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Changes in Shape and Size Discrimination and State Anxiety After Alternate-Nostril Yoga Breathing and Breath Awareness in One Session Each

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Statistical Analysis C
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Manuscript Preparation E
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Background: Yoga breathing techniques like high-frequency yoga breathing (HFYB) and breath awareness (BAW) have been associated with improved performance in the shape and size discrimination task. A PubMed search of the literature revealed that alternate-nostril breathing has been shown to improve performance in attention tasks, but the effect on tactile perception has not been studied. Hence, the present study was designed to assess the immediate effects of alternate-nostril yoga breathing (ANYB) compared to breath awareness on shape and size discrimination and state anxiety.

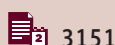
Material/Methods: Fifty healthy male volunteers ages 20–50 years (group mean \pm S.D., 28.4 \pm 8.2 years) were recruited. Each participant was assessed in 3 sessions conducted on 3 separate days at the same time of day. The 3 sessions were (i) alternate-nostril yoga breathing (ANYB), (ii) breath awareness (BAW), and (iii) quiet sitting (QS), and the sequence of the sessions was randomly allocated. The shape and size discrimination task and state anxiety were assessed before and after all 3 sessions. Repeated measures analysis of variance (RM-ANOVA) followed by *post hoc* tests for multiple comparisons, which were Bonferroni-adjusted, were performed to compare data before and after all 3 sessions using SPSS version 18.0.

Results: The errors scores in the shape and size discrimination task showed a significant reduction after the ANYB session ($p < 0.001$). A significant reduction was found in the level of state anxiety after breath awareness ($p < 0.05$) and quiet sitting sessions ($p < 0.001$).

Conclusions: The present results suggest that ANYB: (i) improves performance in a task which requires perceptual sensitivity and focused attention, but (ii) does not reduce state anxiety following this task.

MeSH Keywords: Anxiety • Breathing Exercises • Discrimination (Psychology)

Full-text PDF: <https://www.basic.medscimonit.com/abstract/index/idArt/914956>



Background

Perception is a complex process which involves sensory input, memory, recognition and synthesizing information from these sources [1]. Acuity in perception involves sensory discrimination and the ability to detect minor increments or decrements in specific attributes of the stimulus being perceived [2]. Shape and size discrimination require tactile information about the objects being perceived. This information is typically obtained by stereotypical movements, especially scanning movements of the fingers [3,4].

Practicing yoga techniques has been shown to influence perception, since an early study on Burmese Buddhist meditators found practitioners were particularly sensitive to the size, shape, color, and texture of visual stimuli [5]. Subsequent studies have also shown improved visual perception for a flickering light stimulus [6] and for geometric optical illusions [7].

The Chinese practice of tai chi, which has some similarities with yoga, was found to improve tactile perception in those who had experience of tai chi practice [8]. A blinded experimenter assessed tactile sensitivity in tai chi practitioners compared with controls. Tai chi practitioners' tactile spatial acuity was better than that of the matched controls [8].

A single study showed that 2 yoga breathing practices – high-frequency yoga breathing HFYB (*kapalabhati* in Sanskrit; rate 1.0 Hz) and breath awareness – decreased the errors and the time taken to complete a shape and size discrimination task [9].

Perceptual discrimination requires focusing on the stimuli and focusing is usually associated with increased sympathetic nervous system activity [3]. Sympathetic nervous activity (SNSa) is usually increased when a person is anxious and, in turn, anxiety further increases SNSa.

A specific yoga breathing practice involving breathing through the left and right nostril alternately (alternate-nostril yoga breathing) was found to improve the performance in a Purdue pegboard task, and, in a separate study, performance in a digit vigilance task, while in both studies, alternate-nostril breathing practice was associated with reduced systolic and diastolic blood pressure values [10,11]. This was observed as an immediate effect of 18 minutes of alternate-nostril yoga breathing.

Given the paucity of information on the effect of yoga on tactile discrimination, the present study was designed to assess study whether 18 minutes of alternate-nostril yoga breathing or 18 minutes of breath awareness would influence: (i) shape and size discrimination and (ii) state anxiety, when compared to 18 minutes of sitting quietly as a control.

Material and Methods

Participants

Fifty healthy male volunteers ages 20–50 years (group mean \pm S.D., 28.4 \pm 8.2 years) were recruited. Male participants alone were selected because visuotactile perception has been shown to change with the phases of the menstrual cycle in females [12]. Participants were staying at a residential yoga center located in north India. The inclusion criteria were: (i) the participants had to have at least 3 months of experience in the yoga breathing practices (i.e., ANYB and BAW), (ii) normal vision which did not require correction (based on their self-report), and (iii) normal tactile sensation of the volar surfaces of the fingers based on the participants' ability to sense the test material through touch during the explanation prior to testing. Participants were excluded if they: (i) were on any medication which could impair cognition or cause drowsiness, (ii) had any illness, particularly psychiatric disorders, which could influence cognition and state anxiety, and (iii) if they had calluses or impaired sensation in the fingers based on observation. Since none of the participants had any of the conditions for exclusion, they did not need to be removed from the study. Participants were recruited by notices on the institution's notice boards. They did not receive any incentive to take part in the study. Calculations using G Power Software Version 3.1 based on changes in state anxiety after breath awareness, where effect size=0.175 (medium), showed that the power was adequate (0.678) [13]. Signed informed consent was obtained from each participant and the study was approved by the Institutional Ethics Committee (approval number: PRF/16/0026).

Study design

Each participant was assessed on 3 separate days for 3 different yoga breathing practice sessions held at the same time of the day. Instead of selecting 3 separate groups, this design, where the same individual is assessed on 3 separate days, was selected to reduce inter-individual variation [14]. The sequence of the practice sessions was randomized with the help of a randomizer (www.randomizer.org). The total time for intervention was 18 minutes, with 1 minute of rest after each 5 minutes of practice. This has been shown schematically in Figure 1. This was true for all 3 interventions: alternate-nostril yoga breathing (ANYB), breath awareness (BAW), and quiet sitting (QS) sessions.

Assessments

Shape and size discrimination task

Depending on a person's visual and tactile sensations, as well as their speed of sorting, the shape and size discrimination

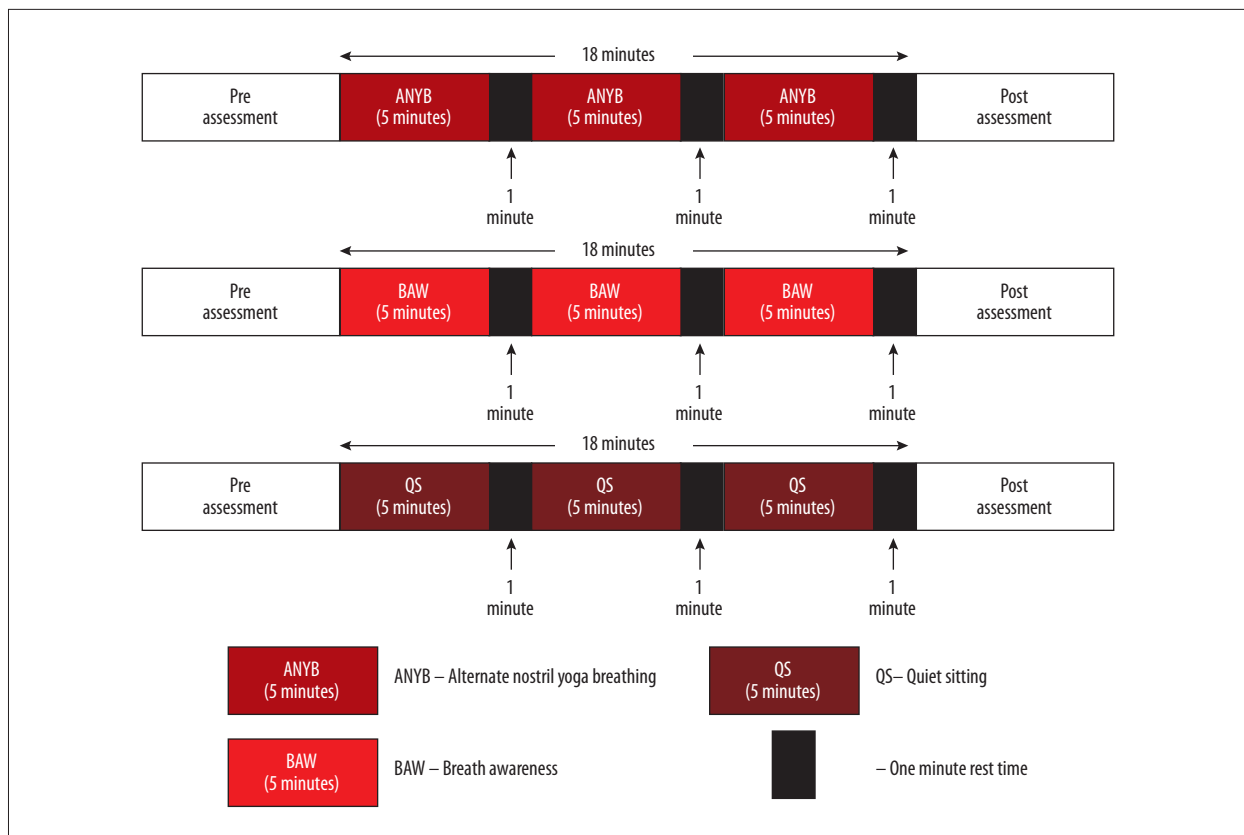


Figure 1. This is a schematic representation of the study design. Each participant was assessed in 3 sessions on 3 separate days. Each session was of 18 minutes duration, with three 5-minute epochs of the intervention and three 1-minute rest periods. The interventions are depicted as follows: the dark red rectangle indicates alternate-nostril yoga breathing (ANYB), the bright red rectangle indicates breath awareness (BAW), the maroon rectangle indicates quiet sitting (QS), and the darkened parts indicate rest periods of 1-minute duration.

task (Takei Scientific Instruments Co., Japan) is used to assess a person's ability to discriminate between coins and squares of different sizes [9]. The participant has to insert 50 such coins and squares of different sizes and thickness into 5 slits of a wooden box, where each slit has been especially designed to allow a square or coin of a specific size and thickness to pass through it. The time taken to complete the task (in seconds) and number of errors (attempts to insert a coin in a wrong slit) were recorded. The experimenter did not know, and hence was blinded to, the intervention the person had practiced.

State trait anxiety inventory (STAI)

Spielberger's state trait anxiety inventory (STAI) has 20 items to assess state anxiety or anxiety at the moment of testing. At the moment of testing, the number that best describes the intensity of feelings of anxiety of a participant has to be selected, on a scale of 1 to 4, where the following numbers have been associated for each item with the associated value – 1: Not at all, 2: Somewhat, 3: Moderately, or 4: Very much so. Assessment was done at the beginning and end of all 3 sessions.

Interventions

Each participant performed 3 practices: (i) alternate-nostril yoga breathing (ANYB), (ii) breath awareness (BAW), and (iii) quiet sitting (QS). The total time of the invention was 18 minutes, with 3 practice periods of 5 minutes each followed by 1 minute of rest.

Alternate-nostril yoga breathing (ANYB)

Alternate breathing from both nostrils without retention of breath is known as alternate-nostril yoga breathing (=anulom-vilom pranayama in Sanskrit). The participants were asked to sit cross-legged (*sukhasana*=comfortable pose), with their spine erect and spine and neck aligned and eyes closed throughout each session. The thumb and ring finger of the right hand (the dominant hand in all participants) were used to manipulate or occlude the right and the left nostril respectively. The participant first starts with exhaling through the left nostril with the right nostril closed, then inhaling through the left nostril, exhaling through the right nostril, then inhaling through the

Table 1. Time taken (in seconds) and number of errors in the shape and size discrimination task pre and post ANYB, BAW, and QS sessions. Values are group mean \pm SD.

Sessions	ANYB			BAW			QS		
	Shape and size discrimination task			Shape and size discrimination task			Shape and size discrimination task		
	Time (seconds)	Number of errors	STAI scores	Time (seconds)	Number of errors	STAI scores	Time (seconds)	Number of errors	STAI scores
Pre	96.40 \pm 37.96	6.64 \pm 3.58	38.66 \pm 10.94	104.76 \pm 53.70	6.24 \pm 3.22	37.70 \pm 10.93	108.37 \pm 49.80	5.92 \pm 3.41	38.06 \pm 8.83
Post	104.70 \pm 43.29	4.44 \pm 2.96	38.00 \pm 11.44	96.29 \pm 40.07	5.14 \pm 3.91	35.12 \pm 10.55	99.87 \pm 39.35	5.30 \pm 3.55	34.24 \pm 9.29
p -value	0.20	0.001	0.57	0.33	0.07	0.03	0.25	0.22	0.001
Percentage change	8.60	33.13	1.70	8.08	17.62	6.84	7.84	10.47	10.03
Cohen's d	0.20	0.67	0.06	0.18	0.31	0.24	0.19	0.18	0.42

Post values were compared with respective pre values for 3 sessions, i.e., ANYB, BAW, and QS. * $p < 0.05$; ** $p < 0.01$, *** $p < 0.001$, RM-ANOVA – post hoc tests with Bonferroni adjustment. ANYB – alternative nostril yoga breathing; BAW – breath awareness; QS – quiet sitting.

right nostril and exhaling through the left nostril. Throughout the practice, nostril manipulation was carried out with the right hand. This sequence has been detailed in previous studies as well [11].

Breath awareness (BAW)

The participants were instructed to close their eyes and then feel the flow of air passing through the nasal passage during the breath awareness session. The participants were asked to sit cross-legged with spine erect and neck aligned.

Quiet sitting (QS)

The participants were seated erect and cross-legged with spine erect and neck aligned, as for the ANYB and BAW sessions. Participants were instructed to keep their eyes closed and to allow their thoughts to wander freely. There was no other activity.

Data analysis

Repeated-measures analyses of variance (RM-ANOVA) followed by *post hoc* Bonferroni adjustment was performed using SPSS version 18.0. There were 2 within-subject factors: sessions (i.e., ANYB, BAW, and QS) and states (i.e., before and after).

Post hoc Bonferroni-adjusted tests for multiple comparisons were carried out to compare values after vs. before within a group, and to compare values between groups before and after the interventions.

Results

Shape and size discrimination task

The errors in the shape and size discrimination task were significantly reduced after the ANYB session ($p < 0.001$). The time taken to complete the task showed no significant difference between the 3 sessions ($p > 0.05$).

State trait anxiety inventory (STAI)

A significant reduction was found in the level of state anxiety after breath awareness ($p < 0.05$) and quiet sitting sessions ($p < 0.001$). Changes in mean, SD, and Cohen's *d* in the shape and size discrimination task total scores are given in Table 1. The ANOVA-related *df*, *MS*, *F*, and partial *eta squared* values are given in Table 2.

Discussion

After 15 minutes of alternate-nostril yoga breathing, there was improved performance in a shape and size discrimination task, while after 15 minutes of breath awareness or sitting quietly, there was a decrease in state anxiety. Contrary to the hypothesis of the study, a reduction in state anxiety did not occur along with improved performance in the shape and size discrimination task.

The shape and size discrimination task requires tactile sensitivity to distinguish between shapes which differ in size (by 1 mm

Table 2. Details of the 3 repeated measures analyses of variance.

Variables	Sources	df	MS	F	Partial eta square
Time taken to complete the task	Sessions	1.88, 92.14	455.47	0.35	0.01
	States	1, 49	625.25	0.52	0.01
	Sessions×States	2, 98	2345.60	1.60	0.32
Number of errors	Sessions	2, 98	.563	0.06	0.00
	States	1, 49	128.05	16.13	0.25
	Sessions×States	1.95, 95.46	16.84	2.21	0.04
STAI scores	Sessions	2, 98	141.77	1.44	0.03
	States	1, 49	415.36	10.27	0.17
	Sessions×States	2, 98	63.37	2.39	0.05

to <4 mm) in thickness and have different shapes (e.g., a circle, square). The task also requires motor speed and co-ordination to place the objects in the correct slot as quickly as possible. Haptic information processing also involves higher-order neural resources [15].

In tai chi, the goal of the practice is to increase body awareness. Practitioners are encouraged to focus their attention on their fingertips as a way of sensing the entire body up to the periphery [8]. Tactile activity was compared in 14 tai chi practitioners and in 14 control participants. In both groups, tactile activity was assessed using dome-shaped pieces of plastic presented to the participant's fingertip for 2.5 seconds, during which participants were required to identify the grating orientation as either parallel or perpendicular. The tai chi practitioners had greater tactile activity than the control group (1.4 versus 1.8 mm, respectively, or 32.6%).

Previously, tactile discrimination was assessed using the same coin-sorting task as the present study [9]. Ninety-four participants were randomized to 2 groups: (i) a high-frequency yoga breathing group (breath rate 1.0 Hz, n=47) and (ii) a breath awareness group (n=47). There was a significant decrease in errors and time taken to complete the coin discrimination task after both high-frequency yoga breathing and after breath awareness. Errors were reduced by 41.0% after high-frequency yoga breathing, and were reduced after breath awareness by 22.0%. The time taken to complete the task was reduced by 15.0% after both high-frequency yoga breathing and breath awareness. In the present study, the reduction in errors after alternate-nostril yoga breathing was 33.1% and 17.6% after breath awareness. Hence, the effect of alternate-nostril breathing on error reduction was less than the effect of high-frequency yoga breathing reported earlier [9]. The changes following breath awareness were comparable in the earlier study [9] and the present study.

Yoga breathing has been found to improve attention based on a digit vigilance task (Cohen's $d=0.61$) [11] and reduce reaction time (Cohen's $d=0.404$) [16]. The yoga breathing practices differed, since in some practices the emphasis was on increasing the rate [17], while in others the emphasis was on the depth of breathing [18].

In the present study, participants practiced alternate-nostril yoga breathing. Breathing through a particular nostril has been studied extensively as a part of a series of studies on the rhythmic alternating patency of the nostrils as part of the ultradian nasal cycle [19]. The nasal cycle is a naturally occurring ultradian rhythm in which the nostrils show alternating congestion and decongestion [20]. The nasal mucosa is innervated by the autonomic nervous system. There are believed to be nerves arising from the superior nasal meatus and ending in different hypothalamic nuclei which activate either the sympathetic or the parasympathetic nervous system [21]. These nerve endings can be activated by air insufflations even if the lung is not inflated [21]. These findings were reinforced by a report that local anesthesia injected locally in the nasal mucosal membrane prevented cortical changes which were shown to follow activation of the upper nasal cavity. When there is increased sympathetic nervous system activity on any side, there would be vasoconstriction in the nasal mucosa on that side, leading to greater nostril patency on that side. In contrast, on the opposite side, parasympathetic dominance would lead to vasodilation in the nasal mucosa leading to the nostril on that side being either partially or totally occluded. The periodicity of the nasal cycle varies widely; time series analysis detected periods of this rhythm at 280–275, 165–210, 145–160, 105–140, 70–100, and 40–65 min bins [22,23]. In contrast to the naturally occurring rhythmic variation in nostril dominance, there have been several studies on forced unilateral nostril breathing. This may require a person to breathe through a nostril which is not patent at the time and hence could be potentially stressful.

In the present study, since the practice involved alternate-nostril breathing, it is unlikely to have had the effect of unilateral breathing related to forcefully inducing breathing through a non-patent nostril.

Alternating nostril patency was found to be coupled to alternating activation and de-activation of the cerebral hemispheres [24]. This rhythm is based on a complex connection between the nasal meatus and cortical centers through anatomically indistinct pathways [21]. Hence, alternate-nostril breathing can modify cortical functions based on changes in the EEG [25], as well as by improved performance in the P300 event-related potential task [26].

The P300 requires auditory discrimination and focused attention to detect and process the difference in the pitch of 2 tones – standard and target – which differ in frequency [27]. This is a form of auditory perceptual sensitivity. It is possible that a similar improvement in attentional processes may contribute to the improved performance in the shape and size discrimination task in the present study.

State anxiety was reduced after breath awareness and after sitting quietly with no breath manipulation. In people who practice mind-body interventions such as yoga and tai chi, breath awareness has a wide range of benefits, including a reduction in anxiety [28]. This is possibly because the attention is focused on the breath, which would not be expected to give rise to disturbing thoughts. Another mechanism could be by activation of the parasympathetic nervous system, particularly the vagus nerve. During normal breathing, the activity of the vagus nerve causes sinus arrhythmia. Activation of the vagus nerve also prevents excessive expansion of the lungs by the Hering-Breuer reflex. The role of the vagus nerve in calming, self-soothing, and relaxation is well known [29]. More recently, more complex roles of the vagus nerve have been given attention due to the effects in enhancing social bonding, as in the polyvagal theory [30], and in increasing flexibility in adapting to different environmental conditions [31]. These effects of increased vagal nerve activity may explain the reduction in state anxiety following breath awareness, as mindfulness is known to increase parasympathetic activity [32].

State anxiety also was decreased after sitting quietly. The reduction in state anxiety during the control session of quiet sitting could be related to the fact that the participants already had a minimum of 3 months of prior experience of yoga practice. It is recognized that experience in yoga practice increases behavioral forms of self-regulation, even when the person is not practicing yoga [33]. Yoga practice is believed to increase proactive coping during stressful situations and increase the possibility of moving towards a healthier lifestyle [34]. Hence, even at rest, a person who has experience in yoga practice may

reach a quiet and restful state with low levels of state anxiety. Physiologically, the basal metabolic rate of yoga practitioners was found to be 12.0% lower than in non-yoga practitioners [35]. The authors attributed this difference to differences in the sympathetic nervous system responses to stressors and baseline differences in sympathetic and endocrine functioning in yoga practitioners compared to non-yoga practitioners, with yoga practitioners being more likely to show lower levels of arousal. Hence, these psychological [34] and physiological [35] differences which occur with experience in yoga may explain why quiet sitting reduced state anxiety in this sample of persons who had 3 months of prior experience of yoga practice.

However, there was no attempt to determine what the participants thought about during the session, and this is a limitation of the study, which also shows the importance of getting adequate subjective information from the participants to understand their experience in its entirety.

Hence, the present results suggest that ANYB: (i) improves performance in a task which requires perceptual sensitivity and focused attention, but (ii) does not reduce state anxiety in the practitioners while performing the task.

In the present study, while participants showed an improvement in shape and size discrimination after ANYB, further studies involving methods to localize the changes in space and time in the brain are required. A review of physiological findings when combined gives a model for shape processing and recognizing objects [36]. In determining the boundaries of a three-dimensional (3D) shape, Gestalt laws which apply good continuation and closure (i.e., encoding and recognition of an object's boundaries) as well as other aspects of the object, such as co-linear terminating lines, are extracted in the prestriate visual cortex. Processing the shape of an object continues rostrally involving the inferior temporal cortex where several 3D shapes are identified. Each object is coded as size-specific as well as orientation-specific. Several components of an object help to understand the appearance of an object, such as orientation and size, which gives the object its 3D appearance. Subsequently, generalization of the object's orientation and size and other sub-components is achieved in the anterior temporal cortex through associative learning. This process appears to be facilitated by ANYB, so that participants were able to identify and discriminate between 3D objects sooner and with less error. Neuroimaging, or at the very least, LORETA images based on high-density quantitative EEG, would help to establish whether these cortical areas are indeed involved, and these speculations form the basis for possible future directions of research in haptic discrimination in yoga practitioners.

A limitation of the present study is that the reason why state anxiety was reduced after the control session when participants sat quietly is difficult to explain, as their subjective report of what they thought about during the session was not obtained. The prior experience in yoga may have facilitated relaxation in this posture and in a quiet environment. Apart from this, as nostril patency varies throughout the day, it would have been ideal to determine nostril dominance prior to each intervention. This was not done and is thus a limitation of the present study. Despite these limitations, the results suggest that ANYB improves haptic perceptual discrimination, while breath awareness and sitting quietly with eyes closed reduce state anxiety.

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Conclusions

Alternate-nostril yoga breathing in a single 18-minute session improves haptic perceptual discrimination. Breath awareness and sitting quietly with eyes closed, also practiced for 18 minutes each, reduce state anxiety.

Conflicts of interest

None.