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THE EFFECTS OF UNILATERAL FORCED NOSTRIL BREATHING ON COGNITIVE PERFORMANCE

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This study describes the effects of 30 minutes of unilateral forced nostril breathing on cognitive performance in 51 right-handed undergraduate psychology students (25 males and 26 females). A verbal analogies task modeled after the Miller Analogies and SAT Tests was used as a test of left-hemispheric performance and mental rotation tasks based on the Vandenburg and Kuse adaptation of Shepard and Metzler's tests were used as spatial tasks for testing right-hemispheric performance. Spatial task performance was significantly enhanced during left nostril breathing in both males and females, $p = .028$. Verbal task performance was greater during right nostril breathing, but not significantly $p = .14$. These results are discussed in comparison to other cognitive and physiological studies using unilateral forced nostril breathing. This yogic breathing technique may have useful application in treating psychophysiological disorders with hemispheric imbalances and disorders with autonomic abnormalities.

Keywords: Unilateral forced nostril breathing, nasal cycle, cognitive performance, cerebral dominance, autonomic nervous system, ultradian rhythms.

Unilateral forced nostril breathing (UFNB) is a therapeutic practice that has its origins in yogic medicine and was apparently discovered more than five thousand years ago (Shannahoff-Khalsa, 1991a, 1991b). Over the last six decades both physiological and psychological studies have been conducted on the selective stimulatory effects of UFNB. Samzelius-Lejdstrom (1939) studied 182 humans and showed that the movements of one thoracal half were much more inflated by forced inspiration through the homolateral nostril in 94% of the subjects. She also observed that the "variations in width of one half of the nasal cavity caused variations in the amplitude of the movements of the homolateral thoracal half." This latter observation suggests that the nasal cycle, an ultradian rhythm of lateralized differences of nasal airflow, correlates with differential levels of lateralized lung inflation. Earlier Wotzilka and Schramek (1930) studied rabbits under experimental conditions and showed that if

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coal dust was inhaled through one nasal opening, it was deposited in much larger quantities in the homolateral lung. Other studies in humans support the existence of a unilateral nasal-pulmonary reflex mechanism which is clearly elicited when there is a forced inhalation through one nostril, producing a significant increase in inflation of the homolateral lung (Sercer, 1930; Stoksted, 1960; Drettner, 1970).

In 1948, Friedell reported an interesting clinical result using UFNB. He found that "diaphragmatic breathing with attention to both phases of respiration and the intervening pauses" coupled with "alternately closing one nostril while inhaling slowly through the other" had profound effects on patients with angina pectoris. The 11 patients in his study all experienced relief from symptoms using this breathing technique and were able eventually to curtail the use of nitroglycerin. Shannahoff-Khalsa and Kennedy (in press) studied the effects of UFNB on the heart and found a differential right-left effect on heart rate and end diastolic volume in humans. They found that right UFNB increased heart rate and that left reduced it. They suggest this effect is the result of a differential unilateral sympathetic activation and that right UFNB increases stimulation of the sino-atrial node. They also found that left compared to right UFNB increases end diastolic volume. These effects appear to be the result of the homolateral nasal reflex mechanisms. They suggest that the result of Friedell (1948) is produced by balancing the autonomic input to the heart and, thus, somehow helping to eliminate the symptoms of angina.

Werntz, Bickford, Bloom and Shannahoff-Khalsa (1981, 1983) and Werntz, Bickford, and Shannahoff-Khalsa (1987) reported on the effects of UFNB on electroencephalographic activity (EEG) in humans and demonstrated how UFNB could produce relatively greater EEG amplitudes in the contralateral hemisphere. They predicted that these shifts towards greater EEG amplitudes correlate with increased mental activity, i.e., UFNB produced increased mental activity in the contralateral hemisphere. Their interpretation of greater EEG amplitudes reflecting greater mental activity was controversial. However, in part, their conclusion was based on the fact that autonomic fibers do not cross over between the central and peripheral systems (Sapen, Loewry, Swanson & Cowan 1976). Therefore, unilateral sympathetic stimulation to the cortex via UFNB would reduce blood flow and mental activity in the homolateral cortex. In 1983 Werntz et al. used the EEG to show that the nasal cycle is tightly coupled to an alternating lateralization of cerebral hemispheric activity in humans (for review of this cerebral rhythm see Shannahoff-Khalsa, 1991a, 1993). This relationship is suggestive that the effects of UFNB are mediated through the autonomic nervous system ANS.

Klein, Pilon, Prosser, and Shannahoff-Khalsa (1986) observed a significant relationship between the pattern of nasal airflow during normal breathing and spatial versus verbal performance that was independent of sex. Right nostril dominance correlated with increased verbal performance, or left brain activity, and left nostril dominance correlated with increased spatial performance. However, they failed to show that UFNB could alter mental activity. Shannahoff-Khalsa, Boyle, and Buebel (1991) used cognitive tasks different from those of Klein et al. (1986) and showed that left UFNB increased spatial skill performance and right UFNB increased verbal skills performance in males (females were not included).

However, a study by Block, Arnott, Quigley and Lynch (1989) found mixed and partially conflicting results with the Werntz et al. (1981, 1983, 1987), Klein et al. (1986), and Shannahoff-Khalsa et al. (1991) studies. Block et al. (1989) found in males that left UFNB increased verbal skills and that right UFNB increased spatial skills, but that in females left UFNB increased spatial skills with no cognitive differences using right UFNB. Therefore, their results with males (but not females for left UFNB) conflict with earlier studies and interpretations. More recently Sanders, Lattimore, Smith, and Dierker (1991) failed to replicate the Block et al. (1989) findings.

The works of Kristof, Servit, and Manas (1981) and of Servit, Kristof and Strejckova (1981) also support the existence of a unilateral nasal reflex mechanism. Kristof et al. (1981) showed that local anesthesia of the mucosal membrane suppressed the cortical effects of EEG activity generated by nasal (versus oral) airflow stimulation. This activating effect could also be produced by air insufflation into the upper nasal cavity without inflating the lung. Servit et al. (1981) showed how deep breathing through one side of the nose could activate abnormalities in epileptic patients with unilateral focal or lateralized paroxysmal abnormalities in the fronto- or occipitotemporal region. "The abnormalities of this type were significantly more activated from the ipsilateral nasal cavity." However, these paroxysmal abnormalities were also generated with contralateral breathing to the foci in 60% of the patients. These abnormalities are not equivalent to the sustained contralateral increases in EEG produced in the Werntz et al. (1981, 1983, 1987) studies, as this paroxysmal activity manifests as intermittent spikes in only a small fraction of the record with epileptic patients. However, it is an example of how lateralized EEG activity can be affected by UFNB.

Backon (1988), Backon and Kullock (1989), and Backon, Matamoros, and Ticho (1989) demonstrated the effects of UFNB on other autonomic related phenomena. As proposed by Werntz et al. (1981, 1983, 1987), right nostril dominance correlates with the "activity phase" of the basic rest-activity cycle (BRAC). Backon (1988) showed how right UFNB significantly increased blood glucose levels and that left UFNB lowered it, supporting this hypothesis. Backon and Kullock (1989) also showed how UFNB can affect involuntary eyeblink rates. They found that right UFNB reduced blink rates and that left UFNB increased involuntary blink rates. Backon et al. (1989) also showed how intraocular pressure can selectively be altered by UFNB. They found that right UFNB led to an average decrease of 23% in intraocular pressure and that left UFNB increased it by an average of 4.5%. They claim that increased vagal tone increases intraocular pressure. This is further evidence that right UFNB increases the generalized sympathetic tone of the body, thus correlating with the "active phase" of the BRAC as proposed by Werntz et al. (1981, 1983, 1987).

The present study was conducted to explore further the effects of UFNB on cognitive performance with the prediction that right UFNB increases verbal performance and that left UFNB increases spatial performance. Different protocols, cognitive tasks, and times of UFNB were employed compared to the previous studies.

METHODS

Subjects

Seventy-four undergraduate psychology students volunteered for this study and received credit towards their class assignments. Twenty-three subjects were eliminated due to left-handedness, nasal abnormalities, respiratory disorders, previous head injury, or recent drug use. The final sample consisted of 51 right-handed subjects: 26 females and 25 males, ages 17–40 (mean 20.7 yr.).

Materials

Nostril dominance was determined by using a mirror to measure the right-to-left condensation patterns upon exhalation; the so-called Zwaardemaker method (Gertner, Podoshin, & Fradis, 1984). With this method the condensation of the dominant nostril is larger and visible longer.

The Verbal Test

The verbal analogies task was modeled after practice exams for the Miller Analogies and SAT tests. Researchers have found that verbal analogies activated the left hemisphere in terms of regional cerebral blood flow (Gur & Reivich, 1980; Risberg, Halsey, Wills, & Wilson, 1975) and glucose metabolism (Gur, Gur, Rosen, Warach, Alavi, Greenberg, & Reivich, 1983). Both the number of attempted questions and the number of correct answers were scored.

The Spatial Test

In 1978, Vandenburg and Kuse adapted Shepard and Metzler's (1971) Mental Rotations for group presentation. This paper and pencil test version of spatial visualization was utilized here. Spatial visualization is defined as the ability mentally to rotate, manipulate, and twist two- and three-dimensional stimulus objects.

The test consisted of 20 sets of stacked cubes with five items per set. There is a criterion figure that serves as the stimulus, two correct alternative figures, and two incorrect figures in each set. Each stimulus has been rotated about the vertical axis to make the correct alternative figures. Vandenburg and Kuse (1978) showed this assessment procedure to have strong associations with tests of spatial visualization and essentially no association with tests of verbal ability. Several experiments have found mental rotations to be an excellent measure of human spatial ability and right hemisphere processes. McGee (1979) reviewed the literature on human spatial abilities and found that mental rotations is a measure of right hemisphere functioning. Right parietal cerebral activation was confirmed using evoked potentials and regional cerebral blood flow measures (Papanicolaou, Deutsch, Bourbon, Will, Loring, & Eisenberg, 1987; Deutsch, Bourbon, Papanicolaou, & Eisenberg, 1988).

The procedure used for scoring was to count two points for each set of questions that had both correct answers identified. If only one design was chosen and it was correct, one point was given. If any figure(s) other than the two correct answers were marked, no points were given. This procedure eliminated the need to correct for guessing. The number of attempted questions answered was also tallied.

Procedures

Subjects were tested in groups of 10 to 12 at a time. Their nostril dominance was determined at the beginning of the experiment by using the Zwaardemaker method. This dominance was used to assign a counterbalanced test booklet for order of verbal and spatial testing randomly. Subjects plugged the side of their nose that they had noted as being the most congested in two out of three trials with a compressible foam earplug and tape. This procedure was designed to help keep the subjects dominant in the more open nostril as they entered the experiment room for the first treatment period.

A verbal and a spatial test were then administered for five minutes preceded by a practice test. Subjects then removed the nostril plug and were given a 5 min free breathing period. At the end of that time they plugged their dominant nostril.

During the next 30 min subjects completed the handedness questionnaire, personal data information, and their school forms. They were reminded to focus on their breathing and to avoid oral breathing. The 30 min limit with the other nostril plugged was considered to be sufficient time to enhance dominance of the contralateral hemisphere. The same procedure using the equivalent forms of the verbal and spatial tests was then repeated. At the end of the last test subjects measured their nostril dominance again.

The data were analyzed using repeated measures MANOVAs on SPSS 4.1 software.

RESULTS

Subjects in the left nostril breathing (LNB) condition (mean = 14.76, std. dev. 5.03) attempted significantly more questions on the spatial task than in the right nostril breathing (RNB) condition (mean = 12.22, std. dev. 4.98) $F(1,50) = 15.80$, $p < .001$. Subjects in the LNB condition (mean = 11.31, std. dev. 7.45) also correctly answered significantly more questions than in the RNB condition (mean = 9.24, std. dev. 5.35) on the spatial task, $F(1,50) = 5.09$, $p < .028$.

Subjects in the RNB condition (mean = 16.37, std. dev. 3.54) attempted fewer verbal questions than in the LNB condition (mean 16.63, std. dev. 3.52). However, the difference was not significant, $F(1,50) = .24$, $p > .05$. Subjects in the RNB condition (mean = 8.78, std. dev. 3.02) correctly answered more verbal questions than in the LNB condition (mean = 8.14, std. dev. 2.53). This was not a significant effect but it was in the predicted direction, $F(1,50) = 2.23$, $p = .14$.

Repeated measures ANOVAs were calculated on the sex × nostril breathing conditions using the spatial scores (number attempted and correct), and the verbal scores (number attempted and correct). Differences in performance on the spatial and verbal tasks between males and females and the nostril breathing condition were assessed.

There was no significant difference between males (mean = 15.12, std. dev. 4.49) and females (mean = 14.42, std. dev. 5.57) for spatial attempts, $F(1,49) = .09$, $p > .05$. There was a significant effect with males (mean = 14.28, std. dev. 8.74) scoring better than females with the LNB condition (mean = 8.46, std. dev. 4.54) on the correctly answered spatial questions, $F(1,49) = 9.80$, $p = .003$.

There was no significant effect between the sexes (males = 16.48, std. dev. 3.07; females = 16.77, std. dev. 3.96) on the number of verbal questions attempted, $F(1,49) = .70$, $p > .05$. There was no significant effect on the nostril breathing condition and the verbal attempted scores, $F(1,49) = .25$, $p > .05$. No significant difference was found on the verbal correct scores between the sexes (males = 8.16, std. dev. 2.56; females = 8.12, std. dev. 2.55) $F(1,49) = 1.06$, $p > .05$. There was no significant effect between the nostril dominant on the number of verbal questions correctly answered (males LNB = 8.16, std. dev. 2.56, males RNB = 8.08, std. dev. 2.69; females LNB = 8.12, std. dev. 2.55, RNB = 9.46, std. dev. 3.22) but the results were in the predicted direction, $F(1,49) = 2.21$, $p = .14$.

It was anticipated in some subjects that the dominant nostril at the beginning of the experiment might shift so that the opposite nostril would be dominant at the end of the experiment. Only 12 (23.5%) subjects recorded a change in nostril dominance. In order to understand whether a nostril dominance change was necessary to affect the outcome, ANOVAs were run only on those subjects who had reported a change in nostril dominance over the experiment and their test scores. There was no significant effect across all tests that would account for nostril dominance change affecting the other measures.

Another methodological consideration was contemplated as potentially affecting the subject's performance. Practice and fatigue effects between the first treatment period and the second administration of the tests were examined. To rule-out these effects, ANOVAs were calculated on the order of task presentation on all spatial and verbal scores. There were no significant effects on either the spatial or verbal questions attempted or correctly answered. The lack of evidence for a significant effect for task administration order implies that there was no practice or fatigue effects to justify the performance difference between the two treatment periods.

DISCUSSION

These results support the hypothesis that left nostril breathing increases spatial performance as scored by the number of questions attempted and answered correctly. However, it did not validate that right nostril breathing increases verbal performance. There was no significant effect on verbal tasks attempted, although the predicted direction was obtained on analysis of the number of verbal questions answered correctly (p = .14).

Both sexes attempted significantly more spatial questions in the LNB condition. However, there were no significant differences on spatial attempts between sexes. Both sexes correctly answered significantly more spatial questions in the LNB condition, but males performed significantly better than females on the number of correctly answered spatial questions in the LNB condition. There were no significant effects across sex and verbal scores attempted; however, the number of verbal questions answered correctly with the RNB condition approached significance.

No practice or fatigue effects were evident. Also, change of nostril dominance between the beginning of the experiment and the end of the experiment appeared to have no effect on the outcome of the results.

Although these results are only statistically significant with the LNB condition for increased spatial performance, or right-hemispheric skills, and are marginal but in the predicted direction for right UFNB in both sexes, they support the interpretation of the EEG studies by Werntz et al. (1981, 1983, 1987). The EEG studies were interpreted such that left UFNB increases mental activity in the right hemisphere and that right UFNB increases mental activity in the left hemisphere in both males and females. These results are also consistent with the findings of Klein et al. (1986) which showed a correlation between left nostril dominance and right-hemispheric ability and right nostril dominance and left-hemispheric ability with normal breathing that is independent of sex. In addition, these results are consistent with those of Shannahoff-Khalsa et al. (1991) who found that left UFNB increases spatial skills, or right-hemispheric performance, and right UFNB increases verbal skills, or left-hemispheric performance, in a study limited to males. However, these results partially conflict with those of Block et al. (1989), who found in males that right UFNB increased performance on spatial tasks and that left UFNB increased performance on verbal tasks. But their results with females for left UFNB are consistent with our results reported here, i.e., improvement on spatial tasks. Block et al. (1989) did not find significant differences for females with right UFNB. When they combined sexes they found no significant nostril × task differences.

A major difference with the studies observing the effects of UFNB on cognition is that the verbal and spatial skills are not the same. The exception is the attempted replication of the Block et al. (1989) study by Sanders et al. (1991) who failed to replicate the results and found no nostril × task differences. Sanders et al. (1991)

also used the same times for the breathing conditions as the Block et al. (1989) study. The present study and that of Shannahoff-Khalsa et al. (1991) both used forced nostril breathing periods of 30 min before testing which is more than twice as long as the period in the Block et al. (1989) study. This may account in part for the differences. It appears that the reliability of the cognitive task as a measure of hemispheric specialization is another important factor.

Additional studies are required to help further elucidate the effects of UFNB on both males and females. However, the only results that are statistically significant and differ from the LNB-right brain enhancement and RNB-left brain enhancement relationships are those with the male subjects in the Block et al. (1989) study.

Also, most recently, Schiff (1992) investigated the effects of UFNB and nasal dominance on emotions. He found that subjects who were left-nostril dominant and continued to force breath through the left nostril gave reports of emotion and stories told about an ambiguous picture that were more negative than after right-sided breathing when subjects were right-nostril dominant. These results also support the contralateral effect of UFNB and hemisphere related mental activity since it is generally held that the right hemisphere is dominant for negative emotions and that the left is dominant for positive emotions (for review see Silberman & Weingartner, 1986).

The application of UFNB in therapy[1] for treating and preventing psychophysiological disorders deserves further study. Its possible value in enhancing educational performance also merits attention. This noninvasive method has a rich history in yogic medicine and apparently has some validity when studied in the laboratory.

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[1]SAJ defines this therapy as "psycholateral psychology."

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