

Effect of Yogic Breathing on Accommodate Braille Version of Six-letter Cancellation Test in Students with Visual Impairment

Abstract

Context: Attentional processes tend to be less well developed in the visually impaired, who require special training to develop them fully. Yogic breathing which alters the patterns of respiration has been shown to enhance attention skills. Letter cancellation tests are well-established tools to measure attention and attention span. Here, a modified Braille version of the six-letter cancellation test (SLCT) was used for students with visual impairment (VI). **Aim:** This study aimed to assess the immediate effects of *Bhramari Pranayama* (BhPr) and breath awareness (BA) on students with VI. **Methods:** This study was a self-as-control study held on 2 consecutive days, on 19 participants (8 males, 11 females), with a mean age of 15.89 ± 1.59 years, randomized into two groups. On the 1st day, Group 1 performed 10 min breath awareness and Group 2 performed *Bhramari*; on the 2nd day, practices were reversed. Assessments used a SLCT specially adapted for the visually impaired before and after each session. **Results:** The Braille letter cancellation test was successfully taken by 19 students. Scores significantly improved after both techniques for each student following practices on both days ($P < 0.001$). BhPr may have more effect on attention performance than BA as wrong scores significantly increased following BA ($P < 0.05$), but the increase in the score after *Bhramari* was not significant. **Conclusions:** Despite the small sample size improvement in attentional processes by both yoga breathing techniques was robust. Attentional skills were definitely enhanced. Long-term practice should be studied.

Keywords: Attention, Braille, pranayama, six-letter cancellation test, visual impairment

Introduction

Higher cognitive functions, including attention and memory, are affected by low visual ability, particularly in those who are visually impaired. Children with visual impairment (VI) are observed to have lower attentional capacity than the normal sighted.^[1] Attention training improves cognitive function, levels of independence, increasing participation in daily activities, awareness of environments, and capacity for focused attention on school work,^[2] all of which contribute to quality of life.

Yoga breathing processes are directly connected to the brain and central nervous system, and also the hypothalamus, which is responsible for transforming perception into cognitive experience.^[3] Breath awareness (BA) is an integral component of the practice of many yoga techniques, and one of the main goals of yoga is to maintain constant awareness of a relaxed breathing process. *Bhramari Pranayama* (BhPr) is one such practice. Performed in a

relaxing body posture, it requires a humming sound to be generated during exhalation.^[3] Through long exhalation and short inhalation, it slows breathing rhythms. Its repetitive, mind-settling aspects relate it to mantra meditation techniques, so it is considered both a pranayama and a meditation technique. Its performance has been observed to produce paroxysmal gamma in the electroencephalogram (EEG)^[4] associated with brain information processing, sensory processing, attention, and working memory. It reduces stress and factors influencing memory, improving academic performance in children.^[5]

Six-letter cancellation test (SLCT) is a widely applied psychomotor function test assessing sensory information processing from a wide visual field; specifically, functions such as focused attention, psychomotor speed, and fine motor coordination.^[6] Some studies have used it to compare changes in attention produced by relaxation techniques;^[7,8] educational systems;^[9] and psychomotor performance

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in depressed patients.^[10] However, to our knowledge, no previous study has measured the immediate effects of BhPr on attention in the visually impaired. Hence, the present study aimed to evaluate attentional performance using a version of the SLCT converted into Braille following two breathing practices, i.e. BhPr and BA.

Materials and Methods

Participants

A total of 19 students, 8 males and 11 females, aged 15–19 years (mean = 15.89 ± 1.59) were all attending a special residential school in Odisha, India, the “Government High School for the Blind.”

Inclusion criteria

Students who had (a) VI since birth; (b) aged 15–19 years; (c) no earlier exposure to yoga, and (d) agreed to give informed consent were included in the study.

Exclusion criteria

Students with (a) other physical or mental challenge; (b) multiple impairments; (c) learning disability; (d) any injury restricting the practice of yoga, or (e) any medically diagnosed neurological illness or brain damage were excluded from the study.

Ethical approval

SVYASA’s ethical committee approved the study prior to its implementation. Details of the study were explained to the school authority and the participants, and signed informed consent forms were obtained.

Interventions (10 min each)

Bhramari Pranayama

Participants sat crossed leg (*Sukhasana*) with head, neck, and spine aligned, thumbs blocking each ear, and middle fingers keeping the eyelids firmly closed (a simplified version of *Shanmukhi Mudra* without closing nose and mouth as well). They were then instructed to breathe in as slowly as was comfortable, and while slowly breathing out, to produce a humming sound like that of a humming bee.

Breath awareness

Participants were instructed to sit crossed leg with spine erect and eyes closed, and observe their normal breathing without manipulating rate, depth, or pattern. To avoid diurnal biorhythm effects, sessions were held at the same time of day (8–8.30 am). Each intervention session was led by the yoga therapist and trained assistants.

Assessment

A modified Braille version of SLCT was used in this study. The normal SLCT worksheet consists of three parts: the first concerns participants’ name, age, gender,

date, and test instructions. The second part specifies the target letters, while the third part is the working section, comprising a 14 row × 22 column array of randomized letters. Participants are instructed to cancel as many target letters as possible within the 90 s test period; possible strategies are suggested, either one letter at a time, or all at once. Tests are scored for: number of cancellations attempted, wrong cancellations, and number of correct cancellations. Uncancelled target letters are not considered as wrong cancellations, since the visual field is broad, and practitioners may not have focused on them.^[11]

The modifications of the SLCT into a form suitable for children with VI took place in five steps, including changes in test design, administration, and scoring. The detail process of modification as well as reason for the changes of the SLCT is mentioned in Flow Chart.

After each modification, it was first tested on seven of the school teachers who were visually impaired and agreed to evaluate the converted version of SLCT. Further changes were then made according to their suggestions. Only when the teachers were comfortable with the test, it was given to the students for preliminary testing.

The final modified SLCT consists of a worksheet containing randomly arranged Braille letters and a separate sheet specifying six target letters. Prior to starting the test, it was clearly explained to the students. First the sheet containing the target letters was distributed and participants were instructed to remember the six letters and repeat them verbally. Then, the worksheet was distributed and the test was conducted.

To make the participants more familiar with the procedure, two SLCT trial sessions were held 2 days prior to the main experiment. The first group practiced BhPr on the 1st day and BA on the 2nd day, while the second group practiced in reverse order. Groups were assessed as mentioned in Table 1.

Data analysis

Statistical analysis was performed using SPSS version 24 (IIM Corporation, California); the specific analysis being repeated measures analyses of variance (ANOVA); there was one within-subjects factor, time with two levels (pre and post), and one between-subjects factor, session with two levels (BhPr and BA). *Post hoc* tests of

Table 1: Assessment protocol for both groups on day 1 and day 2

Day	Group	Test	Practice	Test
Day 1	Group 1	Pretest	BA (10 min)	Posttest
	Group 2	Pretest	BhPr (10 min)	Posttest
Day 2	Group 1	Pretest	BA (10 min)	Posttest
	Group 2	Pretest	BA (10 min)	Posttest

Group 1 and Group 2 took the SLCT before and after both Bhr and BA; order of practice was reversed on both days. SLCT: Six-letter cancellation test, BA: Breath awareness, BhPr: Bhramari pranayama

significance between mean values included Bonferroni adjustments.

Results

Demographic characteristics such as age ($P = 0.261$), gender ($P = 0.663$), and years of experience in learning Braille ($P = 0.929$) were matched for both the groups. There was a statistical difference in both the groups at baseline on net score of SLCT on day 1 ($P = 0.021$) whereas no difference was found on day 2 ($P = 0.330$). Table 2 presents the mean and standard deviation values separately for day 1 and 2. Table 3 shows the combined results for the two groups, comparing overall results for each breathing technique. No learning effect was observed due to prior exposure to test materials on the previous day ($P > 0.05$). Both breathing techniques produced highly significant improvements in attention score. Total SLCT scores increased from 18.84 to 33.37 ($P < 0.001$) and from 21 to 31.53 ($P < 0.001$) after practicing BA and BhPr, respectively. Regarding accuracy level, wrong score significantly increased after the BA session (66%, $P = 0.035$), whereas after the BhPr session, the increase in wrong score (5%, $P = 0.772$) was not significant. In group time interaction, the change over time differences between the groups found significant difference in total score ($P = 0.010$) and net score ($P = 0.015$) but not in wrong score ($P = 0.086$). The groups' mean values and standard deviation of scores for SLCT, in BhPr and BA sessions, are summarized in Tables 2 and 3.

Table 2: Results of Group 1 and Group 2 on day 1 and day 2 separately

	Day-1 BA		Day-2 BhPr	
	Pre	Post	Pre	Post
Group-1 ($n=12$)				
Total	16.17±5.10	30.00±9.73	24.00±6.27	39.14±7.99
Wrong	0.67±0.98	1.33±1.43	1.86±1.57	2.00±1.83
Net	15.50±5.38	28.67±9.47	22.14±5.67	37.14±6.82
	Day-1 BhPr		Day-2 BA	
	Pre	Post	Pre	Post
Group-2 ($n=7$)				
Total	19.25±7.74	27.08±8.25	23.43±5.62	39.14±3.34
Wrong	0.42±0.51	0.42±0.67	1.43±1.81	2.00±1.41
Net	18.83±7.54	26.67±8.05	22.00±5.29	37.14±3.02

Scores for the two groups for day 1 and day 2 separately. BA: Breath awareness, BhPr: Bhramari pranayama

Table 3: The combined results of Group 1 and Group 2 on day 1 and day 2

Scores	BA			BhPr			Pre versus pre	
	Pre	Post	Percentage change	Pre	Post	Percentage change	Learning effect	Group × time
Total	18.84±6.27	33.37±9.06***	77	21±7.43	31.53±9.93***	50	0.109	0.010
Wrong	0.95±1.35	1.58±1.43*	66	0.95±1.22	1.00±1.41	5	0.081	0.085
Net	17.89±6.12	31.79±8.69***	77	20.05±6.94	30.53±9.06***	52	1	0.015

*** $P < 0.001$, * $P < 0.05$. BA: Breath awareness, BhPr: Bhramari pranayama

Discussions

To our knowledge, this was the first self-as-control study on immediate effects of BhPr and BA on attention performance in children with VI. It suggested significant potential benefits. Development of techniques to help children with VI improves school performance and performing activities independently has recently become a priority. The reported results indicate that breathing practices can contribute to both these goals by enhancing students' attention span.

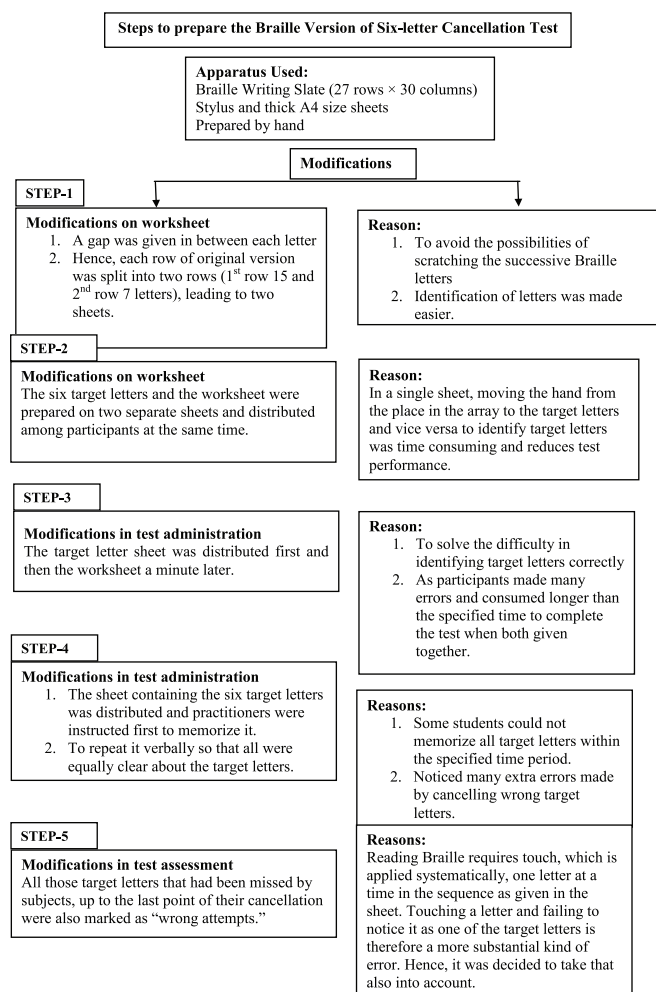
For the purpose of this study, SLCT was developed in Braille script (as far as we know, for the first time) to measure these cognitive abilities in the visually impaired. Some modifications were essential to be made to the original 22×14 letter worksheet.

SLCT counts both the total number of cancellations and the number of wrong cancellations; net score equals the first minus the second.^[11] In scoring of our Braille version for the VI, correct letters that were missed were also marked as "wrong attempts."

Pre-post comparison of SLCT performance indicated highly significant immediate improvement after both kinds of breathing practice, suggesting that the alertness produced by paying attention to the breathing process in both techniques, combined with the restfulness produced during technique performance, was responsible for the observed improvements. Whether this is a purely physiological result, or if it involves a learning process internalized during the 10-minute technique practice, cannot be determined from this experiment alone.

However, the between-sessions comparison found that scores increased more following BA practice (77%) than following BhPr practice (50%). Regarding accuracy, wrong score increased significantly following the BA session, but after BhPr session, the increase in the score was not significant. Though the percentage of improvement was more in BA session, the wrong score also increased significantly, whereas after BhPr session, the increase in the score was not significant which indicates a positive effect of BhPr than BA.

An earlier study had shown significant increase in SLCT performance immediately after the practice of *Kapalabhati* in adult healthy volunteers.^[12] Two separate studies of effects of breathing techniques on SLCT found that yoga practice^[13] and meditation^[14] improved SLCT scores than the control technique.



Flow Chart : Steps to prepare the Braille version of six letter cancellation test

Meditation has been shown not only to benefit higher-order cognitive functions, but also to alter brain activity. A study comparing 22 meditators and 22 age-matched nonmeditators found meditators to have more gray matter in regions of the brain important for attention, emotion regulation, and mental flexibility.^[15] BhPr has been found to be closely linked to meditation; both BhPr and meditation have similar effects on physiological relaxation and mental calmness.^[4,16,17] In BhPr, pressing the eyeballs stimulates the vagus nerve and leads to activation of the parasympathetic nervous system^[18] which governs relaxation, recuperation, and digestion of the body.^[19]

The current results on improved children's attention concur with previous findings that yoga interventions improve SLCT scores. We hypothesized that improved attention may be because the resonating and repetitive effects of BhPr's humming bee sound resemble mantra repetition which has been shown to increase EEG activity in the theta band.^[4] These aspects of BhPr should generate subjective feelings of physical relaxation and mental calmness, and hence reduce any sense of mental fatigue. This reasoning may help explain some of the impact of BhPr on attention.

We conclude that BhPr may be an effective means for improving attention performance in visually impaired children.

Limitations

The study has some important limitations requiring consideration: (a) Validity and reliability of the modified test are not assessed. (b) In the print version, participants were able to quickly refer to the six target letters at the top of the page as they scanned the array for matching letters. In the Braille version, referring back to the target letters was much more of a time-consuming process. Even though the participants were given time to memorize the target letters, and they repeated them verbally to demonstrate that they had memorized them, the Braille version of the test remains, in fact, a memory test. Even if the letters have been memorized, the participant must rely on their memory in matching letters in the array with the target letters. (c) The score letters were not noticed as errors in the Braille version, whereas these omissions were simply not counted in the original print test. Although a justification was provided for this change, stating that failing to notice a letter is a more significant error in Braille than in print reading, this results in a substantial change in the nature of the test. (d) Prior commencing the study, a Braille skill pretest was essential to ensure that all of the participants had the Braille skills. (e) Due to the small sample size, we could not add gender as a factor on ANOVA to see if there were any significant differences. (f) the same 90 s was used for the Braille test as in the print version. (g) The study was too brief to assess lasting effects of the intervention. Considering all these limitations, the further validation process is under progress.

Strengths

The major strength of the study was that the statistics indicate a robust result: both yoga techniques produced highly significant improvements in attention, a crucially important function of awareness, which tends to be reduced in the VI as a consequence of their disability.

Suggestions for future research

Generalizability of these results needs to be tested. Future research requires incorporating different age groups, levels, and onset ages of blindness, and their interaction with different yoga practices to produce various changes at the known different levels of attention by means of various assessment methods needs to be investigated, as so associated changes in other classes of measure, for example, physiological (autonomic, respiratory, etc.), neurophysiological (event-related potentials, etc.), neurochemical (cortisol, etc.), and neuroimaging processes recorded while performing the task to better understand the underlying processes involved.

Conclusion

Producing the humming bee sound of BhPr, related to mental chanting of “M” *kara*, improves attention performance as one of its immediate effects. More generally, the practice of selected yoga techniques may be a valuable means to improve attention performance, especially in children and youth. Further research should be made on their application to visually challenged children.

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Conflicts of interest

There are no conflicts of interest.

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