Understanding Mindful Awareness in Mindfulness Meditation—Investigation of the Psychological, Physiological, and Neural Mechanisms of Mindfulness Meditation

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Abstract

Mindfulness meditation, which is used to cultivate a state of awareness of the experience of the present moment as it is (called *mindful awareness*), has been shown to contribute to enhancing well-being. There are two types of mindfulness meditation: focused attention meditation and open monitoring meditation. To understand mindful awareness, our group focused on the psychological, physiological, and neural mechanisms of open monitoring meditation thought to be involved in mindful awareness.

Keywords: mindfulness, mindful awareness, open monitoring meditation

1. The importance of awareness of the present moment experience as it is

Mindfulness is the state of receptive attention to and awareness of ongoing events and experiences as they are. "Receptive attention" means, as opposed to intentionally focusing attention on a specific object, the spontaneous broadening of attention by letting go of such an intention. "Awareness" means the bringing to consciousness of previously unaware experiences. "Experiences" means the sensations, feelings, and thoughts that arise one after another in one's body and mind. "As they are" means an attitude of not reacting, judging, or inhibiting the experiences within awareness after broadening of attention. We call this kind of awareness *mindful awareness* in this article.

Many studies have shown that mindful awareness of negative experiences can alleviate symptoms such as depression and anxiety [1]. However, it has also been reported that people who think they are aware of negative experiences as they are may react or suppress them unconsciously, resulting in adverse events such as increased anxiety or tension [2]. Considering these studies and reports, it is clear that the key to increasing effectiveness while reducing adverse events of mindfulness practice is to be aware of the experience as it is, that is, mindful awareness. To understand this mindful awareness, we need to elucidate its mechanism.

2. Focused attention and open monitoring meditations

There are two types of mindfulness meditation: focused attention meditation (FAM) and open monitoring meditation (OMM) (**Fig. 1**). FAM is a method of intentionally focusing attention on a specific object [3]. For example, we focus our attention on

breathing, which occurs naturally. However, when distracting stimuli arise, such as stronger sensations or emotions, our attention is captured by them. When we become aware of this, we try to shift attention back to the specific object. This shifting attention allows it to be diverted away from the distracting stimulus. Repeatedly doing this can improve the ability to focus attention on a target object. However, focusing attention on a specific object does not enable us to become aware of experiences that occur one after another in the range other than the narrow range of attention.

OMM, however, is a method for maintaining awareness of the ongoing flow of experiences as they naturally occur one after another, without selectively focusing on specific objects [3]. With this method, since there is no specific object, the range of attention is broadened, and every breath, sensation, and emotion that arises one after the other becomes an object of awareness. However, when distracting stimuli, such as stronger sensations or emotions, arise, our attention is captured by them. When we become aware of this, we try to be aware of the stimulus as it is, rather than moving our attention away from it. The distracting stimulus is then returned to the object of awareness, and the range of attention that was captured by the stimulus is naturally broadened. By repeating this process, it becomes possible to maintain awareness of various sensations, feelings, and thoughts as they are, without differentiation between selected and deselected objects.

Our group has been working to elucidate the psychological, physiological, and neural mechanisms of OMM to clarify the mechanism of mindful awareness. I describe three of these studies in the following sections.

3. Study 1: Investigation of the psychological mechanism of OMM

When we concentrate on a task, we subconsciously inhibit distracting stimuli that are irrelevant to the task, such as visual stimuli. Such inhibition is fatiguing. It is believed that mindfulness meditation reduces such inhibition. However, previous studies have not confirmed that FAM and OMM as well as mindfulness meditation reduce inhibition to distracting stimuli at the behavioral level. Therefore, we designed a cognitive task to assess the degree of inhibition against distracting stimuli and examined the effects of FAM and OMM on inhibition [4].

The experiment was conducted by dividing 72 meditation-naïve participants into three groups: FAM, OMM, and relaxation. A 30-minute intervention was first given using voice instruction [5], followed by a questionnaire to measure the state of relaxation, then two tasks were performed (**Fig. 2**). In Task 1, 24 face images that included 3 facial expressions of 8 people were presented repeatedly in turn, and the participants were asked to respond as quickly and accurately as possible to the orientation of the letter presented in the center of the face images. In this task, the face images were distractors. In Task 2, participants were asked to rate their attractiveness toward the eight neutral face images presented in Task 1 and another eight neutral face images that were not presented. Based on previous research [6], if the face images were not inhibited, the attractiveness toward the face images that were presented repeatedly would be expected to increase. However, if the face images were inhibited, we would not see such an increase in attractiveness.

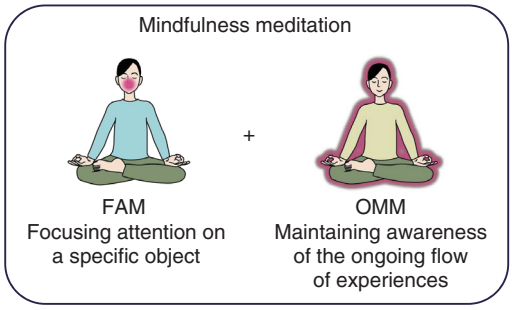


Fig. 1. Two types of meditation methods comprising mindfulness meditation.

The results indicated that the relaxed group did not increase their attractiveness toward the face images they were repeatedly exposed to in Task 1 (**Fig. 3**). This indicates that the relaxed group inhibited the face images during Task 1. However, the FAM and OMM groups showed increased attractiveness toward the face images they were repeatedly exposed to in Task 1 (Fig. 3). This indicates that, compared with the relaxed group, the FAM and OMM groups reduced inhibition to the face images during Task 1. Interestingly, in the FAM group, those who were more relaxed immediately before Task 1 showed less inhibition to the face images, while those who were less relaxed showed more inhibition to the face images (**Fig. 4**). In contrast, no such relationship was observed in the OMM group (Fig. 4). This indicates that the attention-regulation strategy of the FAM

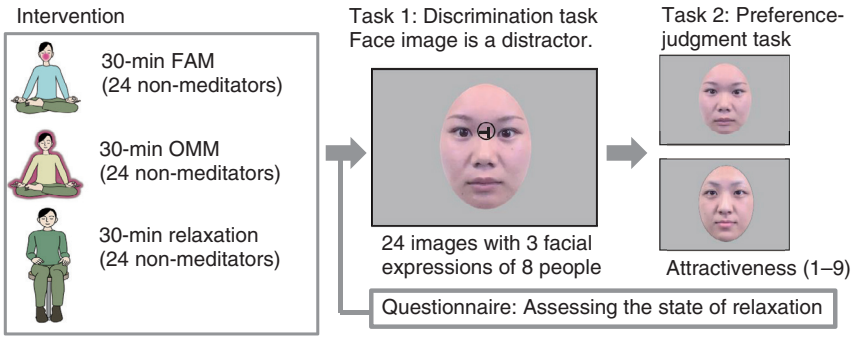


Fig. 2. Experimental design for investigating the psychological mechanism of OMM.

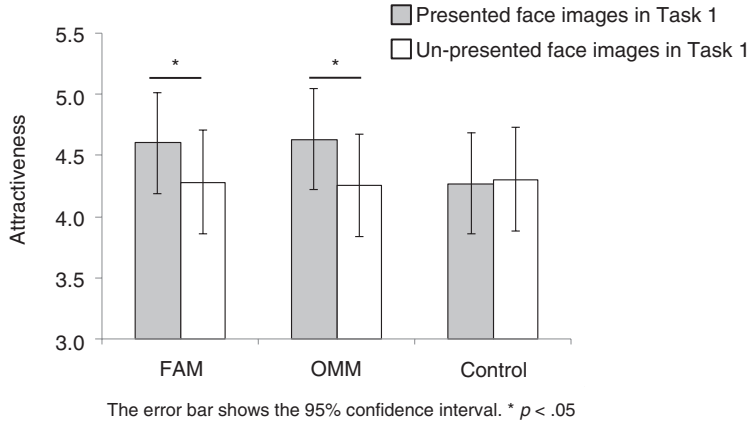


Fig. 3. Attractiveness to face images.

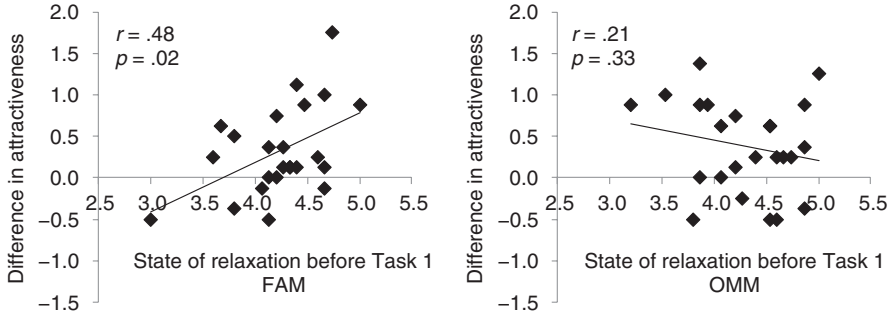
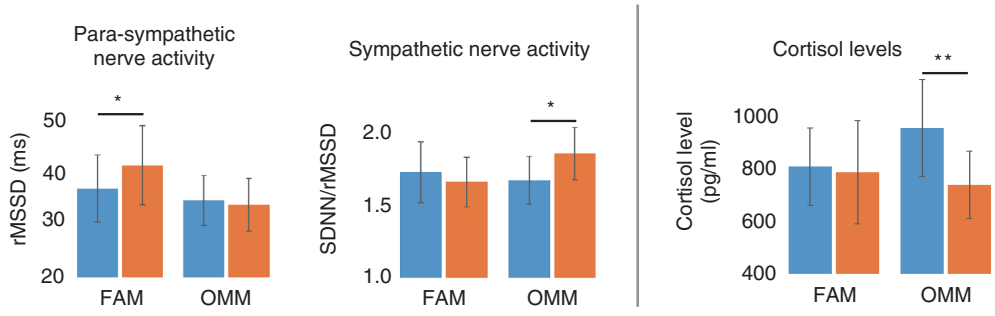


Fig. 4. The correlation between the difference in attractiveness between presented and un-presented face images and the state of relaxation before Task 1.

group was influenced by the relaxation state, whereas that of the OMM group was not influenced by the relaxation state.

4. Study 2: Investigation of the physiological mechanism of OMM

The popular image of mindfulness meditation is



The error bar shows standard deviation. * $p < .05$, ** $p < .01$

rMSSD: root mean square of successive differences
SDNN: standard deviation of normal-to-normal intervals

Fig. 5. The effect of FAM and OMM on the autonomic nervous activity and salivary cortisol levels.

that it relaxes the mind. However, in the field of meditation research, it has been thought that mindful awareness is not simple relaxation since it is a state of being aware of various sensations, emotions, and thoughts. Therefore, the effects of mindfulness meditation on physiological indices related to relaxation and stress have been investigated, but the results have varied. The reason for this is thought to be that mindfulness meditation was examined without considering FAM and OMM separately. Therefore, we focused on them separately and examined their effects on physiological indices [7].

In the experiment, 41 meditation-naïve participants were asked to perform 30 minutes of FAM and OMM, respectively [5], and the effects of each meditation on heart-rate variability before and during meditation and on cortisol levels in saliva before and after meditation were examined.

The results indicated that parasympathetic nerve activity increased during FAM (**Fig. 5**). This indicates a higher state of relaxation. These results also suggest that by focusing attention on a specific object, the participants were less likely to be distracted by other sensations, emotions, and thoughts, thus were able to relax. During OMM, interestingly, sympathetic nerve activity increased while cortisol levels decreased (Fig. 5). This indicates that the stress level was lower despite the higher arousal level. These results suggest that OMM is not simply a state of relaxation but may be a state in which the participants were aware of various sensations, emotions, and thoughts but were less able to react to or inhibit them.

5. Study 3: Investigation of the neural mechanism of OMM

What type of activity occurs in the brain during mindful awareness of various sensations, emotions, and thoughts? Previous studies have not clearly shown the difference in brain activity during FAM and OMM. Therefore, we designed an experiment for extracting brain activity during meditation and identified brain activity during FAM and OMM [8]. This study was conducted while I was a member of the Graduate School of Education, Kyoto University.

The experiment included 17 meditation practitioners. Conventional studies comparing brain activity during FAM and OMM have mainly used a block design, for example, 6 minutes of FAM, 6 minutes of rest, and 6 minutes of OMM, during which brain activity was measured with functional magnetic resonance imaging (fMRI). However, as a meditation practitioner, I realized that it is difficult to achieve an optimal meditative state in a 6-minute meditation session. Therefore, we measured brain activity during 6 minutes using fMRI immediately after 1 hour of meditation in a soundproof room. Because I had felt that the meditative state continued for a while after the 1-hour meditation, we divided the days of FAM and OMM conditions into two separate days.

Functional connectivity analysis, which examines the correlation between activities of brain regions, was used for the analysis. Mindfulness meditation is known to involve a wide range of brain regions because it involves various cognitive functions such as attention control, emotion regulation, awareness of bodily sensations, and change in perspective on the

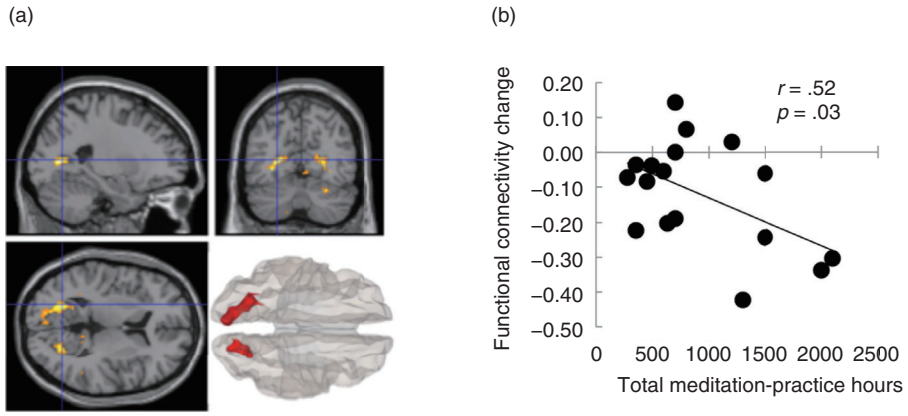


Fig. 6. (a) The retrosplenial cortex showing reduced functional connectivity with the ventral striatum during OMM. (b) The correlation between total meditation-practice hours and altered functional connectivity from the resting state to the OMM state between the right retrosplenial cortex and left ventral striatum.

self. The striatum, which is located below the cerebral cortex, forms multiple different circuits with each brain region of the cortex and involved in various functions such as movement, attention, emotion, motivation, learning, and memory. By examining changes in functional connectivity between the striatum and each brain region, we identified brain activities specific to FAM and OMM and estimated the functions of meditation from these activities.

The results indicated that the functional connectivity between the ventral striatum and visual cortex increased during FAM while it decreased during OMM. This functional connectivity is thought to be related to intentional attention control directed at a specific object. The results support the conventional understanding that FAM enhances intentional attention control, while OMM reduces it. Functional connectivity between the ventral striatum and retrosplenial cortex was also reduced during OMM (**Fig. 6(a)**). Notably, the longer the lifetime of meditation practice, the greater the decrease in functional connectivity (**Fig. 6(b)**). This functional connectivity is thought to be related to the degree to which one is captured by memories. This suggests that when the participants were aware of sensations, feelings, and thoughts during OMM, there may have been a decrease in brain activity that connected these experiences to past memories.

6. Summary

In light of the three aforementioned studies, let me summarize the concept of mindful awareness. Mindfulness is the state of receptive attention to and awareness of ongoing events and experiences as they are. We call this type of awareness mindful awareness. OMM is considered more effective than FAM in cultivating mindful awareness. We have found that OMM reduces inhibition to distracting stimuli. This is consistent with the understanding that mindful awareness does not distinguish experiences as the target object and other distracting stimuli but rather receives everything as an object of awareness. In addition, the physiological parameters of mindful awareness of these experiences revealed that the participants were not merely relaxed but in a state of low stress despite their high arousal levels. We were also able to identify the possibility that such a low stress state may be related to not associating their experiences in the present moment with their past memories.

7. Future perspectives

On the basis of these findings, we are currently developing biomarkers to quantify mindful awareness. We believe that the establishment of such a technology will contribute to increasing the effectiveness of mindfulness-meditation interventions while reducing adverse events. Therefore, we are working to contribute to people's well-being by elucidating the mechanisms of mindful awareness and developing technologies by using this understanding.

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He received a BBA in business administration from Kobe University in 2004 and worked for Sysmex Corporation for 7 years. After starting to practice Buddhism meditation, he left the company and returned to school to understand the mechanism of meditation and share its mechanisms and benefits with others. He received a B.A., M.Ed., and Ph.D. in cognitive psychology in education from Kyoto University in 2014, 2016, and 2019. He served as an assistant professor in cognitive psychology in education at Kyoto University from 2019 to 2020 and at Open Innovation Institute of Kyoto University from 2020 to 2022. In 2022, he joined NTT Communication Science Laboratories to study psychology and physiology of mindfulness meditation. He is also actively working to implement meditation programs in medical and educational settings to enhance the physical and mental well-being of individuals. He received the Best Research Award at the Annual Japanese Association of Mindfulness conference multiple times. He is a member of the Japanese Psychological Association and the Japanese Association of Mindfulness.