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The Effect of Short-Term Mindfulness Training on the Emotional State of College Students with Different Levels of Mindfulness: Evidence from Neurophysiological Signals

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Abstract

Objectives: The objective of this study was to explore the effects of short-term mindfulness training on the emotional state of individuals with different levels of mindfulness, especially from the perspective of autonomic neurophysiological mechanism. **Methods:** 52 college students were divided into higher or lower dispositional mindfulness groups. Then they underwent the measurement periods of baseline, short-term mindfulness training and recovery. During these periods, wrist-worn wearable devices were used for recording their autonomic nervous system activities, including heart rate (HR), galvanic skin response (GSR) and pulse rate variability (PRV). The Positive and Negative affect Scale (PANAS) and the State Anxiety Inventory (S-AI) were used before and after the experiment. **Results:** The results showed that in both groups, instead of positive emotion, negative emotions and state anxiety reduced significantly after the training. In terms of physiological signals, in lower-dispositional group, the HR of the recovery period were significantly lower than that of the other two periods, and the PRV of the recovery period were significantly higher. In higher-dispositional group, the GSR of recovery period was significantly higher than that of the other two periods. **Conclusions:** The results suggest that short-term mindfulness training works mainly by reducing negative emotions rather than increasing positive ones. Our findings also provide neurophysiological evidence for a better emotional intervention effect of short-term mindfulness training on individuals with lower dispositional mindfulness.

Keywords

Short-Term Mindfulness, Emotion, Dipositional Mindfulness, Wearable

Neurophysiology Recordings

1. Introduction

Mindfulness refers to individual's conscious, nonjudgmental awareness of the current internal or external experience (Kabat-Zinn, 2010). Studies have shown that mindfulness training can effectively relieve individual stress, improve symptoms such as anxiety and depression (Goldin & Gross, 2010), help improve individual life and work happiness (Liu, Xu, Wang, & Liu, 2013; Ye, Song, Wang, & Pang, 2019), and also has significant effects in improving emotional regulation (Arch & Craske, 2006). In previous empirical studies, researchers had arguments towards the effect of short-term mindfulness training (one-time training ranging from 3 minutes to 1 hour) on individual emotional valence. Erisman and Roemer (2010) found that after short-term mindfulness training, participants showed more positive emotions responding to positive emotional materials. In Valim's et al. (2019) experiment, he found that this effect only existed in short-term mindfulness based on positive emotion awareness. The training based on concentration has no effect. However, Lalot's et al. (2014) research found after short-term mindfulness training, participants' reports of positive emotions decreased. It can be seen that the impact of short-term mindfulness training on emotional valence needs to be further explored. In view of the fact that some previous studies on the effect of long-term mindfulness training on emotional valence mostly proved the reduction of negative emotions (Liu, Liang, Duan, & Li, 2008), this study will explore if short-term mindfulness training can effectively reduce individual's negative emotions similar to long-term mindfulness training.

At present, some studies have explored the neural mechanisms of how short-term mindfulness training affects emotional states, including brain mechanisms and peripheral neurophysiological mechanisms. Researches on the physiological mechanism of peripheral nervous system mainly involve the discussion of the physiological indicators such as heart rate (HR) and blood pressure (BP) (Howarth, Smith, Perkins, & Ussher, 2019), but their conclusions were quite different. Zeidan et al. (2010) explored the effects of short-term mindfulness training on emotions and cardiovascular variables. They found short-term meditation training improved mood and cardiovascular variables. After each meditation, participants' HR and BP were significantly reduced. Valim et al. (2019) investigated the impact of short-term mindfulness training in different types on emotional states, and measured the heart rate at the same time. The result showed no significant difference in heart rate under any condition. At present, the discussion of peripheral neural mechanisms on how mindfulness affects emotions is still mainly focused on continuous or intensive mindfulness training (Balconi, Fronda, & Crivelli, 2018; Howarth, Smith, Perkins, & Ussher,

2019). Also, the physiological signal indicators used are limited. Therefore, it is necessary to use more physiological indicators to further explore the peripheral neural mechanism of how short-term mindfulness training improved emotional states.

It is worth noting that mindfulness can also be regarded as a trait of individuals, reflecting their tendency of focusing on the present moment and self-regulation (Weinstein, Brown, & Ryan, 2009). Individuals with a high level of mindfulness tend to adopt a more receptive and non-judgmental attitude towards their own experience, and more often use a decentralized perspective towards their thoughts and emotions (Shapiro, Carlson, Astin, & Freedman, 2006). Therefore, compared with those in a lower level of mindfulness, individuals with higher level of mindfulness have more positive emotions, higher subjective well-being, life satisfaction and less negative emotions (Chang, Huang, & Lin, 2014; Goldin & Gross, 2010). They are also more adaptable while the environment changes (Siegling & Petrides, 2014). Based on this, we hypothesize: Individuals with different levels of mindfulness may be different in emotional regulation, which means compared with low-level mindfulness individuals, high-level mindfulness individuals have a weaker emotional regulation effect after short-term mindfulness training.

In a word, this study will explore the impact of short-term mindfulness training on emotional state of individuals with different levels of mindfulness, and try to provide evidence of peripheral neurophysiology for the mechanism of how short-term mindfulness training influences emotional regulation.

2. Materials and Methods

2.1. Participants

All participants were from a university in Nanjing. 52 students (43 females) aged from 18 - 23 (Mean 19.54; SD 1.04) participated the study. All of them had no experience in meditation or mindfulness practice, and had no brain disease, cognitive impairment, or sought treatment for psychiatric problems. Each of them signed the informed consent before the experiment.

2.2. Measures

- **Five Facet Mindfulness Questionnaire (FFMQ)**

FFMQ was used to measure the dispositional mindfulness of the participants. The questionnaire contains 39 items, using the Likert 5-point scoring method. In this study, Cronbach's α for FFMQ is 0.746.

- **Positive and Negative Affect Scale (PANAS)**

PANAS was used to measure the emotional state of the participants. The scale consists of 20 items, including two dimensions: positive emotion (α = 0.868) and negative emotion (α = 0.882). The scale uses the Likert 5-point scoring method. In this study, the Cronbach's α of the scale is 0.822.

- **State Anxiety Inventory (S-AI)**

S-AI is one of the subscales of the State-Anxiety Inventory (STAI). The scale contains two dimensions: anxiety (α = 0.830) and non-anxiety (α = 0.907). Each dimension contains 10 items, using the Likert 4-point scoring method. In this study, the Cronbach's α of the scale is 0.888.

- **Neurophysiological data acquisition**

A custom-designed wristband (Psychorus, HuiXin, Beijing, China) was used to record HR, GSR and PRV. HR was measured by the photoplethysmography (PPG) method at a sampling rate of 20 Hz. GSR was measured by surface electrodes with conductive gels at a sampling rate of 40 Hz. Three-axis acceleration was recorded at 20 Hz as well but not used in the present study.

2.3. Materials

In this study, a self-developed programme was used for short-term mindfulness training. The programme was based on the book *Mindfulness: A Practical Guide to Finding Peace in a Frantic World* by Mark Williams (2011). The training mainly includes two parts: mindfulness breathing and body scanning practice. The training was verbally conducted by a director who had received professional and systematic training of mindfulness courses, and had certain experience of guiding mindfulness.

2.4. Procedure

Before the experiment began, all participants were asked to fill out the FFMQ. Then they were divided into higher or lower dispositional mindfulness groups according to the scores. The study was carried out by group intervention. Both groups underwent three periods, which were baseline period (5 min), training period (20 min), and recovery period (5 min). During the baseline and recovery period, participants were asked to stay in the resting state. When in the training period, they received short-term mindfulness training under the guidance of the tutor. During the whole process, all participants wore the wristbands to record their neurophysiology signals. PANAS and S-AI were used before and after the experiment.

2.5. Data Analysis

The data were analyzed using SPSS 25.0. Group differences in pre-test scores of positive emotion, negative emotion and state anxiety as well as FFMQ scores were respectively checked with independent-samples *t* test. Repeated-measure ANOVAs were used to explore: 1) the changes of positive emotions, negative emotions and state anxiety before and after the experiment (within-group variable: pre-test, post-test; between-group variable: groups); 2) the difference of changes of HR, GSR and PRV in different periods between two groups (within-group variable: periods; between-group variable: groups). For ANOVAs, a Greenhouse-Geisser correction was applied if data failed the Mauchly's test of sphericity. Partial eta square (η_p^2) and Cohen's *d* were used as effect size measures.

3. Results

3.1. Group Differences before the Experiment

The result showed that the group difference in FFMQ scores was significant (t = 10.24, $p < 0.001$), which meant the validity of group classification. There were no significant group differences in pre-test scores of positive emotion (t = 0.334, p = 0.740), negative emotion (t = −0.046, p = 0.963) and state anxiety (t = −1.275, p = 0.208).

3.2. Changes of Emotion Variables in the Two Groups

- **Positive emotion** The main effect of time (F (1, 48) = 0.631, p = 0.431, η_p^2 = 0.013) and group (F (1, 48) = 1.982, p = 0.166, η_p^2 = 0.040) were not significant. The time × group interaction effect was also not significant (F (1, 48) = 0.237, p = 0.628, η_p^2 = 0.005).
- **Negative emotion** As shown in **Figure 1(a)**, there was a significant main effect of time (F (1, 48) = 7.212, p = 0.010, η_p^2 = 0.131), but not in group (F (1, 48) = 0.013, p = 0.910, η_p^2 = 0.001). The time × group interaction effect was not significant (F (1, 48) = 0.049, p = 0.826, η_p^2 = 0.001).
- **State Anxiety** The main effect of time (F (1, 49) = 27.388, $p < 0.001$, η_p^2 = 0.359) was significant, while the main effect of group (F (1, 49) = 2.949, p = 0.092, η_p^2 = 0.057) was not significant. The time × group interaction effect was not significant (F (1, 49) = 0.152, p = 0.698, η_p^2 = 0.003) (See **Figure 1(b)**).

3.3. The Difference of HR, GSR and PRV in Different Periods between the Two Groups

- **HR** There was a significant main effect of period (F (2, 49) = 6.869, p = 0.003, η_p^2 = 0.121), but not in group (F (1, 50) = 0.408, p = 0.526, η_p^2 = 0.008). The interaction effect between period and group was not significant (F (2, 49) = 0.909, p = 0.396, η_p^2 = 0.018). Pairwise comparison showed that, in the higher-dispositional mindfulness group, there were no significant differences

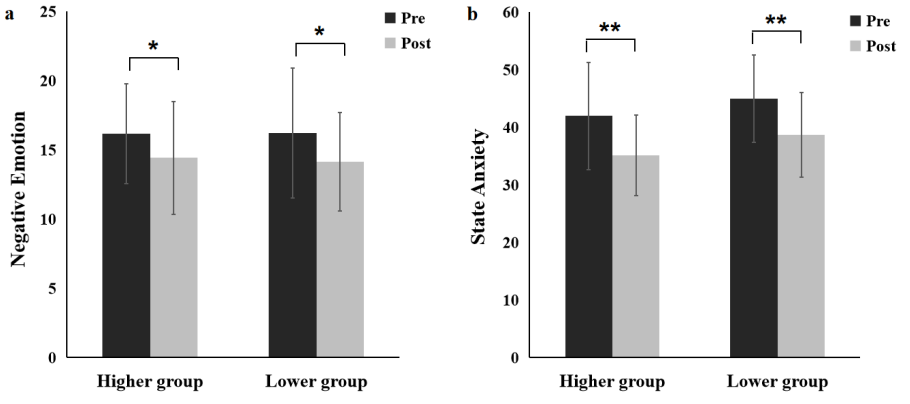

Figure 1. Differences of (a) negative emotion and (b) state anxiety in each group. *p < 0.05, **p < 0.01.

between baseline and training period (p = 0.818), training and recovery period (p = 0.331), as well as baseline and recovery period (p = 0.643). In the lower-dispositional mindfulness group, there were significant differences between training and recovery period (p = 0.021), baseline and recovery period (p = 0.021), but no significant differences were found between baseline and training period (p = 0.989) (see **Figure 2(a)**).

- **GSR** There was a significant main effect of period (F (2, 49) = 3.524, p = 0.048, η_p^2 = 0.066), but not in group (F (1, 50) = 1.067, p = 0.307, η_p^2 = 0.021). The interaction effect between period and group was not significant (F (2, 49) = 2.293, p = 0.122, η_p^2 = 0.044). Pairwise comparison showed that, in the higher-dispositional mindfulness group, there were significant differences between training and recovery period (p = 0.008), baseline and recovery period (p = 0.036), but no significant differences were found between baseline period and training period (p = 0.752). In the lower-dispositional mindfulness group, there were no significant differences between baseline and training period (p = 0.994), training and recovery period (p = 0.898), as well as baseline and recovery period (p = 0.995) (see **Figure 2(b)**).
- **PRV** There was a significant main effect of period (F (2, 49) = 12.514, p < 0.001, η_p^2 = 0.200), but not in group (F (1, 50) = 0.713, p = 0.402, η_p^2 = 0.014). The interaction between period and group was significant (F (2, 49) = 4.596, p = 0.012, η_p^2 = 0.084). Further simple effect analysis showed that PRV during recovery period was significantly higher than that during baseline (p < 0.001) and training period (p < 0.001) in the lower-dispositional

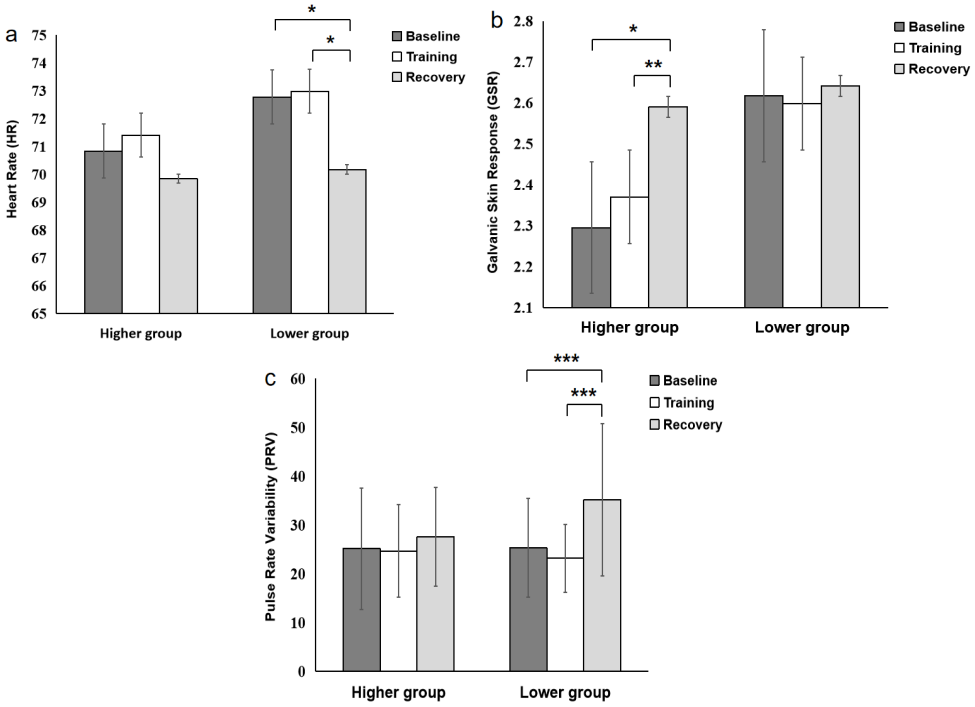

Figure 2. Differences of (a) HR, (b) GSR and (c) PRV in different periods in each group. *p < 0.05, **p < 0.01, ***p < 0.001.

mindfulness group, but there was no significant difference between baseline and training period (p = 0.603). In the higher-dispositional mindfulness group, there were no significant differences among three periods (Baseline vs. Training: p = 0.994; Training vs. Recovery: p = 0.585; Recovery vs. Baseline: p = 0.622) (see **Figure 2(c)**).

4. Discussion

The aim of the present study was to investigate the effects of short-term mindfulness training on emotional state of college students with different levels of dispositional mindfulness. For changes of emotional state, the scale data showed that there was no significant difference between the pre-test and post-test of positive emotion in both groups, while the post-test scores of negative emotion and state anxiety were significantly lower than those of the pre-test. These results indicate that short-term mindfulness training can effectively reduce individuals' negative emotions, but does not significantly affect individuals' positive emotions. This is basically consistent with previous studies based on long-term mindfulness training (Erisman & Roemer, 2010; Liu et al., 2008), indicating that short-term mindfulness training may have a similar mechanism to long-term mindfulness training.

From the perspective of neurophysiology, our study also investigated the changes of HR, GSR and PRV of participants with higher or lower dispositional mindfulness. In terms of HR, the results showed that in the higher-dispositional mindfulness group, no significant difference was found among three periods. However, in the lower-dispositional mindfulness group, HR during recovery period was significantly lower than that during baseline and training period, and there was no significant difference between the baseline and training period. These results indicated that short-term mindfulness training can effectively reduce the HR of individuals with low trait mindfulness. It was shown in the previous studies that HR would significantly improve when individual negative emotions increased (Brosschot & Thayer, 2003), while the change of HR was not obvious when positive emotions increased (Hubert & Jone-Meyer, 1990). These results suggested that short-term mindfulness training may have a better effect on the negative emotions of lower-dispositional mindfulness individuals.

In terms of GSR, the results showed that in the higher-dispositional mindfulness group, the GSR during the recovery period was significantly higher than that during the other two periods. In the lower-dispositional mindfulness group, there was no significant difference among three periods. These results indicated that short-term mindfulness training can effectively improve the GSR of individuals with higher-dispositional mindfulness. Previous studies have shown that human sweat secretion is affected by emotional arousal. When emotional arousal increase, the GSR will increase, while when emotional arousal decrease, the GSR will also decrease (Khalfa et al., 2002). That is, changes in GSR can reflect the individual's ability of emotional arousal to some extent. In this study, only indi-

viduals with high-dispositional mindfulness had a significant increase in GSR, which may be related to the higher ability of emotion detection of individuals with high-dispositional mindfulness. Previous studies have proved that the degree of an individual's emotional awareness can affect his emotional response. For example, the neglect and indifference to emotional information can effectively weaken the emotion, and on the contrary, the emotional response will increase. Compared with individuals with lower-dispositional mindfulness, individuals with higher-dispositional mindfulness tend to have stronger ability to detect emotions, so they are more likely to improve the awareness and arousal of emotions in a short period of mindfulness training.

In terms of PRV, the results showed that there were no significant differences among three periods in the higher-dispositional mindfulness group. In the lower-dispositional mindfulness group, the PRV in the recovery period was significantly higher than that in the other two periods. These results indicated that short-term mindfulness training can effectively improve PRV of individuals with lower-dispositional mindfulness. Previous studies mostly explored the changes of individual heart rate variability (HRV) in mindfulness training, which is considered to be related to mental health (Anderson, Nielsen, McKee, Jeffres, & Kligler, 2012). Some scientists have found that mindfulness training helped enhance HRV and parasympathetic nervous system activity (Krygier, Heathers, Shahrestani, Abbott, Gross, & Kemp, 2013), which in turn can make people relax, thus reducing anxiety and negative emotions. Recent studies have shown that PRV can completely replace HRV to reflect autonomic nerve activity under certain conditions (Wong, Lu, Wu, Liu, Chen, & Kuo, 2012). In general, lower PRV indicates that the body is under stress from sports, psychological events, or other internal or external stressors, while higher PRV usually indicates that the body has a strong ability to tolerate stress or recover from previous stress. At rest, higher PRV is usually favorable. In this study, the improvement of PRV level in the recovery period further confirmed the effectiveness of short-term mindfulness training in improving autonomic nervous system function. It is worth noting that PRV changes were only significant in the lower-dispositional mindfulness group, which may indicate that short-term mindfulness training has a better effect on the emotional intervention of individuals with lower-dispositional mindfulness. The results provide ideas and inspiration for short-term mindfulness emotion regulation intervention for individuals with lower-dispositional mindfulness.

There were some shortcomings in this study. First, the number of subjects needs to be expanded. Due to the limitation of time, space and other research factors, only 52 valid samples were collected in this study. Therefore, the results obtained in this study should be carefully popularized. What's more, the short-term mindfulness training content used in this study mainly involved basic exercises related to attention and awareness, but did not involve practice on acceptance. Lindsay & Creswell (2017) believed that the training of attention in

mindfulness can improve the ability of awareness, and may also increase the emotional response. On the other hand, acceptance exercises on the basis of attention can reduce emotional responses. Therefore, different contents of short-term mindfulness training may also have different effects on individual emotion regulation, which still needs to be further explored in subsequent studies.

5. Conclusion

Short-term mindfulness training works mainly by reducing negative emotions rather than increasing positive emotions. It may promote emotional state by decreasing HR, and increasing GSR and PRV. In addition, short-term mindfulness training may have a better effect on regulating emotions for individuals with lower-dispositional mindfulness.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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