

Short-Term Contemplative Practices with Vocalization Alter Psychological States in an Unexperienced Student Sample

Hiromitsu MIYATA

Abstract

Traditional contemplative practices including yoga and meditation have been shown to cause plastic changes to the neurophysiological, psychological, and somatic functions in adult humans. Would desirable changes in psychological states occur when unexperienced participants engage in short-term contemplative practices? The present study examined changes in affective and relevant psychological states when university undergraduate students with no daily training of yoga or meditation participated in a session of contemplative practices that involve vocalization. Ten university undergraduate students were assigned to a practice group, and participated in a session of contemplative practices lasting for approximately 75 minutes. Specific content of the practice included mantra meditation with vocalization, prostration with mantra chanting, and “overtone chanting,” i.e., a traditional contemplative practice originated in the Nyingma school of Tibetan Buddhism in which participants continuously vocalize vowels in a group. The practice session was guided by a professional yoga instructor. In addition, another 18 undergraduates who were also naïve to meditation were assigned to the control group, and engaged in a 75-min free description regarding the content of the lecture course in which these students participated. Both prior to and immediately after the session, participants from these two groups completed an identical battery of questionnaires concerning positive/negative affect (PANAS), state anxiety (STAI-S), and degree of relaxation. For the practice group, scores of anxiety significantly decreased and those of relaxation significantly increased after the practice session. By contrast, statistically significant changes in the scores failed to be observed for the control group. These results support the notion that short-term contemplative practices that involve continuous vocalization can cause desirable changes to the psychological states such as reducing anxiety and enhancing relaxation, regardless of prior experience with the contemplative training. Future studies may focus on the effect of each specific form of practice, long-term effects of repeated practice sessions, as well as potential changes at the neurophysiological level including autonomic nervous system activities and cerebral hemodynamics.

Key words: yoga, meditation, vocalization, overtone chanting, psychological state

Introduction

Traditional contemplative practices including yoga and meditation have been shown to cause plastic changes to the neurophysiological, psychological, and somatic functions in adult humans. Would desirable changes in psychological states occur when unexperienced participants engage in short-term contemplative practices? The present study addressed this question in a student sample by examining changes in affective and relevant psychological states associated with instructed contemplative practices that involve continuous vocalization lasting for multiple minutes.

Advances in contemplative psychology and neuroscience

The recent decades have witnessed remarkable advances in the emerging field of contemplative psychology and neuroscience by demonstrating desirable effects of meditation-based mental practices at the psychological, physiological, and neurocognitive levels (for reviews see Goyal et al., 2014; Slagter et al., 2011). For example, compassion and loving-kindness meditation in the Tibetan tradition has been extensively studied to show high-amplitude gamma synchrony associated with expertise in long-term meditators (Lutz et al., 2004), activation of the right insular cortex coupled with heart rate increase (Lutz et al., 2009), as well as enhancement of empathic concern (Lutz et al., 2008), prosocial behavior (Weng et al., 2013; 2015), and visual attention (Weng et al., 2018) when confronted with unfortunate others. These empirical data are collectively suggestive of the view that traditional contemplative training can cause plastic changes to the brain and mind of adult humans.

In addition, the idea of mindfulness has recently become increasingly popular among both scientists and people in general. With its origin in the traditional Buddhism, mindfulness refers to the psychological processes of maintaining moment-by-moment attention to one's internal and external experiences in non-judgmental ways (Kabat-Zinn, 1990; Segal et al., 2002). Mindfulness has been effectively applied in the context of stress reduction and enhancement of psychological well-being (for recent reviews see Creswell, 2017; Davis & Hayes, 2011). In clinical contexts, the mindfulness-based stress reduction (MBSR) program originally developed by Jon Kabat-Zinn has been shown to be effective in patients with chronic pain and other medical and psychological symptoms in terms of reducing perceived stress and anxiety and improving self-reported well-being (Carmody & Baer, 2008; Kabat-Zinn, 1990). Based on the MBSR program,

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the mindfulness-based cognitive therapy (MBCT) program was further developed in an attempt to prevent relapse of depression, and has proved effective in reducing relapse rates among individuals who experienced major depression (Segal et al., 2002). These programs have been shown to be effective not only in clinical populations but also in healthy participants such as university students in reducing stress (e.g., Oman et al., 2008).

In Japan, there has been a growing number of studies in recent years that investigated psychological, physiological, and/or neurocognitive impacts of traditional or Zen-based contemplative practices. For example, yoga is a form of contemplative physical and mental practice with its origins in the ancient India (Feuerstein, 2001). Traditional yoga involves multiple practices such as asanas (sitting postures), pranayamas (breathing techniques), and meditation techniques based on sustaining a focused attention on a chosen object such as one's breath, body parts, visual images, and/or mantra chanting. Empirical data have suggested psychological and physiological benefits of continued yoga practice (see McCall, 2013 for a review). Miyata et al. (2015) reported that yoga practitioners in Japan whose practice periods ranged from 0.3 to 34.0 years self-report significantly larger scores on mindfulness, subjective well-being, positive affect, and empathy, and smaller scores on depression and negative affect compared with non-practitioners. In addition, period and (less apparently) amount of yoga/meditation practice were significantly associated with enhanced mindfulness and well-being, and reduced depression and negative affect (Miyata et al., 2015). Miyata (2018) further examined autonomic nervous system activities when a Japanese long-term yoga practitioner engaged in meditations on different themes including focused attention on the breath and covertly repeating a "mantra of love" (a mantra phrase "I love..." or "*Ai-shite imasu*" in Japanese). "Mantra of love" meditation elicited less increase in heart rate and less decrease in skin conductance than did breathing meditation, suggesting differentiated control over autonomic nervous system activities in the yoga expert.

Another example of contemplative training in Japan concerns speed-reading. Specifically, the Park-Sasaki method of speed-reading involves meditative training such as tanden-kokyu (respiration by working the inner part of the lower abdomen) and progressive muscle relaxation as a basis for systematic visual training, to acquire a capability to read Japanese sentences faster than 10,000 characters per minute while maintaining comprehension (for a review see Miyata, 2015). Miyata et al. (2012) reported a case in which an advanced Park-Sasaki expert read contemporary novels in a computerized setting 4.7 times faster than did untrained participants and showed statistically comparable scores on the tests of sentence comprehen-

sion. Miyata et al. (2016) further examined cerebral hemodynamic responses during speed-reading by using near-infrared spectroscopy (NIRS) and found that Park-Sasaki trainees showed hemodynamic changes suggesting enhanced visual form and visuo-spatial processes.

Embodied psychology of vocalization

In the aforementioned research contexts, the present study focused on the psychological impacts of contemplative practices that involve vocalization. Vocalization in the context of embodied psychology refers to the vocal, instead semantic or conceptual, aspects of speech (Haruki, 2011). It is widely observed in animals from different taxa including mammals and birds, and is regarded as one form of emotional expressions to convey fear, anger, happiness, and so on. Vocal behavior in humans has been suggested to alter psychological and physiological status, albeit more weakly than do facial expressions or body postures, addressed as the vocal feedback based on the ideas of the James-Lange theory (Sugamura, 2016). For example, Siegman et al. (1990) instructed participants to speak about their own anger-arousing events and found that both males and females self-reported feeling significantly more anger and showed higher heart rate and blood pressure when speaking fast and loud than when speaking normally. By contrast, when asked to speak about neutral events only male participants reported more anger while they spoke fast and loud. Siegman and Boyle (1993) further reported that changing speech rate and loudness can alter both affective and cardiovascular arousal when participants felt anxiety and depression. These findings are collectively in support of the view that there exists continuous feedback between cognitive, physiological, and behavioral processes when vocal behavior influences affective and physiological status (Siegman & Boyle, 1993).

In Japan, Suzuki (1998) asked participants to vocalize visually-presented Japanese hiragana characters and to evaluate their nuances, awareness, and impressions by using pairs of adjectives. Differences in the nuances and/or impressions were found so that k-line and t-line tended to be evaluated as bright and clear, s-line and h-line as static, n-line and m-line as soft and rounded, and so on. With regard to the Japanese vowels, Mika Morita examined mood and cardiovascular reactions while vocalizing each character (unpublished graduation thesis). Results showed that vocalization of the vowel “a” was associated with relatively positive mood, while vocalization of “un” with warm, loose, and grave mood. Based on these findings, Sugamura (2016) proposed an embodied view regarding vocal behavior that shapes and movement patterns of the mouth when vocalizing each character may be one key factor in forming the impressions of

these characters.

Contemplative practices with vocalization

Despite these empirical data obtained, relatively few studies so far have shed light on the potential effects of vocalization during contemplative practices. Whereas many forms of traditional contemplative practices such as yoga and sitting meditation are practiced silently, there are multiple practices that essentially involve continuous vocalization. For example, mantra meditation refers to a form of meditation that entails chanting a mantra in a repetitive manner. A mantra refers to words or relatively short phrases that have traditionally been believed to have spiritual power with sound vibration (Feuerstein, 2003). Mantra chanting serves as an essential part of the contemplative practices in Hinduism and Buddhism, as well as in traditional yoga and transcendental meditations (Goyal et al., 2014). Whereas some meditation techniques involve covert, internal repetition of mantras, i.e., ajapa-japa, other techniques entail overt repetitive chanting, i.e., japa (Naruse, 2010). One of the most famous mantra phrases is *Om Shanti* (mantra of peace), where *Om* refers to the whole universe and *Shanti* means peace. Another popular mantra is *Om Namah Shivaya* (mantra of Lord Shiva), which literally means “adoration to Lord Shiva” and is regarded as one of the most important mantras in Hinduism. Mantra chanting is often involved not only in the sitting meditation but also in contemplative practices with repetitive body movements such as the prostration practice (Fallahrafie et al., 2016).

Another form of traditional contemplative practice that involves systematic vocalization is “overtone chanting.” Overtone chanting is one of the traditional contemplative techniques with vocalization originated in the Nyingma school of Tibetan Tantric Buddhism (Naruse, 2010). The Nyingma school has many elements of primitive Buddhism and includes multiple forms of contemplative practices that have been believed to have magical significance. Based on these traditions, Naruse (2010) in Japan developed a modified form of overtone chanting that people in general can practice independently of any religious beliefs. In this version of overtone chanting, participants in a group continuously vocalize Japanese vowels in a determined sequence, i.e., $u \rightarrow o \rightarrow a \rightarrow e \rightarrow i \rightarrow$ humming/silent. The starting vowel can vary for each participant, and each vowel is separated by a bell sound after about a minute. Overtone chanting can be practiced for various purposes including relaxation and health promotion, as well as for mind-body purification and spiritual cultivation. Participants in the practice session of overtone chanting reportedly experience various mental and physical reactions such as body trembling,

weeping, and/or hearing various nonexistent sounds like those of musical instruments, sutras, hymns, and so on (Naruse, 2010). An important advantage of overtone chanting is that naïve participants with no prior contemplative training can participate in the practice session with appropriate instruction. However, there has so far been little scientific effort made to examine the psychological and/or physiological effects of overtone chanting.

Purpose of the present study

Accordingly, the present study investigated whether and how traditional yoga and meditation practices that involve vocalization can cause desirable short-term changes to the psychological states. To examine whether such effects are observed with no prior extensive contemplative practices, university undergraduate students with no daily training of yoga and/or meditation were involved. As is typical of the yoga practice, the experimental session lasted for approximately 75 minutes and consisted of a combination of multiple forms of practices including mantra chanting, prostration, overtone chanting, and so on. Because yoga and meditation practices have been associated with psychological and health benefits (McCall, 2013; Miyata et al., 2015), the present study expected that participation in the practice session would result in changes in the psychological states such as reduced anxiety and negative affect and increased degrees of relaxation.

Materials and Methods

Participants

A total of 28 healthy university undergraduate students participated. All participants reported that they do not practice yoga or meditation in daily life. Among these participants, 10 (6 females and 4 males, age: 20-22 [mean age = 20.7] years) were assigned to the practice group, while the other 18 (12 females and 6 males, age: 20-22 [mean age = 20.7] years) to an age- and gender- matched control group. All participants were Japanese except for an overseas student from South Korea (female; 21 years) in the practice group. Data for this individual were included in the analysis, because trends of her data were consistent with those for the other participants. Prior to the experimental session, all participants provided written informed consent upon agreement to cooperate. They were not compensated for participation in the study.

In addition, a Japanese professional yoga instructor (female; 50 years) with 25 years of yoga practice/teaching was present during the experiment for the practice group to guide the session. The instructor was an expert practitioner of different styles of classical yoga and

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meditation including hatha yoga, raja yoga, mantra yoga, as well as overtone chanting. Since 2016 she had registered as an Experienced Registered Yoga Teacher 200 (E-RYT 200) offered by the Yoga Alliance, a nonprofit association in the United States, which is deemed as one of the most honored qualifications for yoga teachers. The instructor had never met or instructed the participants prior to the present study.

Measures

The following battery of questionnaires were administered on separate sheets of paper. Before starting the session, all participants were informed that they should always answer all items honestly because the study does not intend to evaluate any individuals.

Positive and Negative Affect Schedule

The Positive and Negative Affect Schedule (PANAS) originally developed by Watson et al. (1988) is a widely used psychological scale that measures subjective emotions in two dimensions: positive affect (PA) and negative affect (NA). The present study used a Japanese version of the PANAS developed and validated by Sato and Yasuda (2001) as a state questionnaire. This version of the PANAS includes 16 items (emotion terms), each of which is rated on a 6-point scale ranging from 1 (*not true at all*) to 6 (*extremely true*). For this version, both PA and NA scores evidenced good reliability ($\alpha = 0.82-0.91$). Total scores for the PA and NA were calculated separately, which is typical of this scale. Based on the preceding studies suggesting that yoga and meditation results in desirable psychological status (e.g., Miyata et al., 2015), the present study expected to observe reduced NA and enhanced PA associated with the contemplative practice.

State-Trait Anxiety Inventory State

The State-Trait Anxiety Inventory (STAI; Spielberger et al., 1970) is a well-known and frequently used scale of state anxiety (A-State) and trait anxiety (A-Trait). The present study used a Japanese version of the STAI-S (A-State) developed and validated by Shimizu and Imae (1981), which showed good reliability ($\alpha = 0.87$). The STAI-S is a 20-item measure to examine perceived present state level of anxiety. Participants respond to each item (e.g., “I feel nervous,” “I am tense,” and “I feel steady”) by rating themselves on the following 4-point scale that involves values of 1 (*not at all*), 2 (*somewhat*), 3 (*moderately so*), and 4 (*very much so*). All these items are summed up to yield a total score. Based on the same assumptions as above, the present study predicted that state anxiety would decrease after the contemplative practice session.

Relaxation Rating

In addition to the established scales above, a single-item measure of relaxation was included, assuming that contemplative practices should enhance degrees of relaxation. This questionnaire is based on the one used in Pawlow and Jones (2005), which demonstrated that progressive muscle relaxation can enhance self-reported levels of relaxation. Specifically, participants were required to rate their current level of relaxation on a scale from 1 (*not relaxed at all*) to 10 (*highly relaxed*).

Procedure

The experimental session for the practice group took place in a quiet carpeted room in the university, in which all participants and the instructor gathered in a circle. The session lasted for approximately 75 minutes in total, which was all guided by the instructor. The first 10 minutes consisted of mantra chanting, i.e., repeated and continuous vocalization of traditional mantra phrases such as *Om Shanti*. The next 20 minutes involved prostration, which was comprised of successive asanas with mantra chanting. Specifically, participants vocalized *Om* with palms together, sit down, stand up, etc. in a repeated manner. Then, 15 minutes of basic asanas and pranayamas were followed by a practice of overtone chanting that lasted for about 30 minutes in total. The overtone chanting practice consisted of three parts. In the first part, all participants vocalized vowels in a single sequence starting with the vowel “u”. In the second part, each participant started with a different vowel, i.e., “u,” “o,” “a,” “e,” or “i.” The third part basically replicated the second part with the exception that long tones played by the voice flute (baroque recorder at 415 Hz) was added to the vocal sounds. Both prior to and immediately after the practice session, participants were instructed to complete the identical battery of questionnaire sheets.

The session for the control group was conducted in a university classroom, while participants attended a lecture on psychology for undergraduates which usually lasted for 90 minutes. Instead of a typical lecture, participants during this session were required to silently make free descriptions on a sheet of paper with regard to the content of the lecture course. The session lasted for 75 minutes, and participants were instructed to complete the identical battery of questionnaire sheets both prior to and immediately after this description task.

Results

Items with no answers for each scale accounted for 0.0-5.0 % for the practice group and 5.2-8.3 % for the control group. These missing data were excluded from analysis. Table 1 summarizes total scores for the psychological scales obtained before and after the session for each group. For the PA and NA scores from the PANAS, total scores for the STAI-S, and scores of relaxation, respectively, paired-samples *t*-tests made comparisons between the scores obtained prior to the session and those after the session. Given that the rooms and situations in which the study was conducted differed between the two groups, data from each group were analyzed independently for statistical tests. SPSS software version 24 was used for all statistical analyses.

Positive and Negative Affect Schedule

The PA scores from the PANAS failed to significantly differ between prior to and after the session for the practice group ($t_9 = 0.380, p = 0.713$). Data from the control group failed to reach statistical significance as well ($t_{15} = 1.794, p = 0.093$). Regarding the NA, the scores numerically decreased after the session for the practice group. This difference approached but failed to reach statistical significance ($t_9 = 2.238, p = 0.052$). Data for the control group turned out to be non-significant as well ($t_{15} = 1.905, p = 0.076$). Thus, both the PA and NA scores did not significantly change after the session for either group, even though a trend for reduced negative affect was observed after the contemplative practice session.

State-Trait Anxiety Inventory State

Total scores for the STAI-S significantly decreased after the session for the practice group ($t_9 = 2.496, p = 0.034, 95\% \text{ CI} = 0.655, 13.345, \text{Cohen's } d = -1.000$), although no statistically significant differences were observed for the control group ($t_{14} = 1.199, p = 0.250$). These data show that participating in the contemplative practice session involving vocalization resulted in

Table 1. Mean total scores for the psychological scales, i.e., the PA and NA from the PANAS, the STAI-S, and the relaxation rating, obtained prior to and after the session for each group.

Scale	Practice group		Control group	
	Before session	After session	Before session	After session
PANAS: PA	17.50 (5.54)	16.55 (8.82)	21.33 (7.02)	18.94 (6.06)
PANAS: NA	15.30 (7.59)	11.60 (3.44)	20.61 (6.27)	17.81 (7.72)
STAI-S	41.90 (7.88)	34.90 (5.99)	47.06 (6.75)	44.53 (6.82)
Relaxation	6.50 (2.01)	8.11 (1.20)	5.33 (1.83)	6.27 (1.39)

Standard deviations of the mean are shown in parentheses.

reduced state anxiety, whereas engaging in the description task did not.

Relaxation Rating

Scores for the relaxation rating showed statistically significant increase after the session for the practice group ($t_8 = -2.357$, $p = 0.046$, 95 % CI = -3.297 , -0.036 , Cohen's $d = 0.973$). By contrast, scores for the control group yielded no statistically significant changes after the session ($t_{14} = -1.598$, $p = 0.132$). Thus, the contemplative practice, though not the description task, turned out to significantly enhance degrees of relaxation.

Discussion

The present study investigated whether and how a combination of traditional yoga and meditation practices that involve vocalization cause short-term changes in the psychological states, even when participants do not usually practice any contemplative techniques in daily life. Specific content of the practice included chanting of mantra phrases and “overtone chanting,” in which participants continuously vocalized vowels in a determined sequence (Naruse, 2010). The results showed that participating in this contemplative practice session caused statistically significant decrease in state anxiety and increase in the degree of relaxation, although changes in positive and negative affect failed to reach statistical significance. By contrast, engaging in a control, free description task irrelevant to meditation failed to yield statistically significant changes in the psychological states. These results are overall consistent with the hypotheses mentioned above and are supportive of the notion that short-term contemplative practices with continuous vocalization can cause desirable changes to the psychological states, regardless of prior experience with the contemplative training.

Findings from the study seem to have scientific significance from both frontiers of embodied psychology of vocalization and contemplative psychology/neuroscience. As mentioned above, vocal aspects of speech are suggested to have both psychological and physiological impacts (Sugamura, 2016). For example, different Japanese hiragana characters are associated with different mood and impressions, suggesting effects of the sounds independently of semantic significance (Haruki, 2011; Suzuki, 1998). In the religious and/or contemplative contexts, particular words or phrases such as *Om* have been regarded to have a sacred sound in the Hindu and Buddhist traditions and believed to have a spiritual power of purifying mind and body with sound vibration (Haruki, 2011). In these research contexts, the present data seem to provide consistent and novel evidence suggesting beneficial psychological effects of vocalization during contemplative practices. The present study also seems the first to quantitatively exam-

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ine the effects of overtone chanting (Naruse, 2010). This practice is obviously advantageous in that people having no prior experience of meditation can readily participate in the practice session only if an appropriate instruction is given. Overtone changing should also be a suitable subject of empirical studies of meditation, because its methods of practice such as the sequence of vowels are systematically determined and can thus be experimentally modified. In addition, overtone chanting enables us to purely examine the effects of vocal aspects of speech with no semantic limitations, unlike other mantras and/or sutras that have determined semantic significance (Naruse, 2010). Because accumulation of empirical data regarding various traditional contemplative practices remains relatively poor among Japanese participants (Miyata et al., 2015; Miyata, 2018), the present study seems to have notable significance in that respect as well.

Despite these novel findings, there are a number of major limitations of the present research to consider before proceeding to the further investigations in multiple directions. First, the practice session involved a specific combination of several multiple forms of contemplative practices, as is typical of a yoga lesson lasting for one hour or longer. This seems to make sense in that experimental situations should be as natural as possible in order to uncover the effects of daily yoga and meditation practice. Nevertheless, a mixture of different practices inevitably makes it difficult for us to know the effects of each specific practice on the psychological outcomes. In fact, mantra chanting and overtone chanting are different in that the vocalization has semantic significance in the former but does not in the latter. Also, some parts of the practice session involved asanas and pranayamas with no vocalization, which might have significantly influenced psychological outcomes. It should thus be desirable to introduce other groups or conditions by controlling for the content and length of each specific form of practice, in order to differentiate the effects of each practice.

The second issue concerns the fact that the practice session involved both one's own vocalization and hearing the other participants' voices simultaneously. This situation is natural as well, because practice of both yoga and overtone chanting usually involves multiple participants at a time. In such situations, both vocalization and hearing as well as their interactions may well have significant effects on the psychological and physiological states. By contrast, both mantra meditation and overtone chanting can be practiced alone, or with no vocalization while mentally repeating the mantras or vowels, a technique called *ajapa-japa* in the traditions of tantra meditation (Naruse, 2010; Senthilnathan et al., 2018). Based on these traditional techniques, it would be a potential way forward to examine the effects of vocalizing and hearing

situations separately to differentiate their effects on the psychological/physiological states. For example, one could potentially make systematic comparisons between practicing overtone chanting with vocalization (japa), with internal repetitions (ajapa-japa), and simply hearing others' voices, either in a group or alone.

Third, the experimental situations differed in multiple respects between the practice and control groups. Most notably, the sessions for the two groups were conducted in different rooms, i.e., one in a carpeted room suitable for yoga practice while the other in a university classroom where regular lecture courses were run. This difference might have made it difficult to equalize levels of anxiety, degrees of relaxation, etc. between the groups. In fact, the description task for the control group was conducted as a part of the classes, which may in part explain why changes in the psychological states in desirable directions were difficult to occur after the session. In addition, the description task for the control group was not the same as simply resting in the same room as that for the practice group. The present control condition seems reasonable considering the fact that waiting situations with no contemplative practice is quite unnatural for a typical yoga/meditation practice. Nevertheless, it would be one possible way forward to use a randomized controlled trial and a control group in which participants wait for the same amount of time as do those in the experimental group.

Given that the present study is regarded as the first step to empirically uncover the psychological/physiological basis of contemplative practices involving vocalization, there seem a number of directions in which the enquiries should be developed. First, in addition to the short-term effects, middle- and long-term effects of the continued practice need to be addressed. For example, participation in the practice sessions of overtone chanting multiple times and/or regularly for months or years may well result in enduring changes in the psychological traits or altered patterns of practice-induced short-term changes in the psychological states. This seems plausible considering the evidence suggesting long-term psychological and physiological impacts of contemplative practices (e.g., Lutz et al., 2004; 2008; Miyata et al., 2015). Not only effects of participation in a group but also continued practice by oneself can be examined in this respect. In a related context, it should also be noted that studies using longitudinal designs need go side by side with those using cross-sectional designs like the present one (Lutz et al., 2008; Miyata; 2015; Miyata et al., 2015). That is, cross-sectional studies have apparent merits in studying highly advanced experts and examining short-term changes through practice. However, to more convincingly conclude that the observed differences or alterations are attributed to the specific practice or interventions, it is undoubtedly required to introduce longitudinal studies

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that track the same populations of practitioners for days, months, or even years. Finally, in addition to obtaining evidence at the psychological level, it is important to elucidate the somatic and neurophysiological underpinnings of mantra chanting and/or overtone chanting. For these purposes, measurements of autonomic nervous system activities as well as electroencephalographic (EEG) measurements should be effective, because practice-induced changes in these measures have been reported for other yoga/meditation practices (Field et al., 2010; Madanmohan et al., 2004). Non-invasive neuroimaging techniques such as the NIRS (Minagawa-Kawai et al., 2009; Miyata et al., 2010; 2011; 2016) would also prove to be effective in elucidating the hemodynamic changes during relevant styles of contemplative practices. These challenges from multiple perspectives should be the milestones towards a better scientific understanding of the underlying mechanisms of contemplative practices that involve vocalization.

Acknowledgments. This study was supported by the Individual Research Allowance for academic staff (Academic Year 2017) from Waseda University to Hiromitsu Miyata. The author is especially grateful to Akemi Suzuki for her assistance in designing the study and for participation in the practice session as an instructor. The author also thanks Atsuki Tanaka, Dahye Oh, Yuri Sase, and Nana Suzuki, School of Culture, Media and Society, Waseda University, for their cooperation when drafting a previous version of this article.

Conflict of Interest. The author declares that no potential conflicts of interest exist with respect to the research, authorship, and/or publication of this article.

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