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Change in Visuo-spatial and Verbal Working Memory Capacity at Different Stages of Surat-Shabd-Yoga Meditation

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A B S T R A C T

The positive influence of mediation on working memory is reported in empirical researches. The differentiation is not underlined for meditators ranging from novice to advanced and for specific type of meditation. The present study examines the effect of Surat-Shabd-Yoga meditation (which is practiced sequentially in three stages) on visuo-spatial and verbal working memory for novice, intermediate an advanced meditators. The participants were studied for (i) spatial span task which required subjects to temporarily hold and manipulate spatial and movement information displayed on screen and (ii) digit span task which required visual inputs to be recoded so that they can enter the short term verbal store. The automated tasks were administered on participants before and after meditation. The results indicate that all three strata and controls performed same at the baseline level. After the practice of meditation for a period of 20 weeks, the experimental group demonstrated an increase in performance on visuo-spatial and verbal working memory with variation in gain in the three groups. The increase in verbal working memory was significant at all three stages of meditation. The gain in visuo-spatial working memory was significant at third stage of meditation No significant difference in performance of controls was found. The results are discussed in the light of association of different components of working memory with different stages of meditation

INTRODUCTION:

The empirical studies have shown the benefits of yoga and meditation practice on working memory. Participants of Hatha yoga, Kriya yoga, Pranayama breathing, Zazen meditation as well as prayer, all have shown positive influence on working memory, as measured by reduction in spontaneous thoughts (Fabbro, Muzur, Bellen, Calacione, & Bava, 1999). Kozhevnikov, Louchakova, Josipovic, & Motes (2009) found that Deity Yoga (DY) specifically trains one's capacity to access heightened visuo-spatial memory resources via meditation, rather than generally improving long-lasting imagery abilities. Subjects who participated in

Kundalini Yoga have evinced significant improvements in memory (Newberg & Waldman, 2010). Research on mindfulness based practices has also revealed significant enhancement in working memory (Chambers, Chuen & Allen, 2007; Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010). The central mechanism involved in meditation is attention (e.g., Lutz, Slagter, Dunne & Davidson, 2008). Both meditation and attention involve selection of discrete stimuli and inhibition of irrelevant stimuli. The selective attention facilitates control over the content of working memory (Awh & Jonides, 2001; Corbetta, Kincade, & Shulman, 2002). The meditator combines the engagement of selective visual attention with active maintenance of an image in practices like Deity Yoga meditation. In the meditation session of Deity Yoga (DY), the practice begins with visualization and the meditators report to hold the image of Deity for time range varying from minutes to hours. This practice of active image maintenance may enhance the capacity to efficiently keep visuo-spatial information in mind (Jha, 2002). Kozhenikov, et.al. (2009) hypothesized that the selective focused attention directed to specific visual stimuli might activate prefrontal-temporal and prefrontal-parietal connections, facilitating an enhancement of visuo-spatial working memory. But it was uncertain how long this state of access to heightened visuo-spatial resources might last as the post-test in this study was conducted immediately after 20 minutes of meditation. Some respondents reported that the effect lasts for several hours or more whereas others reported it lasts for 20-25 minutes Also, most of these studies are conducted on experienced meditators. Some of the studies are conducted on younger population do not report the comparative effect on different age groups. Zeidan, Johnson, Diamond, David & Goolkasian (2010) found that brief mindfulness training significantly improved working memory but also reported that these findings apply to undergraduates and cannot be generalized to older adults. The results are also not differentiated for different components of working memory and for different age-groups. Certain meditation practices may improve visuo-spatial component of working memory for a particular level of meditators whereas other practices may enhance the performance on components like verbal working memory or the central executive itself. Buttle (2011) suggested that converging evidence should be sought not just from established meditative techniques and experienced meditators, but also from novel tasks designed for experimental investigation with novice meditators. The effect can also be isolated for different meditative techniques. The techniques range from focus on breath to contemplation of form or image. Only a few studies have reported the effects of meditation techniques that are less well known but still very important and prevalent in their specific traditions (Matko, Ott & Sedlmeier, 2020).

To fill these gaps, the effect of yoga and meditation on verbal and visuo-spatial working memory was studied for meditators ranging from novice to advanced. Also, instead of one session, the cumulative effect of several sessions of meditation was studied. The meditation practice selected for the study involved three different forms of meditation practiced sequentially - mantra meditation, contemplation of image and simultaneous contemplation of image and sound. This practice is based on oriental philosophy of Saints (Radhasoami Philosophy) and is referred as Surat-Shabd-Yoga. It is prevalent in the philosophy of Saints since more than 150 years. The scientific description of this meditation practice and

the principles underlying these practices are explained in detail by Sahab (1960, 2004). The novice meditators (NM), also known as pre-initiates, practice mantra meditation i.e. silent repetition of sound Ra-dha-soa-mi at four chakras (ganglia or energy centres) – navel, heart, throat and eye respectively. The intermediate meditators (IM), also known as first initiates, are trained for the practice of contemplation of form. The intermediate mediators are trained for practice of contemplation. The advanced meditators (AM), also known as second initiates, are trained for sound practice along with the practice of contemplation of form. The completion of training at intermediate level is pre-requisite for advanced level training. The repetition of mantra in the first stage of practice can be connected to verbal technique to disrupt the distracting thoughts. The visualization technique in the second phase can enhance the capacity to focus attention and hold visual image for longer time. The simultaneous practice of sound and form in third phase is likely to involve visuo-spatial working memory and phonological loop conjointly. The present study tests this hypothesis of association of different components of working memory with sequential stages of meditation.

Method:

Participants

A twenty week programme of yoga and meditation was announced. The applications were invited from three strata - (i) Novice meditators or pre-initiates with no training of mediation (ii) Intermediate meditators or first initiates who had training of contemplation of form (iii) Advanced meditators or second initiates who had training of contemplation of form and sound. The intermediate and advanced meditators had training of Surat-Shabd-Yoga meditation. The consent was sought from the applicants to participate in the experiment and follow the protocols of the meditation practice if they are selected for the programme. The protocols were based on the Oriental Philosophy of Saints (Radhasoami Philosophy) for practice of Surat-Shabd-Yoga Meditation i.e. abstinence from alcohol and non-vegetarian food.

Forty eight applications were received from 17 novice meditators (NM), 14 intermediate meditators (IM) and 17 advanced meditators (AM). After pre-test and before post-test, data of four participants was excluded as they did not continue the programme after first three weeks. 15 participants who volunteered to participate in the study were allocated to control group. The final sample thus included 59 participants: 15 novice meditators (NM) (M = 20.46 years, SD = 3.11), 13 intermediate meditators (IM) (M = 33.23 years, SD = 6.61), 16 advanced meditators (AM) (M = 42.40 years, SD = 5.26) and 15 non-meditators (M = 34.00 years, SD = 10.00). The study protocol was approved by local ethical committee.

Materials:

Automated tasks were administered on participants before and after intervention to assess different aspects of verbal and visuo-spatial working memory: a digit span task (DST) was used to assess verbal working memory and spatial span task (SST) was used to assess the visuo-spatial memory. Stimuli was delivered on monitor using presentation software of Cambridge Brain Sciences (Owen, Hampshire, Grahn, et al., 2010).

DST:

On each trial of DST, the digits appeared on the screen one after the other. Each digit appeared for 1000 ms and inter-stimulus time was 250 ms. After a beep, the digits disappeared from screen, the participants had to recall the sequence of

digits and type it onto the keyboard in the sequence in which they occurred. Each successful trial was followed by a new sequence that was one digit longer than the last. In case of unsuccessful trial, the sequence was one digit shorter. After three errors, the test terminated. The score was obtained by the average number of digits reproduced in all successfully completed trials.

SST:

For spatial span task, the sample array was presented for 100 milliseconds. 4 x 4 array consisted of squares which blinked one after the other for 900 ms each (inter-stimulus interval 5 x 100 ms). The participants had to remember the location of squares which blinked. They were instructed to remember the spatial relations between the squares. That is, absolute square positions were irrelevant; only the overall pattern of squares was to be remembered. After all of the squares were presented, the participants were cued to reproduce the pattern of squares. The cue was presented using a pattern mask that was the same size as the grid. The number of squares presented increased by one after each successful trial and decreased similarly in case of unsuccessful trial. The test terminated after three errors. The score was the average number of squares' pattern reproduced in successfully completed trials.

Procedure:

All the participants were tested individually. The participants completed DST and SST pretests. They practiced yoga and meditation for 20 weeks (3 days a week). The training for yoga was conducted by yoga instructor with experience of 12 years. An advanced meditator who had experience of training and practice of Surat-Shabd-Yoga of 25 years trained the subjects on the practice of meditation. Each day, the programme commenced with a brief 15 minutes discussion covering the topics aimed to reinforce the subjects for meditation viz. body, mind and consciousness, nerve centres, chakras, kamals and padmas, prevalent yoga practices and Surat-Shabda-Yoga. This was followed by 15 minutes of yogasanas practice and 30 minutes of Surat-Shabd-Yoga meditation. Seven yogasanas were included in the intervention programme for relaxation – Siddhasan, Sarvangasan, Bhujangasan, Paschimottarasan, Padahastasan, Ardhamatsyendrasan and Shavasan. These asanas were selected on the basis of ease of practice for the selected age group. The objective was just to reinforce the subject for meditation. The practice of meditation was based on the training of the respective groups (NM, IM and AM). The regularity in practice of yoga and meditation was the motivation reported by subjects to participate in the experiment for 20 weeks. The control group practiced relaxation technique i.e. sitting quietly for same duration as meditators. The subjects completed DST and SST posttests after 20 weeks of pretest.

Results:

Performance on DST and SST is summarized in Table 1. The four groups of subjects were compared on their performance on DST and SST at pre-test to identify baseline differences. ANOVA indicated that the groups did not differ significantly at pre-test for DST ($F = .740$, $p = .53$) whereas groups differed significantly for SST ($F = 5.382$, $p = .003$). The difference was significant only for NM and AM group ($p = .001$) with greater mean of NM group and rest of the groups did not differ significantly at pre-test for SST. Age difference between NM group ($M = 20.46$ years) and AM group ($M = 42.40$ years) can be one of the factors for difference in performance on SST.

Table 1

Mean Performance on Digit Span Task (DST) and Spatial Span Task (SST)

Measure of performance	Meditators			Resting Control
	Novice	Intermediate	Advanced	
DST accuracy				
Pre-test	5.73 (1.28)	5.00 (1.08)	5.37 (1.31)	5.24 (1.09)
Post-test	6.40 (1.80)	5.92 (1.25)	6.43 (1.75)	5.35 (1.32)
SST accuracy				
Pre-test	5.20 (.86)	4.38 (.65)	3.80 (1.68)	4.76 (1.20)
Post-test	5.27 (.88)	4.08 (1.70)	4.43 (.79)	4.88 (.69)

Note. Standard Deviations are given in parantheses.

Effect of NM versus AM on DST:

Figure 1 presents the results for performance on DST at pre- and post-tests. A 2 (time: pretest vs. posttest) x 4 (group) mixed-model ANOVA yielded a significant main effect of time, $F(1, 55) = 8.12$, $p = .009$, $\eta p2 = .059$ and group, $F(3, 55) = 3.206$, $p = .026$, $\eta p2 = .078$. The group x time interaction effect was not significant, $F(3, 55) = .640$, $p = .591$.

Further, paired sample t-test revealed that there was a marginally significant increase in performance on DST from the pretest to the posttest for the NM group, $t(14) = 2.36$, $p = .06$, a significant increase for the IM group, $t(12) = 2.92$, $p = .01$ and a highly significant increase for the AM group, $t(15) = 3.17$, $p = .006$, $\eta p2 = .114$. There was no significant increase in performance on DST for control group, $t(14) = .02$, $p = .88$.

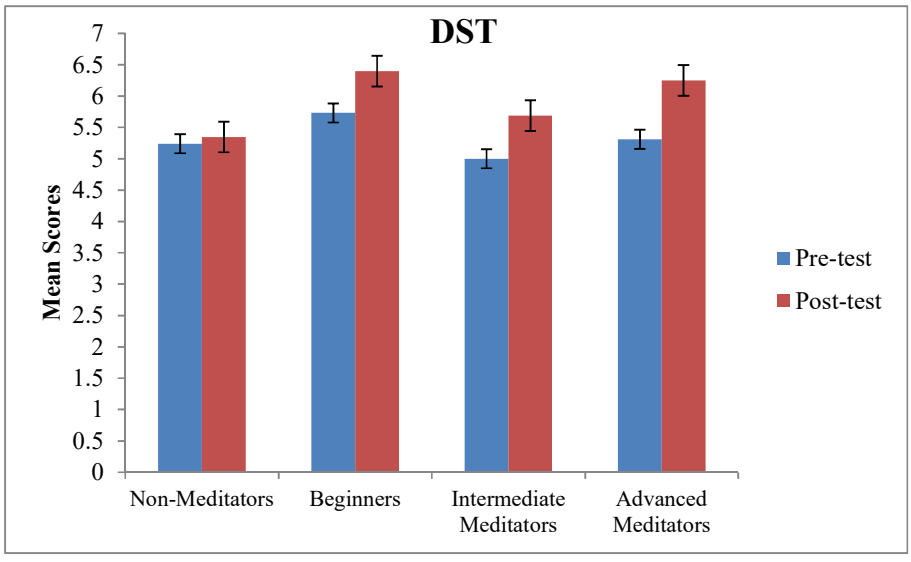

Figure 1: Performance on DST at pre- and post-tests. Bars represent standard error.

Effect of NM versus AM on SST:

Figure 2 presents the results for performance on SST at pre- and post-tests. A 2 (time: pretest vs. posttest) x 4 (group) mixed-model ANOVA indicated that the main effect of time, $F(1, 55) = .97$ was not significant, $p = .32$. The effect of group was significant, $F(3, 55) = 4.30$, $p = .009$, $\eta p2 = .215$. The group x time interaction effect was significant, $F(3, 55) = 2.78$, $p = .05$, $\eta p2 = .151$.

Further, post hoc analysis revealed that the gain of AM group was significantly greater than NM group ($p = .04$), IM group ($p = .008$) and control group ($p = .07$).

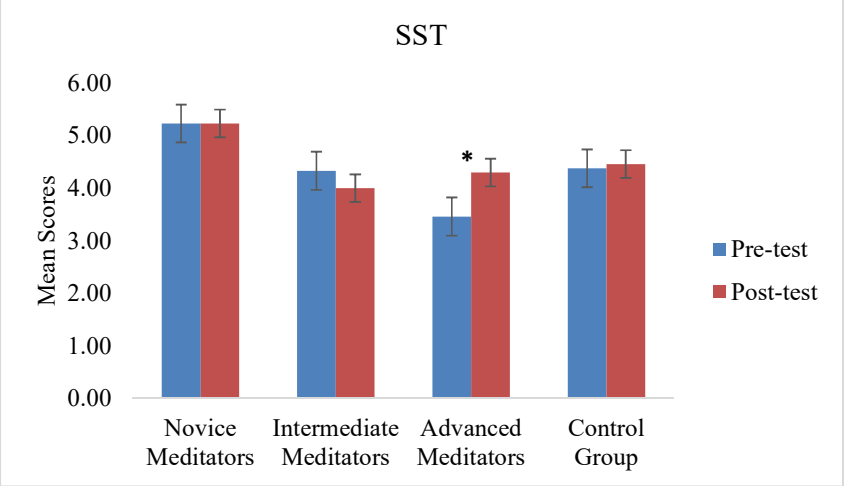

Figure 2: Performance on SST at pre- and post-tests. Bars represent standard error.

Discussion:

The results of this study indicate that there is no baseline difference in verbal working memory among novice meditators, intermediate meditators, advanced meditators and non-meditators despite of age difference among the groups. The existence of age-related decline in digit span has been confirmed in a number of studies (e.g., Gregoire& Van der Linden, 1997; Ryan et al., 1996). Here, the verbal memory of advanced meditators was same as that of novice meditators at pre-test. The exposure to meditation practice can be accounted to this. The practitioners at three levels demonstrated the improvement in performance on digit span task at the posttest (after 20 weeks of meditation) in comparison to control group. The effect on novice meditators is same as that of intermediate and advanced meditators. Thus, the improvement in verbal working memory resources is independent of the stage of meditation and level of practitioners practicing Surat-Shabd-Yoga meditation. At pre-test, intermediate and advanced meditators had training prior to intervention, but the frequency of practice as reported by participants was once a week or once in two weeks. During intervention, all the participants practiced Surat-Shabd-Yoga meditation regularly three days a week. The frequency of practice may have improved verbal working memory at post-test.

The selective attention which was common at all the three stages of meditation, mantra meditation at first stage, contemplation of form and mantra meditation at second stage and simultaneous contemplation of form and sound with mantra meditation at the third stage, can be associated with increase in verbal working memory.

The existence of age-related decline in

digit span has been confirmed in a number of studies (e.g., Gregoire& Van der Linden, 1997; Ryan et al., 1996). In Surat-Shabda-Yoga meditation, at the third stage, the practice becomes more rigorous and may lead to focused attention resulting in the better availability of working memory resources. This may also enhance the capacity to do complex cognitive rehearsal and recall to manage the operation of the phonological loop. The results indicate that it defies the age related effects of perceptual slowing enabling better stimulus encoding and identification. The findings of this study revealed that despite of the age difference of novice meditators, intermediate meditators and advanced meditators; the extent of improvement in the performance on digit span was same. This reflects that Surat-Shabd-Yoga meditation can help to overcome the age related decline in verbal working memory.

In case of spatial span, the groups varied in performance at pre-test, the score of advanced meditators being the lowest and that of novice meditators highest. The visuo-spatial memory has been found to reduce with age (Reuter-Lorenz et al., 2000). The variance in older adults' visuo-spatial working memory is twice as much of the verbal working memory (Conway, Jarrold, Kane, Miyake, & Towse, 2007). Here the age-range of advanced meditators was 38 to 47 years. Thus age can be associated to difference in performance at pre-test for spatial span task. The participants were interviewed to further answer questions raised after the analysis of results. Though the intermediate and advanced meditators had training of second and third level before intervention, the participants reported that they did not practice the meditation of second and third level regularly. They practiced the first form i.e. mantra meditation regularly. The yoga and meditation programme helped them regularize the practice. The difference in the performance on visuo-spatial task at pre-test and post-test can be attributed to regularity of practice.

At post-test, the performance of advanced meditators improved from pre-test and there was no change in the performance on visuo-spatial task for the other three groups. The results of the present study show that it is only at the third stage of meditation, there is significant improvement in the visuo-spatial working memory. At the third stage of Surat-Shabd-Yoga meditation, the meditators practice the contemplation of form and sound along with mantra meditation whereas the novice meditators practice the mantra which can be associated with processing of verbal information using non-spatial phonological loop. The intermediate meditators practice focusing on form. Although this involves processing visual information but they do not have to update the information for further processing. At the third stage, the advanced meditators, practice simultaneously mantra and contemplation of form and sound with the changing forms and associated sounds at the hierarchical levels (Satsangi, 2006; Satsangi, 2013). This requires continuous updation of visual and spatial information, simultaneously keeping phonological loop active. The concurrent use of mantra and visualization is likely to involve visuo-spatial working memory and the phonological loop conjointly leading to increase in both verbal and visuo-spatial working memory for advanced meditators (Buttle, 2013). Kozhevnikov, Louchakova, Josipovic and Motes (2009) also reported in their study that visualization-based meditation enhances visuo-spatial processing efficiency. Van derLinden, Brdart&Beerten (1994) found the age related performance decline in a task that required subjects to continually monitor and update information in working

memory. In particular, Hester, Kinsella & Ong (2004) found the age decrement on digit and span task. The findings of the present study indicate that regardless of age-range, there was improvement in verbal working memory of meditators, and there was significant improvement in visuo-spatial working memory of advanced meditators as compared to novice and intermediate meditators.

Conclusion:

The present study underlines the important result that mantra meditation can be associated to improvement in verbal working memory, and the integration of visualization technique with sound practice can be associated to gain in visuo-spatial capacity. Thus as in previous studies related to mediation and working memory, it cannot be generalized that all forms of meditation influence all the components of working memory. The change in each component may be subject to the stage of meditation. Also, the results indicate that the practice of Surat-Shabd-Yoga can slow down the progression of age-related memory loss and cognitive decline. The limitation of the present study was that only automated tasks were used to assess different components of working memory. Further studies integrating third person non-invasive approaches like Magnetoencephalography (MEG) can be conducted to map the brain activity and to confirm the results.

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