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EFFECTS OF HIGH-FREQUENCY YOGA BREATHING CALLED *KAPALABHATI* COMPARED WITH BREATH AWARENESS ON THE DEGREE OF OPTICAL ILLUSION PERCEIVED[1]

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Summary.—Prior research has shown that methods of meditation, breath control, and different kinds of yoga breathing affect attention and visual perception, including decreasing the size of certain optical illusions. Evaluating relationships sheds light on the perceptual and cognitive changes induced by yoga and related methods, and the locus of the effects. In the present study, the degree of optical illusion was assessed using Müller-Lyer stimuli before and immediately after two different kinds of practice, a high frequency yoga breathing called *kapalabhati,* and breath awareness. A nonyoga, control session tested for practice effects. Thirty participants (with group M age = 26.9 yr., SD = 5.7) practiced the two techniques for 18 min. on two separate days. The control group had 15 nonyoga practitioners assessed before and after 18 min. in which they did not perform any specific activity but were seated and relaxed. After both *kapalabhati* and breath awareness there was a significant decrease in the degree of optical illusion. The possibility that this was due to a practice or repetition effect was ruled out when 15 nonyoga practitioners showed no change in the degree of illusion when retested after 18 min. The changes were interpreted as due to changes in perception related to the way the stimuli were judged.

A wide variety of practices in meditation and yoga have been found to affect aspects of visual perception, including such characteristics as discrimination of color and shade (Brown & Engler, 1980), visual sensitivity (Brown, Forte, & Dysart, 1984), the degree of optical illusions perceived (Telles, Nagarathana, Vani, & Nagendra, 1997), as well as higher brain functions such as memory and attention (Naveen, Nagarathana, Nagendra, & Telles, 1997; Telles, Raghuraj, Maharana, & Nagendra, 2007). Evaluating these relationships sheds light on the perceptual and cognitive changes induced by yoga and related methods, and the locus of their effects.

Research has shown that practitioners of a Burmese Buddhist meditation were more perceptually sensitive than nonmeditators as defined by their increased ability to distinguish subtle differences in color and shade when they were asked to look at the Rorschach ink blots (Brown & Engler, 1980). Practitioners of the same Burmese Buddhist meditation were tested for visual sensitivity before and immediately after a three-month intensive retreat during which they practiced mindfulness meditation for 16 hours a day (Brown, *et al.*, 1984). A control group who did not practice medita-

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tion was assessed similarly. Visual sensitivity was defined in two ways: a detection threshold based on the duration of simple light flashes and a discrimination threshold based on the interval between successive light flashes. The flashes of light were presented with a tachistoscope and had fixed luminance. At the end of the three-month program, practitioners of meditation were able to detect shorter single-light flashes and required a shorter interval to differentiate between successive flashes correctly.

These studies emphasized the effects of meditation alone on sensory perception. Additionally, Telles, *et al.* (1997) found that one month of practicing a combination of yoga which included yoga postures (*asanas*), breathing techniques (*pranayamas*), meditation, and cleansing techniques (*kriyas*) also improved visual perception, as there was a decrease in the perceived Müller-Lyer optical illusion. The participants had not practiced yoga before the one-month program. A control group of nonyoga practitioners was similarly assessed and showed no change. However, since the yoga practitioners' practiced several yoga techniques throughout the month, it was not possible to say which technique influenced the outcome.

Other studies have shown that yoga breathing techniques influence higher brain functions such as memory (Naveen, *et al.*, 1997; Telles, *et al.*, 2007) and improve performance in attention tasks (Telles, Raghuraj, Arankalle, & Naveen, 2008; Joshi & Telles, 2009). In turn, attention has been found to modulate the appearance of visual features and enhance perception of visual contrast (Anton-Erxleben, Abrams, & Carrasco, 2010).

The sensory and perceptual effects of several different yoga techniques have been studied by researchers, such as *kapalabhati,* which is a high-frequency yoga breathing technique characterized by forceful exhalation and breathing at a high frequency, approximately 1.0 Hz, though rates as high as 2.0 Hz are known (Ramdev, 2009). The term is derived from two Sanskrit words, *kapala* which means "cranium" or "forehead" and *bhati* which means light, splendor, or even knowledge (Saraswati, 2003).

Breath awareness, which simply means being aware of the movement of air at the nostrils and in the nasal passages, also improved the performance in an attentional task as measured by the P300 event-related potential (Joshi & Telles, 2009). The P300 event-related potential is most commonly elicited when an oddball paradigm is used and a person is asked to detect an occasional target stimulus from a train of standard stimuli (Picton, 1992). In the Joshi and Telles (2009) study, there were auditory tones which differed in the frequencies alone. Since there are predictable stimuli at one frequency (1.0 KHz) and unpredictable stimuli at another frequency (2.0 KHz), participants required sustained attention to differentiate between the two. The P300 was recorded before and after one minute of practicing (i) *kapalabhati* and (ii) breath awareness, on separate days by the same participants. Both practices influenced the P300 significantly. *Kapal-*

abhati practice decreased the P300 peak latency, which suggests the auditory attention task was less demanding after the practice (Kok, 2001). Following breath awareness, the P300 peak amplitude increased significantly, which indicates an increase in the attentional resources available for this auditory attention task (Polich, 2007). Hence both *kapalabhati* and breath awareness practiced for one minute improved performance in the auditory attention task differentiating the auditory tones. The rate of breathing while practicing *kapalabhati* was approximately 2.0 Hz, which is why the duration was restricted to one minute.

In another study, *kapalabhati,* practiced at the rate of approximately 1.0 Hz for 15 min. as three 5-min. epochs with 1-min. gaps in between, improved participants' performance in a cancellation task (Telles, *et al*., 2008), indicating significant effects on both selective and sustained attention as well as better visual scanning abilities and motor responses. The participants were of different ages and included medical students, middle-aged adults, and older adults. The results suggest that *kapalabhati* practice improves these functions regardless of the age of the individual. There was no improvement in the performance in the cancellation task after 15 min. of breath awareness practice. Hence, *kapalabhati* improved the performance in both the auditory attention task, as measured by the P300 event-related potential, and the cancellation task, whereas breath awareness improved the performance only in the auditory task. Thus, it appears that there are different but overlapping effects from the activities depending on modality and task.

Breath awareness and *kapalabhati* are entirely different, as breath awareness does not involve breath manipulation, whereas *kapalabhati* involves consciously changing the rate and method of breathing. Despite these differences, both practices have been shown to improve the performance in an attention task (Joshi & Telles, 2009). Since attention influences visual perception, to tease apart the differences in effects the present study compared the effects of *kapalabhati* (at approximately 1.0 Hz) and breath awareness. Each was practiced for 15 min., and the performance in detecting the degree of optical illusion on visual perception was measured, as in Telles, *et al*. (1997). It was expected that the effects of the two practices would differ on visual perception of an optical illusion, with *kapalabhati* significantly decreasing the degree of optical illusion compared to breath awareness.

Materials and Methods

Participants

Thirty male participants with ages between 25 and 40 years ($M = 26.9$ yr., $SD = 5.7$) participated in the study. The participants were staying at a residential yoga center, Patanjali Yogpeeth, located in Haridwar, North India. They were recruited using flyers to announce the research program,

which were put on notice boards in the yoga center. Those who fulfilled our criteria, viz., a minimum of 3 mo. experience of yoga (including *kapalabhati* and breath awareness); no addiction to tobacco, intoxicants, or caffeinated beverages (based on their self-report); and normal vision which did not require correction (also based on their self-report). This is a limitation of the study, as ideally their distant and near vision should have been checked. Their participation in the study was voluntary, and each signed an informed consent. The study was approved by the institution's ethics committee. The 15 male participants who formed a control group had not practiced yoga and had no knowledge about yoga. This group was assessed at the beginning and end of an 18-min. period during which they were not given any activity to do, but were asked to allow themselves to think about any subject which occurred to them. At the end of 18 min., their performance was assessed once more to determine whether repeating the test after 18 min. would influence the performance on the test, i.e., whether there were significant practice or priming effects.

Design

The first and second groups were the experimental groups and participants had at least three months of experience with yoga. The assessments were done immediately before and after the two breathing practices (i.e., *kapalabhati* and breath awareness). The third group was a control of 15 male participants who were also assessed similarly, but had no prior experience with yoga.

Apparatus

The degree of optical illusion was measured using the Müller-Lyer apparatus (Anand Agencies, Pune, India). This is shown in Figs. 1 and 2. The apparatus consisted of a wooden rectangle, 50 cm long and 7.6 cm wide. This rectangle was attached with screws to two rods. The front of the plate had the two Müller-Lyer lines drawn side by side. The line on the left was fixed in length (160 mm) and the end of the line had two close-ended arrows. The length of the line on the right could be varied from 0 mm to 200 mm. This line had open-ended arrows at either end. The length was manipulated by the experimenter as there was a shaft (i.e., movable plate) which allowed the experimenter to gradually slide the plate at approximately 1 mm per second. Hence, for "in trials" the experimenter started at 200 mm and moved the movable plate inwards until the participant indicated that the two lines (i.e., line on the left which had a fixed length of 160 mm and the line on the right which was adjustable) were of equal length. For "out trials" the experimenter began with the two open-ended arrows touching each other and gradually moved the plate on the right outwards until the participant felt that the line on the left (160 mm in length) and the line on the right were of equal length.

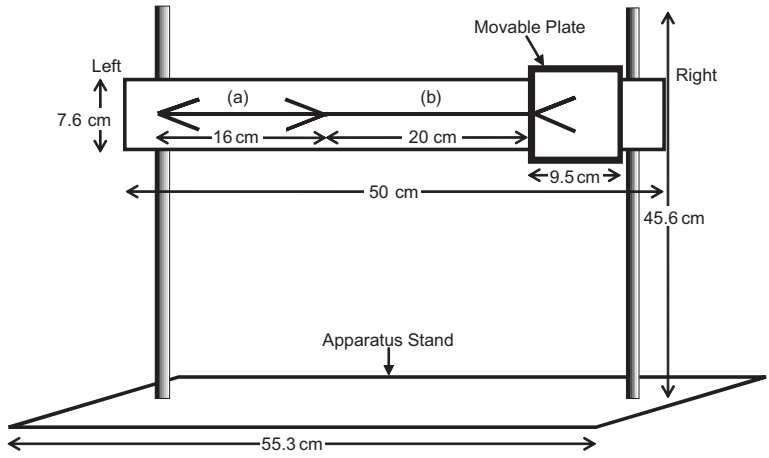

FIG. 1. Front view of the Müller-Lyer apparatus, showing the fixed line on the left and movable or variable line on the right.

Assessment Procedure

The test consisted of two trials: "In Trials" and "Out Trials." The experimenter moved the shaft (i.e., movable plate) so that the participant could direct his attention to the lines and was not distracted by having to move the lines. The movable plate could be continuously moved. There was no way of regulating the rate of movement precisely. However, the experimenter did several practice trials and reached a consistent rate of approximately 1 mm per second. All participants were asked to sit at a

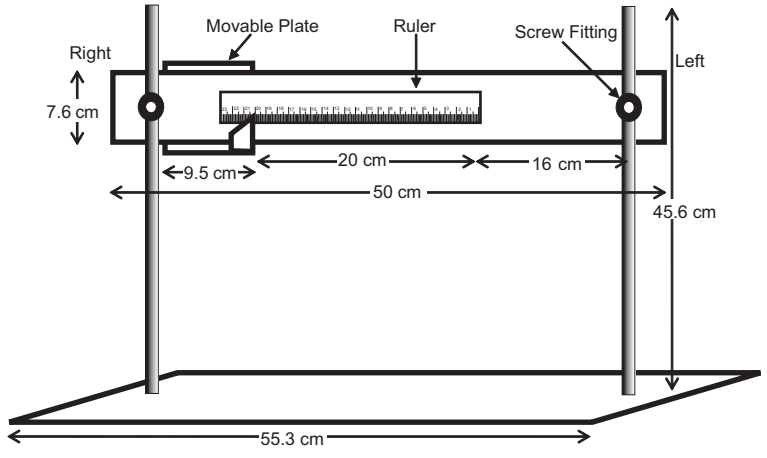

FIG. 2. Back view of the Müller-Lyer apparatus, showing the measuring scale with markings in mm.

distance of 130 cm away from the apparatus for assessment. The difference between the fixed line length of "160 mm" and the measurement of line specified by the participants gave the measure of the amount of illusion for both the trials.

Intervention

There were three experimental conditions, *kapalabhati,* breath awareness, and a control session. The two yoga interventions were *kapalabhati* and breath awareness, which were given on two different days. Participants were randomly allocated to have either *kapalabhati* on the first intervention day and breath awareness on the second intervention day (Group A), or vice versa (Group B). Allocation to Group A or to Group B was carried out using a standard random number table. The total time for the interventions was 18 min. During *kapalabhati,* participants practiced high-frequency yoga breathing at approximately 1.0 Hz with forceful exhalation, for three periods of 5 min. each. After each 5-min. period, there was a 1-min. gap during which they breathed normally. Hence, the duration was 18 min.

During breath awareness, participants were asked to sit with their back straight and the rest of their body relaxed. They were asked to be aware of the flow of air entering and passing through the nasal passage. They were told to avoid modifying any aspect of their breath such as the rate or depth. The duration was 18 min.

Breath awareness involved directing the attention to the breath without changing the rate or depth or any other aspect of breathing. In contrast, *kapalabhati* involved increasing the rate of breathing, so that it is between 1.0 and 2.0 Hz and exhalation is an active not a passive process (as it usually is). In the present study, during *kapalabhati* the breath rate ranged between 0.83 and 1.17 Hz.

The control group was instructed to allow random thoughts to pass through their mind without modifying them. There was no other activity. Experimenters timed the sessions so that all participants did the two practices, as well as the control session, at least 3 hr. after their last meal.

Data Analysis

Statistical analysis was done with Predictive Analytic Software (Version 18.0, SPSS, Inc.). Repeated-measures analysis of variance (RM–ANOVA) was performed with three within-subject factors, i.e., Sessions (*kapalabhati* and breath awareness), States (pre and post), and Trials (In Trials and Out Trials). An ANOVA was followed by *post hoc* analyses with Bonferroni adjustment. In order to assess whether repeating the test after 18 min. without an intervention would influence the result, data were collected in 15 male nonyoga practitioners of comparable age and the pre–post data were compared using a paired *t* test.

Results

The RM–ANOVA showed a significant difference between the two States ($F_{1,29} = 27.20$, $p < .001$; Huyhn-Feldt epsilon = 1.00) and two Trials ($F_{1,29} = 30.92$, $p < .001$; Huynh-Feldt epsilon = 1.00). There was no significant difference between the two Sessions.

Post hoc *Tests for Multiple Comparisons*

Post hoc analyses were performed with Bonferroni adjustment for multiple pair-wise comparisons of values for both trials, i.e., In Trials and Out Trials. Following *kapalabhati,* all participants showed a significant decrease in the degree of optical illusion for Out Trials compared to before ($p < .001$).

Similarly, there was also a significant decrease in the post-mean optical illusion for In Trials following breath awareness compared to before mean values ($p < .05$). The nonyoga practitioners showed no significant change in the pre–postcomparison (i.e., $p > .05$).

The pre–postmean effect sizes of *kapalabhati,* breath awareness, and control sessions for In Trials were 0.30, 0.27, and 0.04, respectively, and for Out Trials were 0.55, 0.20, and 0.54, respectively. Means and standard deviations, effect sizes, and percentage changes are shown in Table 1.

TABLE 1

Degree of Optical Illusion Obtained in Both the Trials From Practices of *Kapalabhati*, Breath Awareness, and Control Sessions; Values Are Group Means and Standard Deviations

Trial	State and Percentage Change	Session					
		Kapalabhati ($n = 30$)		Breath Awareness ($n = 30$)		Control ($n = 15$)	
		M	*SD*	*M*	*SD*	*M*	*SD*
In Trial	Pre-	3.61	1.44	3.86	1.57	3.53	1.16
	Post-	3.12	1.83	3.43	1.65*	3.58	1.08
	Percentage change	−13.57		−11.13		+1.32	
	Effect size	0.30		0.27		0.04	
Out Trial	Pre-	4.59	1.37	4.23	2.13	4.47	1.62
	Post-	3.87	1.27*†	3.83	1.79	5.26	1.28
	Percentage change	−15.68		−9.45		+17.6	
	Effect size	0.55		0.20		0.54	

Note.—The 30 participants in *kapalabhati* and breath awareness sessions were different from the 15 participants in the control session. *$p < .05$, †$p < .001$ using repeated-measures analysis of variance RM–ANOVA, *post hoc* tests with Bonferroni adjustment comparing pretrials and posttrials.

Discussion

The present study assessed the immediate effect of a high-frequency yoga breathing (*kapalabhati*) and breath awareness practice on the degree of optical illusion perceived using the Müller-Lyer illusion. Follow-

ing both the practices there was a decrease in the degree of optical illusion. In order to rule out a possible practice effect between pre- and posttests, fifteen nonyoga practitioners were tested twice over the same period (18 min.) as the experimental groups, and did not show any significant difference. This suggests that a practice effect can be ruled out and the decrease in illusion perceived after *kapalabhati* and breath awareness was due to the practices.

Previously a combination of yoga practices, which included both *kapalabhati* and breath awareness (each as 15 min. practice per day) over a month, decreased the degree of optical illusion by 86.2% (Telles, *et al*., 1997). In the present study the percentage decrease in the degree of optical illusion was significantly less after *kapalabhati* (15.7% for Out Trials) and after breath awareness (11.1% for In Trials). This difference could be due to the fact that in the earlier study (Telles, *et al.,* 1997), (i) participants practiced multiple yoga techniques, and (ii) assessments were made before and after 1 mo. of yoga practice, whereas the present study assessed the immediate effects before and after 18 min. of practice.

Perception of a geometric illusion is influenced by retinal, cortical, and cognitive-judgmental factors (Coren & Girgus, 1978). In general when describing contributory factors to an optical illusion there are structural mechanisms related to the optical and neural properties of the visual system or oculomotor interactions (Hershenson, 1989). The second category of theories invokes strategy mechanisms, referring the illusion to the operation of what are described as cognitive judgmental factors.

Factors such as depth and distance of an object can be perceived because of eye movements, e.g., convergence and binocular disparity between the two eyes, which are signals which reach the brain and are interpreted to help a person judge depth and distance, and hence this helps in visual perception (Bernstein & Nash, 2006). At the level of the retina, mutual inhibition of spatially adjacent neural units accounts for the perception of an illusion involving intersecting and adjacent lines (Von Békésy, 1967). In the present study, particularly considering that the assessment was repeated after 18 min., it would appear more possible that the change could be due to cognitive-judgmental factors (Coren & Girgus, 1973). It is suggested that *kapalabhati* practice activates the neurons concerned with memory, concentration, and perception (Lysebeth, 1983). This might have contributed to the decrease in the degree of illusion following *kapalabhati*. Breath awareness also increases attention and internal awareness (Joshi & Telles, 2009), and hence, breath awareness might also influence cognitive-judgmental factors, reducing the degree of optical illusion perceived.

The study had the following limitations: (i) it would have been ideal to have three separate groups studied in the *kapalabhati*, breath awareness,

and control sessions. In the present study, yoga practitioners ($n = 30$) were studied in *kapalabhati* and breath awareness sessions on separate days, while the nonyoga practitioners ($n = 15$) who formed the control group were studied in a control session; (ii) another limitation of the study was the fact that the numbers in the three groups were not equal; (iii) the actual testing involved the experimenter moving the movable plate of the apparatus at a rate of approximately 1 mm per second; since this was manual and not mechanized, it was not possible for the rate of movement to have been exactly the same for all assessments; and (iv) the participants' distant and near vision were considered normal based on their self-report. It is a limitation of the study that this was not verified by standard tests.

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