Meditators' and Non-meditators' Sustained Attention During a Signal Detection Task: Do They Differ?

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Abstract

This study investigated whether meditators and non-meditators differed on the Sustained Attention to Response Task (SART). We hypothesized that the meditators would perform better than the non-meditators (fewer commission errors and faster Reaction Time (RT)) and report fewer interfering thoughts. The meditators (n = 15) and non-meditators (n = 19) filled out the Dundee Stress State Questionare (DSSQ) concerning their intrinsic and success-oriented motivation towards doing the SART after which they did the actual test. Afterwards, they filled out the thinking contents subscale from the DSSQ concerning task-related and task irrelevant interferences during the SART. The results showed that meditators and non-meditators did not significantly differ on the commission errors on the SART, but did differ in RT (lower RT in meditators). The task-related part of the thinking contents form showed significant differences between the groups. Non-meditators reported more intrusive task-related thoughts than meditators. The two groups differed significantly on each of the motivation subscales with meditators being more motivated towards the test stimulus itself (intrinsic motivation), and non-meditators being more motivated towards excelling in performance (success motivation). We conclude that the SART may not discriminate between meditators and non-meditators in terms of commission errors, and that the role of sustained attention in meditation may be exaggerated. It is also plausible that sustained attention may be greater during meditation but not independently of it.

Keywords: SART, meditation, attention, sustained attention, DSSQ

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Introduction

Meditation has been practiced for thousands of years, even before it was incorporated into religious practice in Hinduism, Confucianism, Taoism, Sufism, Kabbalah and others (Goleman, 1988). It is only in recent decades that it has received considerable attention from the scientific community (Chiesa, Calati, & Serretti, 2011; Hölzel et al., 2011; Lutz, Slagter, Dunne, & Davidson, 2008). Bærentsen et al. (2010) defined meditation as a way to "still the fluctuations of the mind" (p. 57), and Chan and Polich (2006) defined it as "practices that self-regulate the body and mind, thereby affecting mental events by engaging a specific attentional set" (p. 180). Walsh and Shapiro (2006) gave a more extensive definition: "The term meditation refers to a family of self-regulation practices that focus on training attention and awareness in order to bring mental processes under greater voluntary control and thereby foster general mental well-being and development and/or specific capacities such as calm, clarity, and concentration." (p. 228-229). Claxton (1987) simply described it as attention-control training.

Meditation techniques and their effects

There are numerous ways to meditate, but generally they can be categorized into two types of practices: Focused Attention (FA) and Open Monitoring (OM) (Lutz et al., 2008). FA means focusing attention on a single point, such as a mantra or the breath. Every time the attention wanders to anything else—the thoughts, emotions, or something occurring in the vicinity—attention is deliberately and gently brought back on the meditation (Lutz et al., 2008). The process can be summarized into four stages: 1) mind-wandering taking place; 2) the person notices that his or her mind has wandered; 3) attention shifts back to the breath (or point of focus); and 4) attention is sustained (Hasenkamp, Wilson-Mendenhall, Duncan, Barsalou, & Lawrence, 2011). Generally FA improves voluntary focused attention and perceptual discrimination (lower perceptual threshold) (MacLean et al., 2010). OM emphasizes non-reactive moment to moment monitoring of mental occurrences without focusing on anything in particular (Lutz et al., 2008). It reduces elaborate thinking and interpretation, bringing about a more efficient allocation of mental resources, which allows for being more present in the moment (Slagter, Lutz, Greischar, Nieuwenhuis, & Davidson,

2008). Some practices start out with FA in the early stages of practice, only to proceed with OM for intermediate to advanced stages. Zen meditation—which is central to this study—is an example of this, with novices starting out counting their breath (FA), but moving on to shikantaza (OM) as their meditation deepens. Noteworthy is that those who practice OM all have previous experience in FA. Theoretically this would imply that advanced Zen practitioners have benefited from both practices.

Research on meditation has uncovered both physiological and psychological effects. The physiological studies mainly include the nervous, respiratory, and cardiovascular systems. State effect research has found that a 50 % drop in respiration rate due to meditating results in a 40 % decrease in oxygen consumption (Farrow & Hebert, 1982; Wallace, 1970), preventing hyperventilation (Kety, & Schmidt, 1948). Cardiovascular studies showed that blood pressure is lowered, suggesting decreased activity of the sympathetic nervous system and stress levels (Barnes, Treiber, & Davis, 2001; Benson, Marzetta, Rosner, & Klemchuk, 1974). Trait effect research has found that the stress hormone cortisol is significantly lowered in meditators by an inhibition of the pituary adrenaline gland (Carlson, Speca, Faris, & Patel, 2007; Jevning, Wilson, & Davidson, 1978).

The psychological benefits that come with meditation practice are equally as impressive, improving mood states by decreasing depression, anxiety, and anger while increasing empathy (Easterlin & Cardeña, 1998-1999; Kabat-Zinn et al., 1992; McCollum & Gehart, 2010; Polizzi, 2008; Tang, et al., 2007; Wolf & Abell, 2003). In terms of cognitive processes, meditation has been used as a strategy against rumination. Nolen-Hoeksema (1991), defined rumination as repetitive thinking about the causes, consequences, and symptoms of one's negative affect. Rumination can be very painful and has been associated with developing depression (Ramel, Goldin, Carmona, & McQuaid, 2004). The point of rumination from a subjective perspective is to gain understanding and insight of oneself and the subject of rumination, in hope of solving the issue (this is not to say that rumination is always a willed strategy, but can also be fluctuations of the mind). Studies have shown that rumination is highly ineffective in dealing with problems (that often cannot even be solved) (Davis & Nolen-Hoeksema, 2000). Unfortunately, thought suppression is not a successful way of dealing with unwanted thoughts, but instead has the opposite effect: the more you

try to avoid the unwanted thoughts, the more likely they are to recur (Wenzlaff & Wegner, 2000). Meditation, however, does seem to be a way of dealing with rumination in an effective way. Intrusive thoughts decrease proportionally with meditation experience (Ramel, Goldin, Carmona, & McQuaid, 2004).

The importance of attention

How humans attend to and perceive their experiences shape their thoughts and emotions, and therefore also their personal universe. By selecting what to attend to, it is possible to create a more positive (or less negative) experience of life (Wadlinger & Isaacowitz, 2011). The direct result of having better attention is to maintain focus on a stimulus of choice without being disturbed by intrusive distractions (Tang et al., 2007). The indirect effects are subtler, but just as important. As a result of increased attention, other gains in cognition and emotion have been found (Posner & Rothbart, 1998). Cognitive capabilities change (Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005), as well as emotions, and reactivity to emotions (Sedlmeier et al., 2004). Research has shed light on the relation between attention and these gains. For example, examining people with attentional dysfunction revealed that they have more persistent negative mood states (Compton, 2000). Lutz et al. (2009) described impairment of attention as the hallmark of many mental illnesses. In other words, attention is of outmost importance, not only for the sake of keeping focus, but also for self-regulation. With better self-regulatory abilities, emotional and cognitive control becomes easier (Ramel, Goldin, Carmona, & McQuaid, 2004; Tang et al., 2007), resulting in better well-being (Chambers, Lo, & Allen 2008).

Attention is to some extent a heritable trait (Kuntsi & Stevenson, 2001), but is also influenced by external factors (Aston-Jones et al., 1999). Most importantly, attention is a flexible skill that can be trained in various ways (Tang et al., 2007). One of the ways to train attention is through meditation, thus bringing about gains such as a higher state of well-being and better self-regulation (Chambers et al., 2008; Tang et al., 2007; Wadlinger, & Isaacowitz, 2011).

Further evidence of the effect of attention in meditation can be found in neurophysiological studies. An MRI study by Lazar et al. (2005) found greater thickness in the right Anterior Insula (AI) in 20 regular Westerners (averaging nine

years of meditation practice, six hours a week) compared to controls. The AI is related to attention (Manna et al., 2010) and visceral awareness (bodily awareness sensitivity) (Critchley, Wiens, Rotshtein, Öhman, & Dolan, 2004). This greater thickness should also theoretically result in a better ability to handle negative states (Compton, 2000). Other neurophysiological research supports the importance of the AI in meditation (Hasenkamp, Wilson-Mendenhall, Duncan, & Barsalou, 2011; Kozasa et al., 2012). It was also discovered that cortical thickness was more prominent in certain brain regions in meditators than in non-meditators, and that it correlated with experience (Lazar et al., 2005). This and other studies (e.g., Easterlin & Cardeña, 1998-1999), indicate that the more you meditate the more prominent the effects become.

There are different types of attention, including selective attention, alternating attention, divided attention, and sustained attention (Sohlberg & Mateer, 2001). Selective attention is defined as "the ability to maintain a behavioral or cognitive set in face of distractibility" (Sohlberg & Mateer, 2001). Alternating attention refers to "the capacity for mental flexibility that allows individuals to shift their focus of attention and move between tasks having different cognitive requirements, thus controlling which information will be selectively processed" (Sohlberg & Mateer, 2001). Divided attention means "the ability to respond simultaneously to multiple tasks or multiple task demands" (Sohlberg & Mateer, 2001). Sustained attention is defined as "the ability to maintain a consistent behavioral response during continuous and repetitive activity." (Sohlberg & Mateer, 2001). With this diversity in mind, it is important to a) establish what type of attention meditation influences, and b) use a test that is based on the same type of attention. According to Mclean et al. (2010) meditation results in increased sustained attention (among others). This applies both to FA and OM (Valentine & Sweet, 1999), which is convenient since Zen uses both methods.

Previous studies on sustained attention and meditation have shown mixed results. Some studies have shown that meditators are superior to non-meditators in tasks involving sustained attention (Jha, Krompinger, & Baime, 2007; Valentine & Sweet, 1999), but others have not replicated this effect (e.g., Schmertz, Anderson, & Robins, 2009). Josefsson and Broberg's research (2011) is of particular interest to our study as they also investigated meditators' sustained attention using the Sustained

Attention to Response Task (SART) (see below for a detailed description). They hypothesized that meditators would perform better than non-meditators on the SART, but the two groups did not differ. Chiesa, Calati, and Serretti's review (2010) found only two out of seven studies of sustained attention with significant results (e.g., Chambers, Lo, & Allen 2008). The other attention types also showed mixed results as well, with selective attention showing a significant effect in only one study out of eight, executive attention in two studies out of nine, and attention switching showing no significant difference in the four studies conducted. Chiesa, et al's. review (2010), argued that possible factors that determined a significant effect could be the length of the practice (short term or long term with long term being superior, although short term effects may still be seen), and the test of attention itself. Chiesa et al. (2010) concluded that replications of current studies are needed for increased understanding.

For this study, it was hypothesized that the type of attention cultivated through Zen practice is sustained attention (Mclean et al., 2010). A validated test of sustained attention is the SART (Jackson & Balota, 2011; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) and has successfully been used in previous studies on sustained attention (Cheyne, Carriere, & Smilek, 2006). SART performance correlates with sustained attention but not with other types of attention (e.g., attention switching, selective attention and executive attention) (Robertson et al., 1997). The original SART is a computer-based task in which digits (one to nine) are shown sequentially. Each time a digit is presented, the participants are required to press a certain key as fast as possible except when the number three is shown, in which case they must inhibit their inclination to press the button. If they fail to do this, this commission error is defined as sustained attention failure (Robertson et al., 1997), which has previously been used as a measure for mind-wandering (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009; Marcusson-Clavertz, Terhune, & Cardeña, 2012).

How well individuals perform the SART is a good predictor, not only for attention in lab settings, but also for how attention functions in daily life. Patients with brain damage, who reported attentional slips in their daily routine, performed worse on the SART and their self-reported errors correlated strongly with their SART commission errors (Robertson et al., 1997). Insofar as performance on the test can be

generalized to daily life outside the laboratory, this could mean that if meditators have superior performance on the SART (compared to non-meditators), meditators should have less attentional slips in their daily lives.

Motivation

Many meditators have put thousands of hours into their practice. So when they are participating in experimental research, it is possible that they are more motivated to perform well on the cognitive test than non-meditators are. Since motivation is a variable that can influence performance in a positive way (Fortier et al., 1995), evaluating it is important. Otherwise, meditators may perform better simply because they are more motivated to do so. Therefore, a motivation form from the Dundee Stress State Questionare (DSSQ) (Matthews et al., 2002) was administered prior to the SART. The DSSQ has previously been used in a wide range of studies as an additional measure to the main hypothesis (e.g., Stanton & Young, 2007).

Thinking contents

The SART has been known for its relation to mind-wandering (Hu, He, & Xu, 2012). SART commission errors, for example, have been predicted by self-reported mind-wandering (i.e. the more the subjects drift away in their thoughts, the more commission errors they make) (Manly et al., 1999; McVay, & Kane, 2009). During the period mind-wandering takes place, the Default Mode Network (DMN) is increasingly activated (Christoff et al., 2009). The DMN is a proposed cortical network and has been described as referring to a "stream of thoughts occurring automatically in the absence of goal-directed activity" (Pagnoni, Cekic, & Guo, 2008), when the mind is not engaged in anything in particular and ruminative thoughts are automatically generated. Those who are prone to mind-wandering also have greater DMN activity (Mason, et al., 2007). In order to evaluate whether the meditation group does have significantly fewer interfering or irrelevant thoughts than the control group, a thinking contents questionnaire, a subscale of the DSSQ, (Matthews, et al., 2002), will be included at the end of the SART.

Rationale of this study

All aforementioned descriptions of meditation (Bærentsen et al. 2010; Cahn & Polich, 2006; Claxton, 1987; Walsh & Shapiro, 2006) share a common theme: that attention is the core mechanism in meditation that controls such fluctuations as emotional turmoil and mental rumination. To underline the importance of this mechanism, Cahn and Polich (2006, p. 200) wrote: "The primary psychological domain mediating and affected by meditative practice is attention." Therefore, attention will be the focus of this study, using the SART as a measuring tool. Since meditation is associated with reduced DMN activity (Pagnoni et al., 2008) and therefore plausibly also mind-wandering, the meditation group in this study should be more attentive towards the SART and therefore also have fewer commission errors than the non-meditators.

To distinguish this study from similar studies of attention and meditation (Josefsson & Broberg, 2011; Kozasa et al., 2012) a different approach using subjective measures of motivation and thought contents were added to the behavioral measures of sustained attention. Motivation can factor in on the participants' performance, making those participants who are most motivated perform the best (Fortier, Vallerand, & Guay, 1995). Should there be a significant difference between the meditator's and the non-meditators' motivation, it could be used as a covariate in the statistical analysis. Interfering thoughts may also play a central role in how participants perform on the SART. Participants with less cognitive interferences are possibly more attentive. If meditators have fewer commission errors than non-meditators, the thinking contents form might provide a possible explanation, should the meditators also have fewer self-reported thoughts. Further, Josefsson and Broberg (2011) did not match for age in the meditation and non-meditation group. This limitation was rectified in the present study.

The researcher's personal interest in meditation comes from the need to know and understand how the mind works in different states and how attention contributes to the construction of humans' personal universe. Further, Controlling attention may be a way to control the mind and thereby gain better mental health. The east's view of psychology is vastly different from that of the west and may therefore give a broader and fuller picture of the workings of the mind.

This study aimed to a) evaluate the relationship between meditation and

sustained attention; b) explore and explain attention and its relation to meditation by adding additional measures from the DSSQ: the thinking contents and motivation form.

Hypotheses

This study tested the following hypotheses:

1. Meditators will make fewer commission errors than non-meditators.
2. Meditators will have faster RT than non-meditators.
3. Meditators will have significantly fewer thoughts than the non-meditators.

Method

Participants

Participants *(N* = 34) consisted of a meditation group and a control group. The meditation group (6 male, 9 female, M_{age} = 39, *SD* = 14) was recruited from a few selected Zen retreats: Lund Zen Center; Malmö Chan-Buddhistiska Tempel, and mostly from Zen Gården, a Buddhist temple retreat in Arboga. Non-meditators were recruited from the public workforce of the city hall of Trelleborg and were selected with the age of the meditation group in mind (7 men, 12 women, M_{age} = 41.89, *SD* = 15.60). The non-meditation group had zero hours of meditation practice. The meditators had varying amounts of experience (see appendix 1) (min = 122 hours, max = 28,392 hours, $M_{experience}$ = 7,932 hours, *SD* = 8,505).

Although mind-wandering and attention have been suggested to be the same for both young and old people (Jackson, 2011), previous studies have also shown a relation between age and performance on attention tests (Jha et al., 2007). Therefore, matching the two groups in terms of age was prioritized. Groups did not differ in age ($M_{age\text{-}meditators}$ = 41.89, *SD* = 15.60; $M_{age\text{-}non\text{-}meditators}$ = 38.93, *SD* = 14.76, *p* = 0.578).

Groups did not differ significantly in gender (*Chi-square*(1) = 0.04, *p* = 0.851).

It was not possible to test both groups at the same location, due to logistic difficulties, but steps were taken to make sure the testing locations were as similar as possible by minimizing distractions and disturbances. To reduce possible sequencing effects, the testing for both groups was interspersed, although this was not possible at

Zen Gården because it was isolated from the control group and all meditators had to be tested at the same time. The meditators in Zen Gården were tested at their own temple retreat in a small, secluded room. The temple was a silent and calm place, with little noises or distractions of any kind. The meditators from Malmö Chan-Buddhistiska Tempel and Lund's Zen Center were tested at their own locale when there was no one else present. The non-meditation group members were tested at their workplace. In order to ensure that the testing locale was comparable to the meditators', an empty, quiet room was used.

The researcher of this study is a 26 year old male with approximately four years of practical experience of Zen meditation. He had no previous affiliation with the meditators, but did know some of the non-meditators.

Materials

The Sustained Attention Response Test (SART). The main instrument for this study was the SART, a computer-based test paradigm. This modified version of the original SART (Robertson et al., 1997) displays a quasi random number from one to nine (size approximately 2.5", font Gothic, on a 15 inch Personal Computer (PC) laptop) in the middle of the screen. The digits are presented in 15 blocks with 20 digits in each block. The digits are shown in rapid succession, with each number being displayed for 500 ms, followed by 1500 ms of inter stimulus interval before the next digit is shown. Every time a digit is shown, participants are required to press a key on the keyboard as fast as possible. However, when the number three is shown, they have to inhibit their response and prevent themselves from pressing the key. The SART was developed for this study using E-Prime. It was not substantially different from previous tests (Josefsson & Broberg, 2011) using similar parameters.

Dundee Stress State Questionnaire (DSSQ): Motivation and Thinking Contents. The DSSQ motivation scale consists of two subscales: success motivation and intrinsic motivation (Matthews et al., 2002). Success motivation measures the participants' motivation to excel in their performance, and intrinsic motivation refers to their interest in the task (the SART). There is also a single item (number 15) that measure overall motivation. Both subscales were of interest for this study. The

motivation form evaluates how eager the participants were to do the test. The motivation form consisted of fifteen items. Item number two was excluded since the test did not give any rewards such as cinema tickets. The motivation test was divided into two subscales: Intrinsic motivation and success motivation. Intrinsic motivation refers to motivation related to the contents of the task and includes item number one, two (which was excluded), three, six, ten, eleven and twelve of the DSSQ: Motivation questionnaire (see appendix 3). Success motivation refers to motivation to excel in performance and included item number four, five, seven, eight, nine, 13, and 14 (out of 15 items). Item number 15 provided an overall motivation score. Item number two (which was removed), three, six, eleven and twelve was reverse scored. The items for each subscale were then averaged.

The thinking contents form measures the self-rated attention and mind-wandering of the participants (see appendix 2). It basically refers to either the participants' reappraisal of the task itself (Matthews et al., 2002), in this case the SART (I thought about how I should work more carefully, I thought about how much time I had left, etc.), or to thoughts outside of the SART (e.g., I thought about something that made me feel angry. I thought about something that happened earlier today). The thinking contents form consists of 16 items divided into two subscales: task-related interference (thoughts that in this case would be related to the re-appraisal of the SART but not to current SART stimulus) and task irrelevant interference (concerns outside of the SART) (Helton, Kern, & Walker, 2009). Self-reported task irrelevant interferences have a strong coupling to SART performance, meaning that the more the mind is occupied with thoughts outside of SART, the harder it becomes to inhibit responses (Helton et al, 2009; Smallwood et al., 2004). Both subscales will be used for this study, but taking previous studies into account (Smallwood et al., 2004), task irrelevant interferences should be a stronger predictor of SART commission errors. The task-related subscale consists of item number 1-8, and task irrelevant interference consists of item 9-16. The items of each subscale were summed separately for the statistical analyses. All participants filled out a general demographics information form.

Procedure

Both meditators and non-meditators followed the same procedure. They were briefed about all parts of the procedure (see appendix 4 for the standardized briefing): the motivation form, the SART, and the thinking contents form. They were not, however, briefed on any details regarding the purpose of the test until afterwards.

Participants received instructions for the SART and then filled out the motivation form. The motivation form was followed by the SART after the researcher had left the room. Then the participants filled out the thinking contents form to check for any thoughts or mind-wandering they had experienced during the SART. Finally, they filled out the general information form. This last procedure took some extra time for the meditators who had to account for how many hours of meditation they had. This was done with the help of the researcher who also calculated and summarized their total amount of meditation hours. The whole procedure took approximately 30 minutes to complete.

Statistical analysis

One-way ANOVAs and t-tests were used to determine whether the mean difference between the meditators and non-meditators were significant. Pearson's correlations were used for relationship between variables that met the normality assumptions whereas spearman's rho was used for the remaining analyses.

The alpha value in this study was set to the standard value of 0.05, double-tailed. All data had a normal distribution save for meditation hours (including both groups in the calculation) (min = 122 hours, max = 28392 hours, $M_{\text{experience}}$ = 7932 hours, SD = 8505).

Three outliers were found in the variable task irrelevant thinking contents, but removing them did not alter significance in either the ANOVA or any of the correlations. Therefore, they were kept for the final analysis. Two outliers were found in the variable meditation hours. The removal of these outliers did not alter the significance of any of the correlations. Therefore, these outliers were kept as well for the final analysis.

Results

Primary results: SART and thinking contents

Contrary to the hypothesis, the one way ANOVA did not show a significant difference between the meditators and non-meditators on the SART commission errors, $M_{\text{meditators}} = 6.87$, $SD = 3.09$; $M_{\text{control}} = 6.26$, $SD = 4.20$), $F(1,32) = 0.22$, $p = 0.64$ ($p > 0.05$), $\eta_p^2 = 0.01$.

The RT between the meditators and the non-meditators was significantly different, $M_{(RT\geq200)\text{control}} = 342.38$ ms, $SD = 31.93$; $M_{(RT>=200)\text{meditators}} = 315.02$, $SD = 23.08$, $F(1,32) = 3.46$, $p = 0.009$, $\eta_p^2 = 0.20$. The meditators were faster in their response to the digits. RT also had a strong negative correlation with commission errors, $r(32) = -0.58$, $p = 0.001$, meaning that commission errors increased with faster reaction times.

Commission errors did not differ significantly even after RT was controlled for in an ANCOVA, $F(1,32) = 1.59$, $p = 0.217$, $\eta_p^2 = 0.01$.

The one way ANOVA showed a significant difference on the task-related subscale of the thinking contents form between the meditators and the non-meditators. The meditators reported significantly fewer task-related interfering thoughts ($M_{\text{control}} = 2.67$, $SD = 0.78$, $M_{\text{meditators}} = 2.15$, $SD = 0.49$), $F(1,32) = 5.21$, $p = 0.029$, $\eta_p^2 = 0.14$.

Task-Related interferences were moderately correlated with commission errors, $r(32) = 0.34$, and was marginally significant ($p = 0.051$), meaning that those participants who reported more thoughts about the reappraisal of the SART during the task also tended to make more commission errors.

The meditators and non-meditators did not differ significantly on the task irrelevant thinking contents form ($M_{\text{control}} = 1.43$, $SD = 0.56$, $M_{\text{meditators}} = 1.26$, $SD = 0.34$, $F(1,32) = 1.13$, $p = 0.296$, $\eta_p^2 = 0.03$).

Secondary results: Motivation and miscellaneous correlations

There was a significant difference on the success motivation subscale between meditators and non-meditators, $M_{\text{control}} = 2.43$, $SD = 0.74$, $M_{\text{meditators}} = 1.82$, $SD = 0.82$, $F(1,32) = 5.36$, $p = 0.027$, $\eta_p^2 = 0.14$, with non-meditators having a higher motivation score than the meditators.

Task-Related interferences had a moderate positive correlation with success

motivation which was significant, $r(32) = 0.49$, $p = 0.003$, indicating that those participants who were highly motivated to perform well also reported more thoughts concerning the task itself. However, they did not have more thoughts outside of the task (i.e., task irrelevant interferences, $r(32) = -0{,}04$, $p = 0.80$).

There was a significant difference on the intrinsic motivation subscale between the meditators and the non-meditators, $M_{control} = 2.65$, $SD = 0.45$, $M_{meditators} = 3.21$, $SD = 0.53$, $F(1,32) = 12.57$, $p = 0.001$, $\eta_p^2 = 0.28$. On this subscale it was the meditators who had the higher motivation score.

There were no other significant correlations with DSSQ. Neither intrinsic motivation nor success motivation correlated with commission errors, $r(32) = 0.11$, $p = 0.545$; $r(32) = 0.19$, $p = 0.294$.

Since previous research has found that meditation experience increase some of meditation's positive effects (e.g., Easterlin, & Cardeña, 1998-1999), it was assumed that a negative correlation between meditation hours and commission errors should be found (the more experience, the fewer commission errors). This, however, was not the case, $r_{(32)rho} = -0.16$, $p = 0.581$.

The RT correlated strongly and positively with age, $r(32) = 0.63$, $p < 0.001$. The older the participants were, the slower they responded. Neither age nor gender correlated significantly with commission errors, $r(32) = -0{,}06$, $p = 0.753$, and $r(32) = -0{,}22$, $p = 0.217$, respectively.

Discussion

The aim of this study was to find out whether meditators were better able to sustain attention than non-meditators. The main hypotheses were 1) that meditators should perform better on the SART than non-meditators, with fewer commission errors; 2) that meditators should have faster RT than non-meditators; and 3) that the better performance could be explained by the meditators being less occupied with interfering thoughts, as measured by the self-rate thinking contents form.

The meditators did not have significantly fewer commission errors than the non-meditators (the meditators had slightly higher mean score than the non-meditators), but the meditators' reaction time was faster than the non-meditators' with RT correlating negatively with commission errors. These results can be interpreted as

meditators being more attentive than the non-meditators, enabling them to respond more quickly, but in the process making more commission errors. But when differences in RT was controlled for, the groups still did not differ in terms of commission errors. Even though the meditators responded faster, this did not alter their amount of commission errors significantly.

The task irrelevant subscale of the thinking contents form was not significant, meaning that the two groups reported similar amounts of thoughts unrelated to the SART, however the mean scores were so low that perhaps there was a floor effect.

The task-related subscale did show a significant difference between the groups, the meditators having fewer thoughts concerning the SART. Since the task-related form had significant results, whereas the task irrelevant form had low mean scores, it is possible that the SART did not produce mind-wandering effect as expected (task irrelevant interference = mind-wandering). Perhaps most surprising is that task irrelevant interferences did not correlate with commission errors or RT but task-related interference did. Since SART has been described as a measure for mind-wandering, it is surprising that task-irrelevant interferences did not affect outcome like it was predicted. As previously stated, the self-reported number of mean task-irrelevant thoughts was rather low. Had the mean scores been higher, that is, had SART produced more mind-wandering, perhaps they would have had an influence on commission errors and RT. Alternatively SART did produce mind-wandering, but the task irrelevant subscale may not have been sensitive enough to register this. Also possible is that participants were not aware of their own mind-wandering and therefore believed they had nothing to report.

The low mean scores in the task irrelevant subscale as well as the lack of a correlation with commission errors and RT begs the question of whether SART does in fact induce mind-wandering to the extent it was meant to. According to some participants' own testimonies during this study, they explained that they were so focused on the SART that they had little room for any thoughts. This, at least explains the higher mean scores of task-related interference.

There is an ongoing debate over whether the SART actually measures sustained attention, or simply participants' speed versus accuracy response strategy (impulsive responding) (Helton, 2009; Helton, Kern, & Walker, 2009). Helton (2009)

argued that the monotonous key pressing leads to a feed-forward motor routine where the participants automatically press the key, even though they may be perceptually aware of the stimuli (they are consciously aware of the number three, but nevertheless press the key as a purely automatic motor reaction, unable to interrupt this system). This, Helton (2009) continues, is not in line with what traditionally is regarded as sustained attention. Cheyne, Carriere, and Smilek (2006), reported that their participants had no problem perceiving and identifying the target number (three), but still failed to inhibit their response. They explained that they pressed the key even though they knew they should not do so. Actually perceiving the target, yet pressing the key is not characteristic of sustained attention, which involves attentional slips and mindlessness when the target number occurs, explained Helton et al., (2009). In traditional tests of sustained attention, participants do not report direct awareness of their mistakes (Helton, Kern & Walker, 2009; Williges, 1973). Helton (2009), however, admitted that the SART may measure both motor response as well as sustained attention, although not purely sustained attention. However the case may be, it is clear that the validity of SART as a tool for measuring sustained attention and producing mind-wandering is questionable. Despite this critique, it is important to remember studies that did show a relation between the SART and mind-wandering. (e.g. Christoff et al., 2009; Smallwood, 2010). Thus, the choice of using the SART for this study was not necessarily a mistake.

Motivation

Meditators and non-meditators differed on both the success and intrinsic subscales of the motivation form. Meditators reported higher intrinsic motivation than non-meditators, whereas non-meditators reported higher success motivation. That is, non-meditators were more performance-oriented whereas meditators were more interested in the contents of the task itself. A possible explanation for this result is that meditation emphasizes calm and tranquility. For this reason it can be assumed that the meditators' competitive drive (success motivation) is lower than that of the non-meditators. Meditation does aim to rid their practitioners of all worldly desires and not have them strive for wordily success to the point of suffering. The intrinsic motivation is in line with this postulate. The intrinsic motivation form did show that

the meditators had a greater interest in the task, which can reasonably be explained by their interest in the mind and meditation.

Intrinsic motivation and success motivation did not correlate significantly with commission errors or RT. This indicate that the participants motivation to perform well, as well as their motivation towards the task itself were irrelevant to the outcome of the SART with regard to commission errors and RT. Thus, even though the meditators and the non-meditators significantly differed on both of the motivation subscales (but in the opposite direction of what was presumed for success motivation), it made no difference in the outcome of the SART. This was beneficial to the study since the purpose of including the motivation form was to make sure motivation was not a confounding variable.

Task-Related interferences, correlated moderately with success motivation. This means that those who were motivated to perform well re-appraised more often their own performance and the task itself as they performed it. This makes sense since it was the non-meditators who were most motivated to perform well, and also had more thoughts concerning the test. It is possible to argue that higher success motivation produces more thoughts concerning the test itself rather than thoughts irrelevant to the test, whereas those participants who did not particularly care about performance did not have as many thoughts about the test. However, correlation does not equal causation. That is, the non-meditators' amount of self-reported interference may not be due to their motivation to succeed, but rather a reflection that the meditators' meditation practice has had an effect, resulting in having less thoughts than the non-meditators. Alternatively, the non-meditators may have had different types of thoughts that were not measured by the questionnaire.

Intrinsic motivation did not correlate with either subscale of the thinking contents form. Thus motivation to do the SART did not influence either task irrelevant or task-related interferences.

Miscellaneous discussions

Worth mentioning is the trait/state debate and whether sustained attention is affected by meditation short -or long-term. Meditation has been shown to produce both state and trait effects such as reduced depression and anxiety (Cahn & Polich, 2006). The

present study investigated meditation's long-term effect rather than the effect of ongoing meditation during the test. A possibility is that sustained attention is only affected by a meditative state, thus explaining why no significant difference was found between the two group's commission errors.

A few other features worth of discussion are the correlations of age, gender and meditation hours with commission errors and RT. If meditation is indeed a practice of cumulative experience and effect gain as previous studies have found (Cahn & Polich, 2006; Easterlin & Cardeña, 1998-1999), there should be a negative correlation of commission errors and experience. This study had a wide range of meditation experience, varying from novice experience of roughly 120 hours, to an impressive 28000 hours for the most advanced. Still, there was no correlation. The reason for not finding a strong enough correlation is either a) the SART is not a valid test to measure sustained attention for meditators. In this case, meditation still has an accumulated effect gain that is simply not visible through the tools used in this study, and may be detected in other studies; or b) meditation does not have cumulative effect gain. This is unlikely the case, however, since previous studies have indicated the opposite. It could be argued that this study lacked power for such an effect to be seen. This alternative is viable, but with fifteen participants, a correlation higher than r = -0.06 was expected. Also, Josefsson and Broberg (2011), had significantly higher power in their study with as many as 92 participants, but still failed to find a correlation with meditation experience and the SART. They argue that the importance of sustained attention in meditation might not be as crucial as formerly assumed, or, alternatively that other measures, such as the Wilkins' Counting Test, might be more appropriate. This instrument consists of a random number (from two to eleven) of auditory bleeps in intervals. Participants must be attentive and count and report the number of bleeps they hear. The test has successfully been used in the sense that meditators were superior to non-meditators in their sustained attention (Valentine & Sweet, 2009).

Josefsson and Broberg's study of meditators, non-meditators and SART (2011), did not match for age in their sample, using university students as non-meditators to compare to experienced meditators with a higher mean age. The mean age difference between the groups was large with the mean age of the meditators

being nearly twice that of the non-meditators. Josefsson and Broberg (2011) expressed concern over not using matched samples and therefore used age as a covariate in an ANCOVA in case it would intervene with the results. They found that age was correlated to RT, but not to commission errors. The present study found the same results. The older the participants were, the higher their reaction time was, but their age did not matter to their push/withhold response. Since age did correlate with RT, it would have to be used as a covariate in an ANCOVA had the age groups not been matched.

That gender did not have an effect on commission errors or RT was expected. Previous studies have shown that gender does not have a big impact on the SART (Chan, 2001).

Overall, the results support previous findings. Most notably, Josefsson and Broberg's (2011) similar study that did not find significant differences on SART accuracy but on RT. The lack of a significant difference of sustained attention was also found in other studies, using different measuring tools than the SART (e.g., Pagnoni & Cekic, 2007).

Limitations

A limitation in the present study was the low power (small *N*). It was harder to recruit meditators than controls, as the meditators seemed less willing to participate. This was unexpected as it was assumed that meditators would have a greater interest in this sort of task, especially since their intrinsic motivation was significantly higher compared to non-meditators. This could be due to a sampling error, in which the gathered meditators all had rather high motivation to participate, leaving out less motivated meditators who would provide more variation. In other words, the sampling group of the meditators might not have been representative for the population. On the contrary, while higher power can give more reliable results, it also makes it harder to understand the details of the research and the individual's subjective experience of the process. In other words, with higher power, the individuals disappear in the statistical mass.

Another possible limitation to this study is group differences. The meditation and non-meditation group might have differed on several variables that were not

investigated and may have been confounding. In retrospect, these variables could have been important to examine. Education was a variable that was not considered in this study. A majority of the non-meditators were recruited at a workplace that demands a university degree of some sort. As for the meditators, education was not evaluated and may have varied. However, previous studies have found that education has a minimal effect on the SART (Chan, 2001). Further, the fact that the non-meditators did the SART (and the forms) during work hours might also have been a determining factor. During this time, they were possibly more stressed and may have felt interrupted in their work. Finally, some of the non-meditators did have a shallow relationship to the researcher (they knew who he was) and may therefore have behaved differently. For future studies, having similar education level among both meditators and non-meditators may control this possibly confounding variable.

There is also the issue of demand characteristics: the participants' habit to change their own behavior to suit the hypotheses of the study. If for instance the meditators guessed the hypothesis, it is likely that they put an extra effort on the SART. What speaks against this is that the meditators were less motivated to excel at the SART than the non-meditators as seen in the success motivation form. Of course, there may also have been a demand characteristic involved when the participants were filling out the forms. It is less likely that the non-meditators had demand characteristics because they had no knowledge of the meditation group until after the test.

Finally, ecological validity is worth mentioning since this study takes meditators from their natural setting, when they are meditating, into a lab with possible cofounding variables. That is, even though the lab settings were optimal in terms of being calm and quiet, they did not replicate the actuall experience of meditation by any means. However, this is not a big issue since this study was concerned with the trait effects of meditation, and not the state effects.

Conclusion

In conclusion, meditators did not make fewer commission errors than the non-meditators but the meditators did have faster reaction time. They also had less task-related interferences than the non-meditators. SART is either not a valid test for

measuring sustained attention, or the role of sustained attention as a mechanism in meditation has been exaggerated. Also possible is that sustained attention is more influenced by being in a meditative state than of having previous experience with meditation. A limitation in this study, which might have influenced the results is the lack of information on education levels. Although several studies affirm that meditation improve attention in general, it is still inconclusive whether it promotes sustained attention specifically. Future studies on meditation and sustained attention may benefit from using other measuring tools. And as for the SART, it is still questionable whether it measures sustained attention or is a feed-forward motor routine.

This study is of importance for establishing reliability for previous studies in meditation using the SART, as well as establishing validity for the SART itself. Unique to this study is that the motivation and thinking contents forms of the DSSQ were used as additional measures to the SART. They gave an insight to the workings of the minds of both meditators and non-meditators.

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Appendix 1

General Information

Namn:_____

Kön:_____

Ålder:_____

Telefonnummer (valfritt):_____

Mail:_____

Hur många år har du totalt mediterat?_____

Hur många gånger i veckan mediterar du vanligtvis?_____

Hur länge mediterar du i snitt per gång?_____

Har du någon gång haft ett längre uppehåll från din regelbundna meditationsutövning? Om ja, hur länge?

_____

Uppskatta hur många timmars meditationsträning du har totalt (exempelvis, 30 min, 5 gånger i veckan, i 2 år blir 260 timmar).

_____

Vilken typ av meditation utövar du inom Zen? Ringa in ditt svar.

(Räkna andetag) (Följa andningen) (Schikan-taza) (Mindfulness)

(Annan)

Försöksperson #:_____

Appendix 2

Thinking Contents

This set of questions concerns the kinds of thoughts that go through people's heads at particular times, for example while they are doing some task or activity. Below is a list of thoughts, some of which you might have had recently. Please indicate roughly how often you had each thought **DURING THE LAST TEN MINUTES** or so, by circling a number from the list below.

1= Never 2= Once 3= A few times 4= Often 5= Very often

1. I thought about how I should work more carefully.
   1 2 3 4 5
2. I thought about how much time I had left.
   1 2 3 4 5
3. I thought about how others have done on this task.
   1 2 3 4 5
4. I thought about the difficulty of the problems.
   1 2 3 4 5
5. I thought about my level of ability.
   1 2 3 4 5
6. I thought about the purpose of the experiment.
   1 2 3 4 5
7. I thought about how I would feel if I were told how I performed.
   1 2 3 4 5
8. I thought about how often I get confused.
   1 2 3 4 5
9. I thought about members of my family.
   1 2 3 4 5
10. I thought about something that made me feel guilty.
    1 2 3 4 5
11. I thought about personal worries.

1 2 3 4 5

12. I thought about something that made me feel angry.

1 2 3 4 5

13. I thought about something that happened earlier today.

1 2 3 4 5

14. I thought about something that happened in the recent past (last few days, but not today).

1 2 3 4 5

15. I thought about something that happened in the distant past

1 2 3 4 5

16. I thought about something that might happen in the future.

1 2 3 4 5

Appendix 3

Motivation

Please answer some questions about your attitude to the task you are about to do. Rate your agreement with the following statements by circling one of the following answers:

Extremely = 4 Very much = 3 Somewhat = 2 A little bit = 1 Not at all = 0

1. I expect the content of the task will be interesting

0 1 2 3 4

2. The only reason to do the task is to get an external reward

0 1 2 3 4

3. I would rather spend the time doing the task on something else

0 1 2 3 4

4. I am concerned about not doing as well as I can

0 1 2 3 4

5. I want to perform better than most people do

0 1 2 3 4

6. I will become fed up with the task

0 1 2 3 4

7. I am eager to do well

0 1 2 3 4

8. I would be disappointed if I failed to do well on the task

0 1 2 3 4

9. I am committed to attaining my performance goals

0 1 2 3 4

10. Doing the task is worthwhile

0 1 2 3 4

11. I expect to find the task boring

0 1 2 3 4

12. I feel apathetic about my performance

0 1 2 3 4

13. I want to succeed on the task

0 1 2 3 4

14. The task will bring out my competitive drive

0 1 2 3 4

16 . I am motivated to do the task

0 1 2 3 4

Appendix 4

Instructions—Presented orally to the participants:

You will perform an attention test on this laptop. The test will take about 15 minutes to complete. Figures from 0-9 will be presented on the display for a brief period of time. Every time a digit is presented you must press the computer key (computer key is shown) as fast as possible. Do this every time a digit is presented except when the number 3 is shown. When number 3 is shown you must prevent yourself from pressing the key. But before the test begins, you should fill out a short form (the motivation form is presented to the participant who fills out the form). Okay, now you are ready to start the test. I will leave the room once the test has started. Any questions? (Experimenter leaves the room when the SART begins and comes back after 15 minutes). Now you have to fill out another short form (thinking contents is presented to the participant who fills out the form). (Participant is briefed in more detail on what the test was about).