니다. 귀하께서는 참여 의사를 결정하기 전에 본 연구가 왜 수행되는지 그리고 연구의 내용이 무엇과 관련 있는지 이해하는 것이 중요합니다. 다음 내용을 신중히 읽어 보신 후 참여 의사를 밝혀 주시길 바라며, 필요하다면 가족이나 친구들과 의논해 보십시오. 만일 어떠한 질문이 있다면 위에 제시된 담당 연구원의 연락처로 연락해주시면 자세하게 설명해 줄 것입니다.

1. 이 연구는 왜 실시합니까?

이 연구는 준임상적 수준의 우울이 대인관계 반응성과 어떤 관계 양상을 보이는지 알아보는 데 목적을 두고 있습니다.

2. 얼마나 많은 사람이 참여합니까?

만 18세 이상, 65세 미만인 성인 40명이 참여할 것입니다.

3. 만일 연구에 참여하면 어떤 과정이 진행됩니까?

만일 귀하가 참여의사를 밝혀 주시면 다음과 같은 과정이 진행될 것입니다.
1) 귀하는 두 가지 자기보고식 검사를 실시하게 됩니다. 하나는 우울수

준을 측정하는 검사이고, 다른 하나는 대인관계 반응성을 측정하는 검사입니다. 약 10분 정도 소요될 예정입니다.
2) 1번의 자기보고식 검사를 마친 후, EEG 실험이 진행됩니다. 실험 과정에서 연구 참여자들의 생리심리데이터(뇌파)는 EEG 전극을 통해 수집될 예정이므로, EEG 전극이 달린 캡을 쓰고 실험을 진행하게 됩니다. 먼저 EEG 전극이 달린 캡을 쓴 후, 생리심리데이터가 잘 수집될 수 있도록 두피와 전극 사이에 젤을 도포합니다. 그리고 더욱 정확한 측정을 위해 전극 4개(오른쪽, 왼쪽 각각 눈 아래 하나씩, 눈 바깥쪽에 하나씩)를 붙인 채로 실험을 진행하게 됩니다. EEG 캡을 장착한 상태에서 실험은 앞에 있는 스크린에 나오는 지시문에 따라 제시되는 사진들을 보게 됩니다. EEG 캡 장착 및 준비시간을 포함하여 약 60분 이내의 시간이 소요될 예정입니다.

4. 연구 참여 기간은 얼마나 됩니까?

1일 1회, 약 1시간 30분이 소요될 것입니다.

5. 참여 도중 그만두어도 됩니까?

예, 귀하는 언제든지 어떠한 불이익 없이 참여 도중에 그만 둘 수 있습니다. 만일 귀하가 연구에 참여하는 것을 그만두고 싶다면 담당 연구원이나 연구 책임자에게 즉시 말씀해 주십시오. 그만두는 경우 모아진 자료는 즉시 폐기될 것입니다.

6. 부작용이나 위험요소는 없습니까?

본 연구는 실험실 도착 후 작성할 2가지 자기보고식 검사와 EEG 실험으로 이루어집니다. EEG 실험 중 제시되는 사진들은 일반적으로 문제가 없으나, 바늘에 대한 공포증을 가지고 있는 경우 불편감을 불러일으킬 수 있어 연구에 참여하지 않도록 안내합니다. 실험 중에 생리심리반응을 수집하기 위해 EEG 전극을 사용하며 이 방식은 특별한 부작용이나 위험요소가 없습니다. EEG에서는 전극과 두피 사이를 연결하기 위해 인체에 무해한 젤을 사용합니다. 따라서 실험 과정에서 인체에 해를 가할 요인은 없을 것입니다. 하지만 만약 연구에 참여하는 과정에서 불편감이나 위험을 느끼신다면, 연구원에게 즉시 말씀해 주십시오. 귀하의 안전을 위해 최대한 신속하게 필요한 조치를 취하도록 하겠습니다.

7. 이 연구에 참여시 참여자에게 이득이 있습니까?

귀하는 이 연구에 참여하는 데 직접적인 이득은 없습니다. 그러나 귀하가 제공하는 정보는 준임상적 우울을 경험하고 있는 사람들의 대인관계 반응성에 대한 이해를 증진하는데 도움이 될 것입니다.

8. 만일 이 연구에 참여하지 않는다면 불이익이 있습니까?

귀하는 본 연구에 참여하지 않을 자유가 있습니다. 또한, 귀하가 본 연구에 참여하지 않아도 귀하에게는 어떠한 불이익도 없습니다.

9. 연구에서 얻은 모든 개인 정보의 비밀은 보장됩니까?

개인정보관리책임자는 서울대학교의 김진주(010-****-****)입니다. 본 연구에서 수집되는 개인정보는 성별과 나이입니다. 이러한 개인정보는 연구담당자인 김진주, 그리고 공동연구자인 김창대에게만 접근이 허락되며, 보안된 파일로 보관이 될 것입니다. 본 연구에서 수집되는 개인식별정보는 연락처이며, 이는 연구 및 사례지급에 동의할 경우에만 수집됩니다. 수집된 개인식별정보는 사례지급을 위해서만 사용되고, 사례지급 직후 폐기됩니다. 동의서는 관련 법령에 따라 3년을 보관한 후 폐기할 예정이며, 연구자료의 경우는 서울대학교 연구윤리 지침에 따라 가능한 한 영구 보관할 예정입니다. 저희는 이 연구를 통해 얻은 모든 개인 정보의 비밀 보장을 위해 최선을 다할 것입니다. 이 연구에서 얻어진 개인 정보가 학회지나 학회에 공개 될 때 귀하의 이름 및 기타 개인 정보는 사용되지 않을 것입니다. 그러나 만일 법이 요구하면 귀하의 개인정보는 제공될 수도 있습니다. 또한 모니터 요원, 점검 요원, 생명윤리위원회는 연구참여자의 개인 정보에 대한 비밀 보장을 침해하지 않고 관련규정이 정하는 범위 안에서 본 연구의 실시 절차와 자료의 신뢰성을 검증하기 위해 연구 결과를 직접 열람할 수 있습니다. 귀하가 본 동의서에 서명하는 것은, 이러한 사항에 대하여 사전에 알고 있었으며 이를 허용한다는 동의로 간주될 것입니다.

10. 이 연구에 참가하면 사례가 지급됩니까?

귀하의 연구 참여시 감사의 뜻으로 모든 참여자에게 30,000원의 사례금을 드립니다.

11. 연구에 대한 문의는 어떻게 해야 됩니까?

본 연구에 대해 질문이 있거나 연구 중간에 문제가 생길 시 다음 연구 담당자에게 연락하십시오.

이름: 김진주 전화번호: 010-****-****

만일 어느 때라도 연구참여자로서 귀하의 권리에 대한 질문이 있다면 다음의 서울대학교 생명윤리위원회에 연락하십시오.
서울대학교 생명윤리위원회 (SNUIRB) 전화번호: 02-880-5153
이메일: irb@snu.ac.kr

동 의 서 (연구참여자 보관용)

연구 과제명 : 우울과 대인관계 반응성의 관계: EEG를 중심으로
연구책임자명 : 김진주 (서울대학교 교육학과, 석사과정)

1. 나는 이 설명서를 읽었으며 담당 연구원과 이에 대하여 의논하였습니다.
2. 나는 위험과 이득에 관하여 들었으며 나의 질문에 만족할 만한 답변을 얻었습니다.
3. 나는 이 연구에 참여하는 것에 대하여 자발적으로 동의합니다.
4. 나는 이 연구에서 얻어진 나에 대한 정보를 현행 법률과 생명윤리위원회 규정이 허용하는 범위 내에서 연구자가 수집하고 처리하는 데 동의합니다.
5. 나는 담당 연구자나 위임 받은 대리인이 연구를 진행하거나 결과 관리를 하는 경우와 법률이 규정한 국가 기관 및 서울대학교 생명윤리위원회가 실태 조사를 하는 경우에는 비밀로 유지되는 나의 개인 신상 정보를 확인하는 것에 동의합니다.
6. 나는 언제라도 이 연구의 참여를 철회할 수 있고 이러한 결정이 나에게 어떠한 해도 되지 않을 것이라는 것을 압니다.
7. 나의 서명은 이 동의서를 받았다는 것을 뜻하며 나와 동의받는 연구원의 서명이 포함된 동의서를 보관하겠습니다.
8. 나는 연구를 수행하는 중에 뇌전도 데이터(EEG)가 수집되는 것을 알고 있으며, 연구에 사용되는 것을 허락합니다.

동의함 □ 동의하지 않음 □

연구참여자 성명	서 명	날짜 (년/월/일)
동의받는 연구원 성명	서 명	날짜 (년/월/일)

[민감정보 수집동의]

○ 본 연구는 개인정보보호법 제23조에 따라 개인정보에 대한 개별 동의 사항에 대하여 귀하의 민감정보(피부질환여부, 정신과 치료 병력 여부, 바늘에 대한 공포증)에 대한 정보를 처리(수집, 이용 등) 하고자 합니다. 이에 대하여 동의하십니까?

- 나는 민감정보 처리에 대하여 동의합니다.

연구참여자 성명	서 명	날짜 (년/월/일)
동의받는 연구원 성명	서 명	날짜 (년/월/일)

동 의 서 (연구자보관용)

연구 과제명 : 우울과 대인관계 반응성의 관계: EEG를 중심으로
연구책임자명 : 김진주 (서울대학교 교육학과, 석사과정)

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5. 나는 담당 연구자나 위임 받은 대리인이 연구를 진행하거나 결과 관리를 하는 경우와 법률이 규정한 국가 기관 및 서울대학교 생명윤리위원회가 실태 조사를 하는 경우에는 비밀로 유지되는 나의 개인 신상 정보를 확인하는 것에 동의합니다.
6. 나는 언제라도 이 연구의 참여를 철회할 수 있고 이러한 결정이 나에게 어떠한 해도 되지 않을 것이라는 것을 압니다.
7. 나의 서명은 이 동의서를 받았다는 것을 뜻하며 나와 동의받는 연구원의 서명이 포함된 동의서를 보관하겠습니다.
8. 나는 연구를 수행하는 중에 뇌전도 데이터(EEG)가 수집되는 것을 알고 있으며, 연구에 사용되는 것을 허락합니다.

동의함 □ 동의하지 않음 □

연구참여자 성명	서 명	날짜 (년/월/일)
동의받는 연구원 성명	서 명	날짜 (년/월/일)

[민감정보 수집동의]

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- 나는 민감정보 처리에 대하여 동의합니다.

연구참여자 성명	서 명	날짜 (년/월/일)
동의받는 연구원 성명	서 명	날짜 (년/월/일)

초록

수많은 선행연구가 존재함에도 불구하고 우울과 공감의 상관에 대한 연구결과는 상이한 것으로 확인되었다. 본 연구는 뮤 리듬을 측정해 우울과 공감의 관계에 대한 이해를 넓히고 상관관계를 확인하는 것을 목표로 하였다.

총 40명의 피험자들은 두 집단(비우울 집단과 준우울 집단)으로 나누어 배정했다. CES-D 척도에서 0~15점이 나온 경우 비우울 집단으로 배정하였으며, 16~24점이 나온 경우 준우울 집단으로 배정하였다. 각 집단에 20명씩 배정되었으며, 준우울집단 피험자 2명의 데이터 손상으로 인해 분석에 포함되지 않았다. 모든 참여자들은 참여조건(시력, 청력, 정신병력, 약 복용, 오른손잡이 여부 등)을 충족하였다. 피험자들은 집단 배정을 위해 CES-D 척도를 실시하였고, 뮤 리듬을 측정하기 위해 EEG 실험에 참여하였다. EEG 실험에서는 고통스러운 상황을 제시하는 사진들을 보았으며, 조건(공감, 비공감)에 따라 사진들을 바라도록 하였다. 연구결과 집단과 조건 간에 유의미한 상호작용 효과가 나타났다. 더 구체적으로 살펴보았을 때, 비우울 집단은 두 조건 간 유의미한 뮤 리듬의 차이를 나타냈고, 공감 조건에 더 유의미한 뮤 리듬을 보였다. 그 반면, 준우울 집단은 두 조건 간 유의미한 차이를 나타내지 않았다.

본 연구의 결과는 우울한 경우, 인지적 공감 능력이 저하되어 조절하는 역할을 제대로 수행하지 못하고, 이로 인해 공감할 때 타인의 상황임에도 불구하고 본인의 상황인 것처럼 공감하게 되는 이전 연구들의 결과를 뒷받침한다. 또한 뇌파를 측정하여 보다 객관적인 측정방식으로 실험함으로써 우울과 공감 간 상반되는 이전 연구 결과들의 문제점을 보완하였고, 의미 있는 결과를 도출해내었다. 더 나아가, 준우울 수준의 우울을 지니고 있는 경우 달라지는 공감의 메커니즘을 파악하였고, 우울에 대한 개입 경로를 제안하였다. 한계점 및 향후 계획 또한 논의된다.

키워드 : 우울, 준임상적 우울, 공감, 뮤 리듬, EEG, 뇌파반응
학번 : 2019-24999