Neurofeedback Training Intervention for Persons with Major Depression Disorder: Reducing Depressive Symptoms

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ABSTRACT

According to the World Health Organization, 322 million people in the world were depressed in 2015. This study aimed to develop an effective training intervention for minimizing the depressive symptoms in persons with depression disorder. Neurofeedback Training (NT) was tested in a control-group experimental design: immediately after the NT and one week later. Participants were 32 Chinese college students (22 female students; mean age = 22.18). Our experimental study found positive effects of the training intervention on alpha band and depressive symptoms. Overall, NT can protect persons with depression disorder from an increase in depressive symptoms at the stage of depression.

Key Words: Neurofeedback, Depressive Symptoms, Recurrence of Symptoms, Training Intervention

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Introduction

Depression is one of the most common diseases and causes of disability in the world (Lopez *et al*., 2006), and approximately 13% of the planet's people are seeking serious treatment (World Health Organization, 2010). Depression levels among females are higher compared with males during their lifetime (Kaplan and Sadock, 2006). Kaplan and Sadock (2006) found the prevalence of female depression to be between 10% and 25%, and male depression to be between 5% and 12%. Furthermore, the World Health Organization has predicted that depression will be the second common illness in the coming years which crashes the world's population (Ustun *et al*., 2004).

Major depression disorder is not a benign disorder and tends to become chronic, and the patients develop symptoms of recurrence. Each stage of major depression increases its re-occurrence by as much as 16%. If the patient can spend more time without depression, the likelihood of a re-occurrence of depression decreases sharply (Leahy and Kaplan, 2004; Gao 2017). According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-Fifth Edition), major depression is described as a period of at least two years in which there is one of two symptoms of depressed mood or a lack of interest or pleasure in almost all activities (American Psychiatric Association, 2013).

Some studies give evidence for a negative impact of depression on academic performance (Fröjd *et al*., 2008; Mihăilescu *et al*., 2016; Owens *et al*., 2012; Deroma, Leach & Leverett, 2009, Gao,2017). For example, Owens *et al*. (2012) investigated academic performance among young people with high levels of depression.

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He showed a negative impact of depression causes on performance, mediated through worry and central executive processes. Furthermore, Christopher & MacDonald (2005) showed that adults with clinical depression show high levels of worry by deficits in working memory.

In addition to numerous etiologies and related therapies, investigating depression emotions is one of the most recognized basic neurobiological patterns of major depression (Adolphs and Tranel, 2004). Neural structures, such as brain's left and right hemispheres, amygdala, anterior cerebral cortex, basal ganglia, cingulate gyrus and hippocampus, process the emotions in humans. The brain's left hemisphere is more involved in positive emotions, and the brain's right hemisphere is more involved in negative emotions (Walker, Lawson and Kozlowski, 2006). Probably major depression is an interaction between mental-social and biological variables, but it seems reasonable relationship between treatment response and physiology of the cerebral cortex. The explanation of this relationship clearly has important meanings and implications for the implementation of effective treatment plans (Deldin and Chiu, 2005).

Studies have shown resting on the relationship between the high activity of the right frontal area of the brain or the low activity of the left frontal area and depression (Gotlib and Hammen, 2009; Henriques and Davidson, 1991; Muheem,2016).Davidson and Irwin (1999) assumed a dimension of approach/withdrawal including high arousal in the right hemisphere along with increased emotional withdrawal behavior such as fear or sadness, and also depression tendencies are related and correlated with high activity in the left hemisphere accompanied by an increase in reactive behaviors (emotions such as joy). Davidson (2004) showed that positive emotion is associated with high beta and low alpha in the left forehead cortex and low beta and high alpha in the right forehead cortex, while negative emotion is associated with high alpha and low beta in the left forehead cortex and low alpha and high beta in the right forehead cortex. More activity on the left forehead alpha means that the left frontal area has less activity, a situation that people are expected to be less affected by positive emotions. Given that negative emotions are affected by the right hemisphere, this situation indicates that there is a biological field for depression (Hammond, 2005).

Drug therapies related to major depressive disorder have long focused on monoamine mechanisms and antidepressants including monoamine oxidase inhibitors and tricyclic. A great transformation was created by the emergence of selective serotonin reuptake inhibitors. Despite these developments, the failure rate in treatment imposes a significant delay in relieving and reducing depression. In this regard, the electroencephalographic alpha wave is a non-invasive and cost-effective indicator, and it is a boost and fun state for the brain (Tenke *et al*., 2011). Neurofeedback training is a new treatment to learn actively and consciously control the various modes of brain waves. The inventors of this method claim that it is possible to direct brain waves toward a desired frequency by providing a specific sound or image for feedback on brain neuronal activity and change the pattern of brain waves (Sterman, 1996). Initially these changes are sustainable for a short time, but they can be permanent through exercises and training.

The purpose of this study is to test the effects of a NT programme on depression symptoms for college students with major depression disorder. As an indicator of depression symptoms, we used the variable depressive intensity (Whisman and Miller, 1989; Beck *et al*., 1996; Sharifi er al., 2004). Furthermore, we included regulated brain waves as an important emotion-related outcome variable (Rosenfeld, 1997; Barlow and Herson, 2002; Wang, 2017; Shanshan and Zichao, 2017). For our sample of college students with major depression disorder, which depression tends to be chronic, we expected growing recurrence of symptoms during the depression. We used the variable recurrence of symptoms (Leahy and Kaplan, 2004; Muheem,2016). Specifically, the following hypotheses were tested about the NT's effects in the NT group compared with the control group:

1- The NT intervention has a positive effect on recurrence of symptoms.
2- The NT intervention has a positive effect on depressive intensity.
3- The NT intervention has a positive effect on regulated brain waves.

Methods

Sample and design

Before the main study, we tested our instruments with a sample consisted of 38 college students, referred to a counseling center in Beijing. In the

main study 32 Chinese college students participated (22 female college students; 10 male college students), with a mean age of 22.18 years. Most of the participants were freshmen (n=24), the remaining participants were in the first to second semester (n=8). The participants were randomly assigned to a NT group (n=16) and a control group (n=16). The NT group learned and practiced the strategies of neurofeedback, but the control group received no such training intervention. Furthermore, we did not find the difference in the type of study of the participants (intervention group: 71% medicine, control group: 73% medicine).

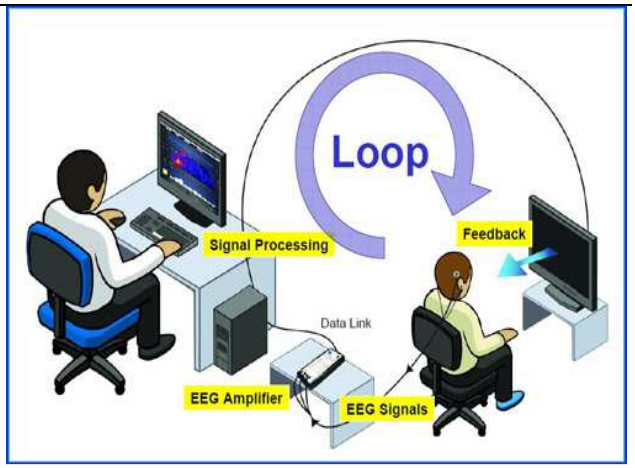

Figure 1. Screenshot of the training intervention

Training condition

We developed the NT programme with respect to neurofeedback intervention used in the study of Hammond (2001). In the training condition, participants of the intervention group received a neurofeedback training to reduce depressive symptoms in college students with major depression disorder. The intervention was performed in 30 sessions (2-hours) and 3 sessions per week. We used the ProComp 2 (Technology Thought, Canada) device in the neurofeedback training. The participants sat on a comfortable chair in a quiet room. The trainer put one electrode on the head and one or two electrodes on the eardrum, and then based on individual brain waves, a visual and audio feedback, in the form of a game or image with a computer sound, was provided to the person (Fig. 1). To run the alpha-beta protocol, the trainer connected the active electrode to the F3 and two other electrodes to the ears. At the beginning of each session, the base line was taken for 2 minutes and consequently, the thresholds for movement were determined. In this study, which was done on the left hemisphere, the alpha wave (Frequency between 8 and 12 brain waves) was suppressed and at the same time, the beta wave (Frequency between 15 and 18 brain waves) was amplified. The thresholds received an audio boost so that if the reinforced band references be maintained (80% of the time) above the threshold (at least half a second) and the repressed gangs are kept (20% of the time) at the bottom of the threshold. By the way, the person controlled and regulated these feedbacks using his own brain waves and creating different mental states. The continuation of this process led to changes in the status of the brain waves and their abnormal development.

Procedure

Before working on the NT environment, we distributed a questionnaire on demographic data among the selected volunteers. Then we provide a questionnaire to measure the three variables: recurrence of symptoms, regulated brain waves and depressive intensity. Directly 3 weeks after the intervention, to measure effects on recurrence of symptoms, regulated brain waves and depressive intensity, we also administered three tests as posttests. Two of these participants from the intervention group and one from the active control group withdrew from the study. There was drop out in both groups (n=3 in each group). To explore the effects of the NT programme on depressive intensity and regulated brain waves during the depression, the chosen time interval was 3 weeks.

Instruments

Recurrence of symptoms

We used the scale recurrence of symptoms of the second version of the depressive symptoms questionnaire (Beck, Steer & Brown, 1996; Yang *et al.*, 2012, 2014; Wang *et al.*, 2011; Tan *et al.*, 2011). The scale covers ratings of recurrence of symptoms one has to face such as more time with depression. The scale consisted of 13 items. The validity and reliability of the scale recurrence of symptoms was supported (Yang *et al.*, 2012, 2014; Wang *et al.*, 2011; Tan *et al.*, 2011). The internal consistencies of the scale was good (α coefficient from 0.73 to 0.77), and the Cronbach's α of the total scale was 0.85.

Depressive intensity

We used the scale depressive intensity of the second version of the depressive symptoms questionnaire as indicator of depressive symptoms (Beck, Steer & Brown, 1996; Yang *et*

al., 2012, 2014; Wang *et al*., 2011; Tan *et al*., 2011). The scale recurrence of symptoms reflected the perception of recurrence of symptoms one has to deal with, while the scale depressive intensity measured the cognitive-emotional perception of depression causes in particular (Yang *et al*., 2012, 2014; Wang *et al*., 2011; Tan *et al*., 2011). Negative aspects of depressive symptoms were covered by the scale depressive intensity. The scale consisted of 13 items. The validity and reliability of the scale recurrence of symptoms was supported (Yang *et al*., 2012, 2014; Wang *et al*., 2011; Tan *et al*., 2011). The internal consistencies of the scale was good (α coefficient from 0.74 to 0.80), and the Cronbach's α of the total scale was 0.81.

Regulated brain waves

Regulated brain waves were measured with a computer-neurofeedback device (ProComp II). By this device, the brain waves were recorded, and then these data were carefully compared with the basic data in the device. With this evaluation method, we meaningfully and scientifically compared the referenced-EEG patterns with the normal EEG patterns and determined the differences.

Results

The α level of used in this study was 0.05. We presented the findings with respect to the three dependent variables for our experimental groups.

Prior recurrence of symptoms, depressive intensity and regulated brain waves

Given the participants' prior recurrence of symptoms value, we observed no significant differences between the NT group (M = 2.43, SD = 0.48) and the control group (M = 2.49, SD = 0.57), $t(15) = 2.61$, $\rho = 0.12$ (one-tailed). Further given the participants' prior depressive intensity value, we observed no significant differences between the NT group (M = 5.51, SD = 0.71) and the control group (M = 5.59, SD = 0.63), $t(15) = 1.24$, $\rho = 0.42$ (one-tailed). Finally given the participants' prior regulated brain waves value, we observed no significant differences between the NT group (M = 3.39, SD = 1.12) and the control group (M = 3.31, SD = 2.48), $t(15) = 1.87$, $\rho = 0.72$ (one-tailed). Consequently, we observed no significant differences between both groups with respect to recurrence of symptoms, depressive intensity and regulated brain waves.

Effects of the NT intervention on recurrence of symptoms

Our first hypothesis stated that the NT intervention has a positive effect on recurrence of symptoms. As expected, college students with major depression disorder reported an increase of recurrence of symptoms during the depression in the control group (M = 2.49, SD = 0.57 at time 1, and M = 2.68, SD = 0.76 at time 2). In the NT group there was a tendency of increased recurrence of symptoms, but no significant effect (M = 2.43, SD = 0.48 at time 1, and M = 2.54, SD = 0.42 at time 2), thereby confirming our first hypothesis.

Effects of the NT intervention on depressive intensity

The second hypothesis was that the NT intervention has a positive effect on depressive intensity. After the training, college students with major depression disorder in the control group reported an increase of depressive intensity (M = 5.59, SD = 0.63 at time 1, and M = 6.28, SD = 1.26 at time 2), whereas the members of the NT group did not (M = 5.51, SD = 0.71 at time 1, and M = 5.38, SD = 0.39 at time 2). Thus, our second hypothesis could be partially supported.

Effects of the NT intervention on regulated brain waves

The third hypothesis stated that the NT intervention has a positive effect on regulated brain waves. As expected, participants in the NT group reported an increase of regulated brain waves (M = 3.39, SD = 1.12 at time 1, and M = 3.57, SD = 0.75 at time 2), while found no changes in the control group (M = 3.31, SD = 2.48 at time 1, and M = 3.26, SD = 0.45 at time 2), thereby confirming our first hypothesis.

Table 1. Results for recurrence of symptoms, depressive intensity and regulated brain waves

Measure		NT group	Control group
Recurrence of symptoms	Pretest	2.43(0.48)	2.49 (0.57)
	Posttest	2.54(0.42)	2.68* (0.76)
Depressive intensity	Pretest	5.51 (0.71)	5.59 (0.63)
	Posttest	5.38* (0.39)	6.28* (1.26)
Regulated brain waves	Pretest	M = 3.39 (1.12)	M = 3.31 (1.48)
	Posttest	M = 3.57** (0.75)	M = 3.26** (0.45)

*$\rho < 0.05$, **$\rho < 0.01$

Discussion

Our study provides two contributions to the literature:

(a) We extended the scarce literature on the influence of NT on college students' depressive symptoms. The NT intervention significantly reduced recurrence of symptoms (hypothesis 1) and depressive intensity (hypothesis 2) and increased regulated brain waves (hypothesis 3) among college students with major depression disorder.

As expected, the stages of the depression in university are marked by a strong increase in recurrence of symptoms for students with major depression disorder in the control group. It is quite reasonable that major depressive disorder tends to be chronic, as well as emotion-related recurrence of symptoms is potential depression cause for most of the college students. Our hypothesis could be supported for college students in the control group, which demonstrated the expected increase of recurrence of symptoms. We observed also a tendency in the NT group with a nonsignificant effect. The NT intervention seems to lessen the increase in recurrence of symptoms. For all college students with major depression disorder similar recurrence of symptoms occurred during the depression, but the NT programme might have been useful for reducing recurrence of symptoms.

Regarding the reported increase in recurrence of symptoms in the control group, it came from an increase in depressive intensity with medium effect size. We observed no increase in depressive intensity in the NT group. These findings emphasize the effectiveness of our NT intervention on depressive symptoms. Our finding indicates that the development without the NT intervention would be marked by an increase in depressive intensity, with a significant effect, resulted in the control group. The college students with major depression disorder of the NT intervention showed no such increase. Our data suggested that a NT programme can prevent recurrence of symptoms from becoming reflected in higher levels of depressive intensity. The results of this study show positive effects of NT interventions on indicators of depressive symptoms shown in previous studies (Peeters *et al*., 2014; Young *et al*., 2017; Hammond, 2001, 2005; Walker *et al*., 2006).

(b) Despite being a short-term intervention it significantly protected college students with major depression disorder from an increase in depressive symptoms during the depression. Bearing in mind that the control group received something about how to develop training courses for the occupational context, these findings emphasize the effectiveness of our NT intervention. Furthermore, the NT intervention's effects on recurrence of symptoms and depressive intensity were stable 3 weeks after the NT. Hence, the findings of our study develop the field of application of practicing's effectiveness shown in previous studies (Hammond, 2001, 2005; Walker *et al*., 2006) as well as of respective trainings interventions (Peeters *et al*., 2014; Young *et al*., 2017).

One of the limitations in our study is the use of only two dependent variables, namely depressive intensity and regulated brain waves. Besides these variables, the future researches should examine the impact of NT interventions on academic performance. Although the participants of this study were gotten as a selective sample by a cover story, the future researches can use samples of college students with especially high scores in anxiety or stress.

Conclusion

Our results show that a short-term training intervention can protect patients with major depression disorder from an increase in depressive symptoms during the depression. It had a positive effect on recurrence of symptoms, depressive intensity and regulated brain waves. Furthermore, our short-term training intervention also fostered the participants' conceptual knowledge about how depressive intensity affects recurrence of symptoms during the depression.

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