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Right uninostril yoga breathing influences ipsilateral components of middle latency auditory evoked potentials

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Abstract A previous report described selective electrical activity of the cerebral hemispheres with uninostril breathing. In the present study, middle latency auditory evoked potentials (MLAEPs) were recorded from symmetrical scalp sites during the practice of uninostril yoga breathing. There were two sessions (40 min each) of right nostril yoga breathing (RNB) and of breath awareness (BAW), with (i) 'before', (ii) test (either RNB or BAW) and (iii) 'after' periods. The participants were 14 male volunteers aged between 18 and 33 years, and the setting was a yoga centre. MLAEPs were recorded from symmetrical scalp sites (C4 and C3). During RNB, the peak amplitudes of two negative components (viz. Na wave and Nb wave) were significantly increased on the right side. Increased peak amplitudes of Na and Nb waves suggested that RNB increased the number of neurons recruited on the right side, suggesting a possible application of RNB in certain psychiatric disorders with cerebral hemispheric imbalance.

Key words Right nostril yoga breathing • Breath awareness • Middle latency auditory evoked potentials

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Introduction

The nasal cycle is an ultradian rhythm with alternating patency of the left and right nostrils, occurring every one to eight hours [1]. In awake humans, these spontaneous shifts in nostril dominance have been correlated with changes in the activity of the two cerebral hemispheres, based on electroencephalographic (EEG) studies [2], performance in hemisphere-specific tasks [3] and studies of cerebral blood flow [4]. In addition to spontaneous shifts the EEG changes with forced uninostril breathing were also studied, and a higher amplitude was reported over the hemisphere contralateral to the nostril kept patent [5]. Previous experiments studying the effect of hyperventilation through the nose on EEG activity in the cortex suggest that the activity is produced by a neural reflex mechanism in the superior nasal meatus [6].

There are specific yoga breathing practices (*pranayamas*) that involve breathing selectively through a particular nostril. These techniques can be practiced effortlessly for prolonged periods and allow the effects of unilateral nostril breathing to be evaluated. Uninostril yoga breathing may be exclusively through the right or left nostril. For the present study, the effects of right uninostril yoga breathing were evaluated. Left uninostril yoga breathing was not studied as traditional yoga texts mention that this practice can make a person "lethargic and lead to an introverted state of mind" and hence should not be practiced unless specifically advised by a teacher (*guru*) [7]. However, unpublished data comparing left nostril yoga breathing and breath awareness (BAW) are detailed in the Discussion, in which no specific effect was observed when breathing through the left nostril.

With this background this study was designed to compare the middle latency auditory evoked potentials (MLAEPs), recorded from symmetrical scalp sites over left and right cerebral hemispheres, during a right nostril yoga breathing (RNB) practice as compared to BAW. MLAEPs were chosen to be studied, as the MLAEP components are known to have similar latency and amplitude characteristics on the right and left side, in normal persons [8]. This evaluation of the effects of uninostril yoga breathing on MLAEPs was expected to add to the understanding of possible lateralised changes in MLAEPs and therapeutic implications in certain psychiatric disorders known to be lateralised, such as schizophrenia [9].

In summary, the present study aimed at testing the scientific hypothesis that uninostril yoga breathing influenced the electrical activity of the two cerebral hemispheres, selectively producing detectable alterations in MLAEPs.

Materials and methods

Subjects

Fourteen healthy male volunteers with ages ranging from 18 to 33 years (group average age±SD, 26.3±3.5 years) were studied. These individuals had experience of the practice of uninostril yoga breathing as well as of BAW, ranging from 6 to 36 months prior to the study (group average±SD, 27.3±10.9 months). The signed informed consent of all subjects was obtained. None of the subjects had: (i) upper respiratory tract infection which could have resulted in nasal blockage or (ii) nasal septal deviation, or any other nasal abnormality.

Design

Subjects were assessed in two separate sessions (i.e., RNB and BAW) at the same time of the day on different days. Each session consisted of 40 min of recording for each subject, with 30 min of a test period preceded and followed by two periods of 5 min each. During the test periods of the two sessions, two recordings each were obtained for RNB and for BAW, which were averaged for analysis. Baseline nostril patency was confirmed using a mirror to measure the right and left nostril vapour condensation patterns upon exhalation. With this method the condensation of vapour of the dominant nostril was larger and visible longer [10].

Recording of evoked potentials

MLAEPs were recorded in the 100-ms, poststimulus time period without delay (Nicolet Bravo, USA), from both left and right symmetrical scalp sites referenced to the ipsilateral ear lobes (i.e., C_3-A_1 and C_4-A_2 respectively), with the ground electrode on the ventral surface of the left forearm. The preamplifier bandwidth was set at 10-1500 Hz and 1500 responses were averaged for each assessment. The rejection level was expressed as a percentage of the full-scale range of the analog-to-digital converter. This level was set at 90%. Binaural click stimuli of 50 ms duration and alternating polarity at the rate of 5 Hz were delivered through acoustically shielded earphones (Amplivox, UK). The threshold of hearing was noted for each subject and the intensity was kept at 60 dB above the normal hearing level (nHL) [average dB (nHL)±SD, 27.9±4.5 dB (nHL)].

MLAEP components

Peak amplitudes of short latency wave V, and middle latency Na, Pa and Nb waves were measured from a zero DC baseline. Peak latency was measured from the time of click delivery.

The auditory evoked potential components were described as follows: wave V was the maximum positive peak between 5 and 8 ms, and the Na wave was the maximum negative peak preceding the Pa wave, which is a positive component occurring between 25 and 32 ms. The Nb wave was taken as the first maximum negative component immediately following the Pa wave [11].

Right nostril yoga breathing and breath awareness

RNB is voluntary breathing through the right nostril, while the left nostril is kept occluded with gentle pressure from the ring and little fingers of the right hand (*nasika mudra* in Sanskrit) [12, 13]. Breathing is voluntarily regulated to be slow and deep with awareness of breathing.

During BAW there was no voluntary manipulation of the nostrils, instead subjects breathed slowly and deeply, being aware of their breath, as for RNB.

Data analysis

Two factor analyses of variance [14] were performed to compare peak amplitudes of the MLAEP components recorded in the two sessions (Factor A, i.e., RNB sessions and BAW sessions). The test conditions (i.e., pre, during, post) constituted Factor B. Separate analyses were performed for MLAEPs recorded from symmetrical scalp sites on the left and right side. The Tukey test for multiple comparisons was used to detect significant differences between group mean values.

Similar analyses as mentioned in 1 above, were done for the peak latencies of the MLAEP components.

Results

Two factor ANOVA and Tukey test

The peak amplitudes of the Na and the Nb waves recorded during RNB were significantly higher over the right hemisphere than those of the corresponding waves collected during the BAW session and during the preceding and following periods of RNB.

Na wave peak amplitudes recorded on the right side for RNB sessions were significantly different from BAW sessions [F=4.47 (Factor A=RNB *vs*. BAW), since F (2,78)=3.09, at p=0.05, hence p<0.05]. The multiple comparison Tukey test for the highest significant difference showed that the Na wave peak amplitude on the right side was significantly greater during RNB compared to the values during BAW (q=3.04, as q (2,78) at p=0.05 is equal to 2.82, hence p<0.05).

The Nb wave peak amplitude recorded on the right side for the RNB session was significantly different from the BAW session [F=3.15 (Factor A=RNB *vs.* BAW), as F (2,78)=3.11 at p=0.05, hence p<0.05]. The multiple comparison Tukey test for the highest significant difference showed that the Nb wave peak amplitude on the right side was significantly greater during RNB compared to the values during BAW, q=3.45, as q (2,78) at p=0.025 is equal to 3.25, hence p<0.025. Similarly, the Nb wave peak amplitude on the right side was significantly greater during RNB compared to the preceding value, q=3.23, as q (2,78) at p=0.05 is equal to 2.82, hence p<0.05.

There were no significant differences between baseline values for RNB and BAW sessions.

The Tukey test did not show any significant differences between the Na and Nb waves recorded on the left side during the two sessions. Also, waves V and Pa were not significantly different on either side.

Figure 1 shows recordings of MLAEPs pre-, during and post-RNB session, recorded on the left (C_3-A_1) and right side (C_4-A_2) for all subjects, with each tracing representing the averaged MLAEP from a single subject. Similarly, Figure 2 shows the recordings made pre-, during and post-BAW session on left and right sides.

The group average values of peak amplitudes and latencies of the MLAEPs for RNB and BAW sessions are given in Tables 1 and 2 respectively.

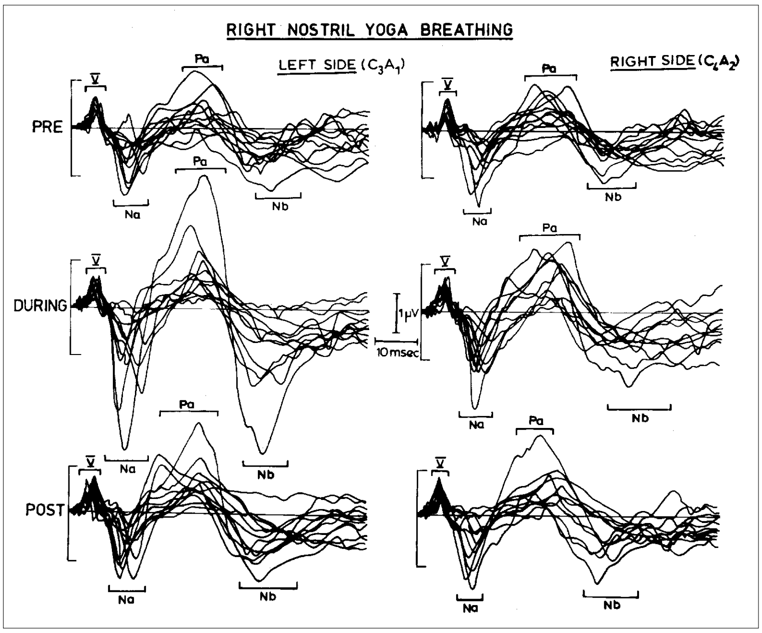

Fig. 1 Recordings of MLAEPs pre-, during and post-RNB recorded on the left (C_3-A_1) and right (C_4-A_2) side for all subjects, with each tracing representing the averaged MLAEP from a single subject

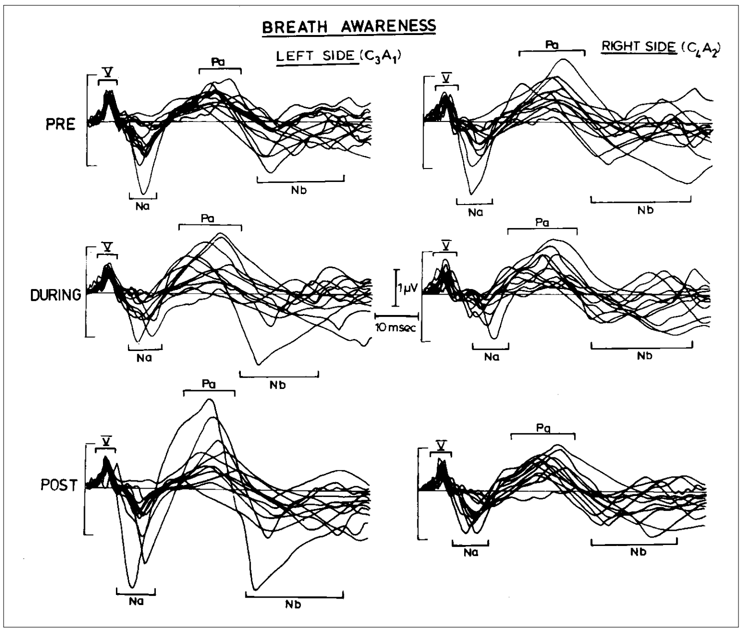

Fig. 2 Recordings of MLAEPs pre-, during and post-BAW recorded on the left (C_3-A_1) and right (C_4-A_2) side for all subjects, with each tracing representing the averaged MLAEP from a single subject

Table 1 Peak amplitudes of MLAEPs in RNB and BAW sessions

	V wave		Na wave		Pa wave		Nb wave	
	RNB	BAW	RNB	BAW	RNB	BAW	RNB	BAW
Pre								
L	0.71±0.23	0.87±0.28	1.68±1.57	0.79±0.76	0.95±0.89	0.96±0.34	0.95±0.89	0.92±0.54
R	0.67±0.21	0.88±0.35	1.21±1.04	0.75±0.50	0.88±0.56	1.00±0.56	0.88±0.56	0.81±0.60
During								
L	0.60±0.30	0.82±0.26	1.67±1.23	1.00±0.62	1.36±1.20	0.95±0.44	1.36±1.20	1.01±0.44
R	0.64±0.21	0.76±0.20	1.86±2.04*	1.01±0.70	1.59±1.55	1.00±0.45	1.59±1.55**†	0.83±0.38
Post								
L	0.68±0.28	0.84±0.27	1.20±0.68	0.97±0.70	1.13±0.77	1.19±0.85	1.13±0.77	1.46±1.53
R	0.75±0.21	0.74±0.23	1.10±0.80	0.91±0.65	1.01±0.91	0.92±0.36	1.01±0.91	0.87±0.43

L, left side; *R*, right side. Values are group mean±SDs
*p<0.05, **p<0.025, multiple comparison Tukey test, during RNB *vs*. BAW; †p<0.05, multiple comparison Tukey test, 'during' *vs*. 'pre', RNB

Table 2 Peak latencies of MLAEPs in RNB and BAW sessions

	V wave		Na wave		Pa wave		Nb wave	
	RNB	BAW	RNB	BAW	RNB	BAW	RNB	BAW
Pre								
L	5.5±0.30	5.5±0.30	13.9±1.50	13.6±2.20	30.3±3.50	30.7±3.60	49.0±6.80	51.9±8.80
R	5.6±0.30	5.5±0.20	13.7±1.30	13.9±1.40	30.8±2.90	30.8±2.50	48.2±4.20	50.2±7.90
During								
L	5.8±0.90	5.3±0.40	14.5±1.90	14.6±1.90	29.6±3.60	30.6±3.90	50.9±6.50	50.8±7.10
R	5.4±0.40	5.4±0.40	13.7±1.60	14.8±1.90	29.9±3.70	30.3±3.90	49.6±6.50	48.0±7.00
Post								
L	5.3±0.40	5.6±0.20	14.0±1.70	13.8±1.10	30.7±3.70	30.7±3.30	48.6±5.40	52.3±8.10
R	5.2±0.20	5.2±0.20	13.7±1.30	15.0±2.10	31.2±2.40	31.2±2.80	49.6±7.70	50.7±6.80

L, left side; *R*, right side. Values are group means±SDs

Discussion

During RNB, compared to a period of BAW, there was a significantly higher peak amplitude of the Na wave on the right side. This is the negative peak preceding the positive Pa wave (25–32 ms). Similarly, the peak amplitude of the Nb wave (the first maximum negative peak following the Pa wave) was significantly higher on the right side during RNB compared to the preceding period as well the period of BAW. There were no changes found on either side during BAW. There was no correlation between changes during the session and pre-session nostril patency.

Regarding the origins of the MLAEPs, there are two schools of thought which claimed the neural and the muscular origin of MLAEPs, and have been equivocal. Ruhm and colleagues [15] termed the smaller potentials as cochleoneurogenic and the bigger ones as vestibulomyogenic. Davis [16] also differentiated these responses according to their myogenic and neurogenic origin. The myogenic part which originated from posterior auricular and neck muscles was called the sonomotor reflex with an onset at 12 ms. In the present study it is also important to note that the auricular reference electrodes may have picked up myogenic activity. However, ear lobe recording has been shown to have less muscle artefacts compared to recording from the mastoid [17], which was the reason for selecting auricular reference recording.

The neurogenic part according to Davis [16] originated at the medial geniculate body (thalamus), primary cortical areas and the immediate adjoining secondary areas. Ruhm and colleagues [15] were among the first to establish the neurogenic origin of auditory middle latency responses by recordings from the brain surface during craniectomies . Currently the neural generators of the different components are as follows: the Na wave has been postulated to be due to activity at the mesencephalic or diencephalic level [18], the Pa wave corresponds to the activity at the superior temporal gyrus [19] and the generator of the Nb wave is relatively localised in the dorso-posterior-medial part of the Heschl's gyrus, i.e., the primary auditory cortex [8].

In summary, the MLAEPs have a myogenic component that can be minimised by fully relaxing the subject [20]. In the present study the amplitudes of the Na wave and the Nb wave increased during yoga breathing. While the earlier component (i.e., the Na wave) may have been modified by myogenic activity, the chance of muscle artefacts contributing to the Nb wave amplitude is unlikely. Also, in pranayamas involving nostril manipulation, voluntary occlusion of the nostrils is traditionally done with the right hand [13]. Hence the tonic muscular contraction of the right arm could have influenced (if at all) the activity over the left hemisphere in the form of movement-related activity. This was not seen in the present study.

Apart from the myogenic contribution to MLAEPs, a report on the variation of the middle latency evoked potentials with the physical characteristics of the stimuli, showed the Na and Pa waves are the most consistent and reliable waves evoked [21–23]. P0 and Nb are the next most reliable.

An increase in the amplitude of an evoked potential component has been interpreted as being indicative of effective activation of the underlying neural generator [24]. The Na wave has been postulated to be due to activity at the mesencephalic or diencephalic level [18]. Intracerebral recording in man has shown that the neural generator of the Nb wave is relatively localised in the dorso-posterior-medial part of the Heschl's gyrus, i.e., the primary auditory cortex [8]. As described above, the Na wave is believed to correspond to the mesencephalic-diencephalic (thalamic) level, possibly the medial geniculate body, while the Nb wave is relatively localised in the Heschl's gyrus. Changes at the cortical level during the yoga breathing practice studied here could be expected to be lateralised, as was described in other studies on uninostril breathing [2, 5]. In attempting to understand why subcortical changes were also lateralised (i.e., the Na wave), a possible explanation is that the descending corticofugal control mechanisms could be expected to exert significant influences on the processing of information at the brainstem and thalamic levels [25]. As it has been recognised that the corticofugal descending inputs to the medial geniculate body are stronger ipsilaterally than contralaterally, these descending pathways may explain the lateralised effect at these subcortical levels [26].

The Pa component has been shown to be correlated with activity at the level of the superior temporal gyrus [19]. If the uninostril yoga breathing were to produce a lateralised effect, it would be likely to have had a lateralised effect at this level. In the present study the Pa wave amplitude showed a higher value on the right side during RNB as compared to the changes on the left side, but this difference was not significant. A possible explanation is as follows. When measuring the peak amplitudes of individual components of evoked potentials, an inherent difficulty is that an increase in a positive component would influence the amplitude of a subsequent negative component and vice versa [27]. In the present case, the Pa wave is a positive component occurring between two negative waves i.e., the Na and the Nb waves, both of which showed an increase in amplitude. Hence the increase in the amplitudes of the preceding Na and succeeding Nb negative waves may have influenced the amplitude of the Pa wave, which is in between them. A usual way of overcoming this problem is to measure the peak-to-peak amplitude. However, in the present study this method was not chosen as the changes in neural generators corresponding to specific waves individually were intended to be studied.

A previous report on cytoarchitechtonic data suggests that the primary auditory cortices of right and left hemispheres are similarly organised [28]. This may explain why under baseline conditions auditory evoked potentials with neural generators in the right and left primary auditory cortices have similar latency and amplitude characteristics [8]. Hence the asymmetric increase in amplitudes of MLAEP components during RNB appears to be related to the breathing practice, rather than asymmetry in the underlying neural generators.

Previous studies on EEG activity of right and left hemispheres related to spontaneous shifts in nostril dominance have suggested that there was an increase in the EEG amplitude over the contralateral hemisphere [2]. Similarly, contralateral hemispheric activation based on EEG activity was also demonstrated during forced uninostril breathing [5]. In these studies increased EEG amplitudes were considered indicators of increased mental activity in that hemisphere.

Performance in hemisphere-specific tasks immediately after forced uninostril breathing showed that after forced left nostril breathing there was improved performance in spatial tasks, considered as right hemisphere functions. As verbal tasks were performed better after forced RNB, it was stated that contralateral hemisphere activation occurred with forced uninostril breathing [29].

Previous studies described a contralateral hemisphere function enhancing effect based on the EEG, whereas in the present study changes in MLAEPs suggested that enhancement occurred ipsilaterally. Other studies on the performance in hemisphere-specific tasks related to both spontaneous shifts in nostril dominance and forced uninostril breathing reported improved performance in tasks specific to the contralateral hemisphere [3, 29]. In contrast, yoga breathing through right, left and alternate nostrils as well as BAW with no nostril manipulation, improved performance in a right hemisphere task (spatial memory) with no lateralised effect following yoga [30]. In order to determine whether the trend of an increase in amplitudes of evoked potential components ipsilateral to the nostril through which breathing is practiced occurred irrespective of the nostril, it is necessary to refer to unpublished data of a study also on 14 male volunteers (group average age±SD, 26.86±5.04 years) who were evaluated in 'left nostril yoga breathing (LNB)' and in 'BAW sessions'. There were no significant changes during the left nostril yoga breathing and the peak amplitudes of the Na and Nb waves are mentioned here. For the Na wave on the left side in the LNB session: 1.12±1.45 μV (pre), 1.45±1.72 μV (during), 1.19±1.67 μV (post); and in the BAW session: 0.67±0.87 μV (pre), 0.62±0.45 μV (during), 0.74±0.68 μV (post). For the Na wave on the right side in the LNB session: 1.22±2.21 μV (pre), 1.03±0.78 μV (during), 1.08±1.45 μV (post); and in the BAW session: 1.37±1.11 μV (pre), 1.14±1.42 μV (during), 1.14±0.79 μV (post). For the Nb wave on the left side in the LNB session: 0.64±0.68 μV (pre), 0.65±0.45 μV (during), 0.52±0.56 μV (post); and in the BAW session: 0.51±0.54 μV (pre), 0.45±0.38 μV (during), 0.38±0.17 μV (post). For the Nb wave on the right side in the LNB session: 0.76±0.81 μV (pre), 0.60±0.51 μV (during), 0.64±0.66 (post); and in the BAW session 0.84±0.53 μV (pre), 0.53±0.47 μV (during), 0.30±0.25 μV (post).

Spontaneous shifts in nostril patency and forced uninostril breathing have similar effects (i.e., contralateral enhancement of hemispheric activity). In the present study, the higher peak amplitudes of two MLAEP components on the right side suggested that RNB brought about effective activation of underlying diencephalic and primary auditory cortical generators on the right side.

Certain psychiatric disorders are known to be associated with selective disruption of the function of a specific hemisphere. Uninostril breathing practices have potential use in conditions like this. For example, left forced uninostril breathing was tried with success in obsessive compulsive disorder, which was described by Shannahoff-Khalsa and Beckett (1996) as a disorder of the right hemisphere [31]. This makes it desirable for the effects of these practices to be understood in normal volunteers.

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