Can hyperventilation be a trance mechanism in Nganasan ritual dance accompaniment?

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Abstract

Background in ethnomusicology. We have descriptions of Nganasan round dance of North Siberia, documented in different periods. The accompaniment consists of the sounds with rasping timbre. Specific respiratory technique is an important feature of the accompaniment. The dance carries a ritual function.

Background in physiology. Religious rituals generate in people extreme bodily reactions including fainting. Fainting connected with hyperventilation (deep and rapid respiration) is in the focus of our research.

Aims. 1) To describe the imitative timbre; 2) To propose the hypothesis of a deliberate hyperventilation as a mechanism that causes fainting in the process of music making.

Main contribution. In ritual practice, dance serves as a medium for reaching the state of trance. It is usually caused by a gradually escalating tempo. In Nganasan dance the tempo remains moderate. We argue that tempo is not the most important factor. Nganasans may have fallen into trance with the help of breathing. The respiratory technique is also important from the perspective of timbre.

Implications for musicological interdisciplinarity. Attaining the desired timbre is connected with specific respiratory technique. We can define it as controlled breathing similar to hyperventilation. Hypocapnia resulting hyperventilation explains certain features of trance (fainting) in Nganasan religious ritual.

Introduction

We analyse the Nganasan bear dance that formed a part of the sacrificial rite occurring at the commencement of the polar day. Bear is an important psychopomp in Siberian religious concept. The dancers imitated a bear with their movement and by adding a specific roaring timbre to their voice. A Nganasan informant: "With these sounds a she-bear calls her cubs to follow after her."

Figure 1. The Nganasan dancers

Material

1. A video recording made by T. Ojamaa on the Taimyr Peninsula (1989). It is a dance demonstration that did not take place in its traditional context, and therefore it lasts only for about 15 minutes.
2. Descriptions of the dance in traditional context were provided by Middendorff (visited Taimyr in 1884) and by Simchenko (1961).

Background in ethnomusicology

Choreography

Dancers. The dance is performed by middle-aged or older men and women.
Movement. The bear dance is a round dance. The dancers move clockwise. They swing their arms back and forth with each step.

Figure 2. The steps of bear dance

Knee bending (a); return to the initial position (b); push-off (c); sidestep (d).

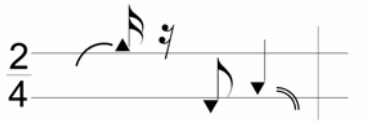
Tempo. Tempo is slow. The tendency towards acceleration occurs. At the beginning of the dance tempo = about 1 beat per second;
on the 15th minute
tempo = about 1.5 beats per second.
Duration. Existing data on the duration of the dance in its traditional setting differ:

1. The dance lasted for the whole night (Middendorff 1956: 208–209);
2. The dancers continued until they collapsed (Simchenko 1963).

The Nganasans have never used fly agaric or any other narcotics while dancing.

Accompaniment

Figure 3. Shape notation of the basic motive



The accompaniment basis on respiratory technique:

inspiration ▲ and expiration ▼ alternate in a certain rhythm.
We can characterize the accompaniment as rhythmically organized panting.

Timbre

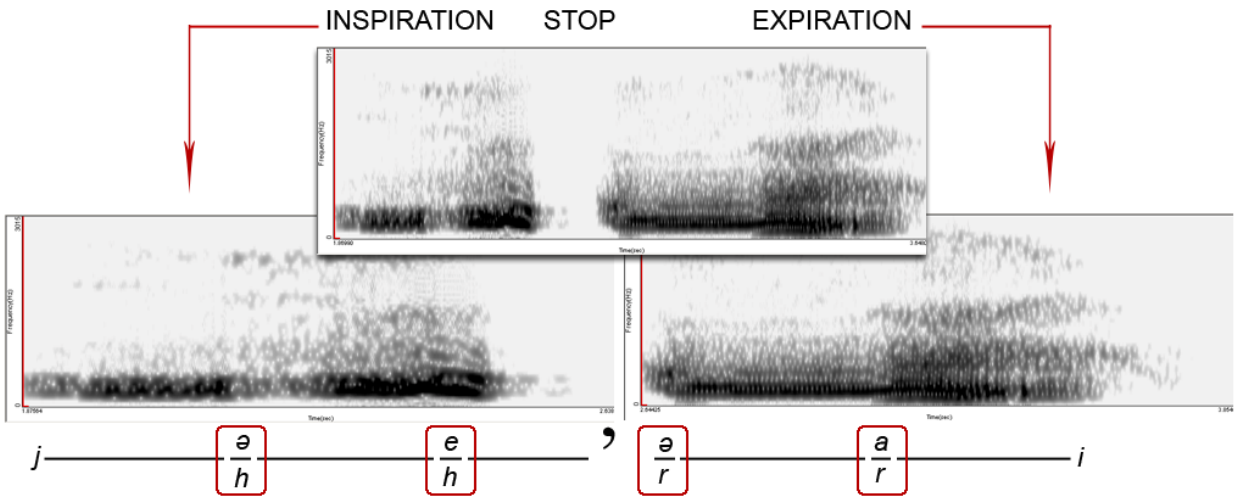
Figure 4. The singers' explanations about attaining the desired timbre

A	EXPLANATIONS	B
First, there are voiced words *əe'-ə-ai**. Then I'll add throatiness: *əeh***.		Glottis is semi-opened – in regime of hoarse phonation. False vocal fold are cooperating. Air is sucked onto the vocal fold unlike the ordinary singing.
Now my throat as if swallows the voice to the inside: *əe'* – like an hiccup.		Configuration of my throat moves from a wide position towards a narrow one resolving to a glottal stop.
After that the air is let out again: *əar* … like dogs growl.		Sound is squeezed: opening around the fluttering uvula is narrow. The result is slightly tremulous sound.
*The sign ' designates a glottal stop. **Pronounced while inhailing.		

A traditional singer (A) was asked to describe the process of producing the sounds that he used to imitate a roaring bear.
A professional singer (B) was asked

1. to acquire the Nganasan vocal technique (the adequacy was tested by spectral analysis);
2. to give a scholarly explanation to the operational functions of his vocal organs in the production process of the sounds.

Figure 5. Spectrogram of the panting motive



The explanations given in Figure 3 have been supported by the results of a spectral analysis.
The spectrums of ə and *e* have merged with the spectrum of *h* in the first segment.
The spectrum of ə and *a* have merged with the spectrum of *r* in the second segment.
It confirms that the specific timbre is a result of coexistance

1. of vowels and spirant ə/*h* and *e*/*h* (connected with inspiration);
2. of vowels and uvular tremulant ə/*h* and *a*/*r* (connected with vibration).

Aims

An example from a comparable religious practice:
dhikr (Arabic countries)
↓
Slow dancing
+
specific sound (described as panting, roaring)

Guttural voice
Vocal cords vibrate during the inhalation and exhalation
↓
Defined as hyperventilation that may cause dizziness.
Vibration modifies the vascular and neurological balance of the encephalon.
The result may be a
trance.
(Rouget 1985: 262–301).

Based on the information given above, we propose the next hypothesis:

Neuropsychological symptoms in the Nganasan ritual dancing and music making are related to the effects of hyperventilation (and hypocapnia). Vibration caused by specific imitative timbre may be an additional component to attain various psychodynamic effects.

Background in medicine

Hyperventilation

Hyperventilation is defined as
excessive (exceeding metabolic demands), rapid and deep breathing that results in the decrease of carbon dioxide in the blood.

Hyperventilation syndrome depicts the classic triad of

↓ massive overbreathing
↓ paraesthesiae
↓ tetany

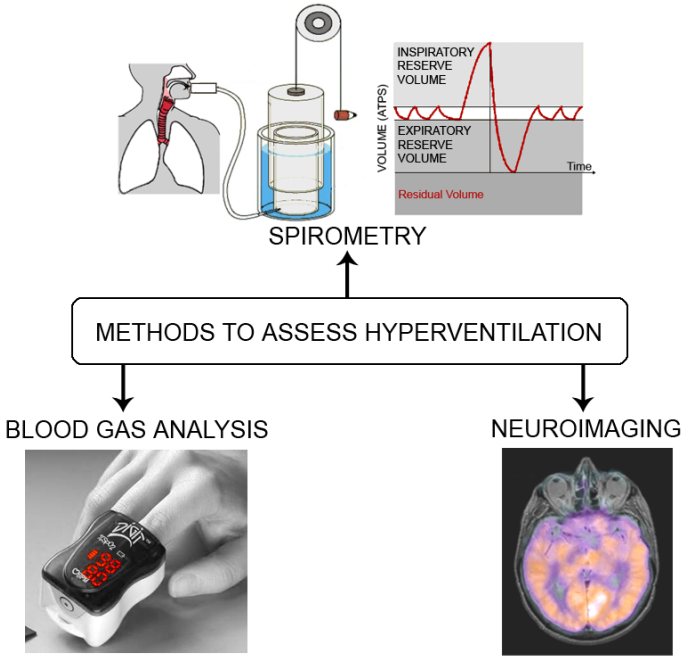
Table 1. Clinical symptoms of hyperventilation

System	Symptoms
Cardiovascular	Palpitations, tachycardia, precordial pain, Raynauds phenomenon
Neurological	Central: dizziness, disturbance of consciousness/vision. Peripheral: Paraesthesiae, tetany.
Respiratory	Shortness of breath, asthma, chest pain
Gastrointestinal	Globus, dysphagia, epigastric pain
Musculosceletal	Muscle pains, tremors, tetany
Psychic	Tension, anxiety
General	Fatigability, weakness, exhaustion, sleep disturbance, nightmares

Table 1. lists the main symptoms observed by a general physician in a series of 270 cases. Symptoms may show up anywhere, in any organ, in any system; for we are dealing with a profound biochemical disturbance, which is as real as hypoglycemia, and more far-reaching in its effects.[1]

[1] http://members.westnet.com.au/pkolb/lum.pdf. See also Lum, L. C. 1975. Hyperventilation: The Tip and the Iceberg. In *Journal of Psychosomatic Research, Vol.* 19, 375–383.

Figure 6. Methods to assess hyperventilation



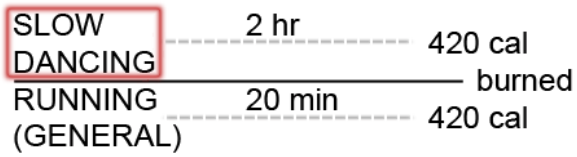
Spirometry. Historically the first method to evaluate ventilation was spirometry (measurement of the volume of air or gas in the lungs). Spirometry continues to be important in evaluating special breathing patterns. For example, it helps to find out to what extent the expiration with occlusion diminishes expiratory residual volume.

Blood gas analysis. Blood gas analysers enable to determine the status of CO_2 and acid-base status in the blood.

Neuroimaging. Contemporary neuroimaging techniques like the Magnetic Resonance Imaging (MRI) or the Positron Emission Tomography (PET) enable to visualise regions of the brain that are activated by various stimuli (incl. hypocapnia).[2]

Physiological comments on Nganasan dance

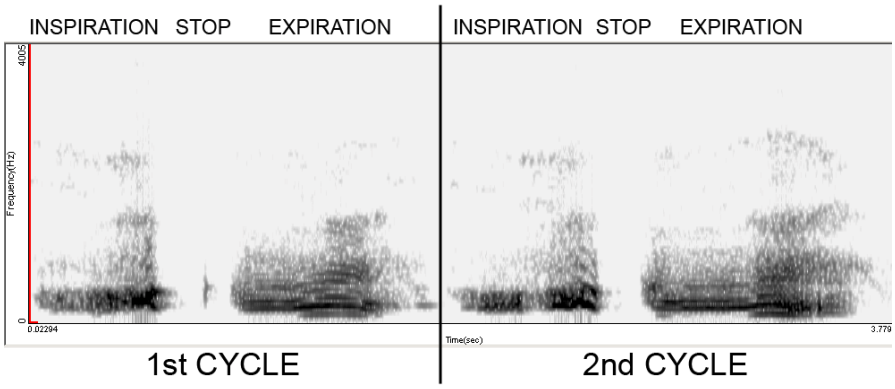
Figure 7. The physical load of the dancers



The diagramme indicates an approximate burning rate of calories during the act of dancing.
A dancer (sex: male; age: 55; height: 170 cm; weight: 70 kg) burns 420 calories in 2 hours.
In comparison: the same amount of calories is burnt in 20 minutes while running with the average speed of 5 km per hour.
Thus the physical load of the dancers is not heavy during the bear dance.

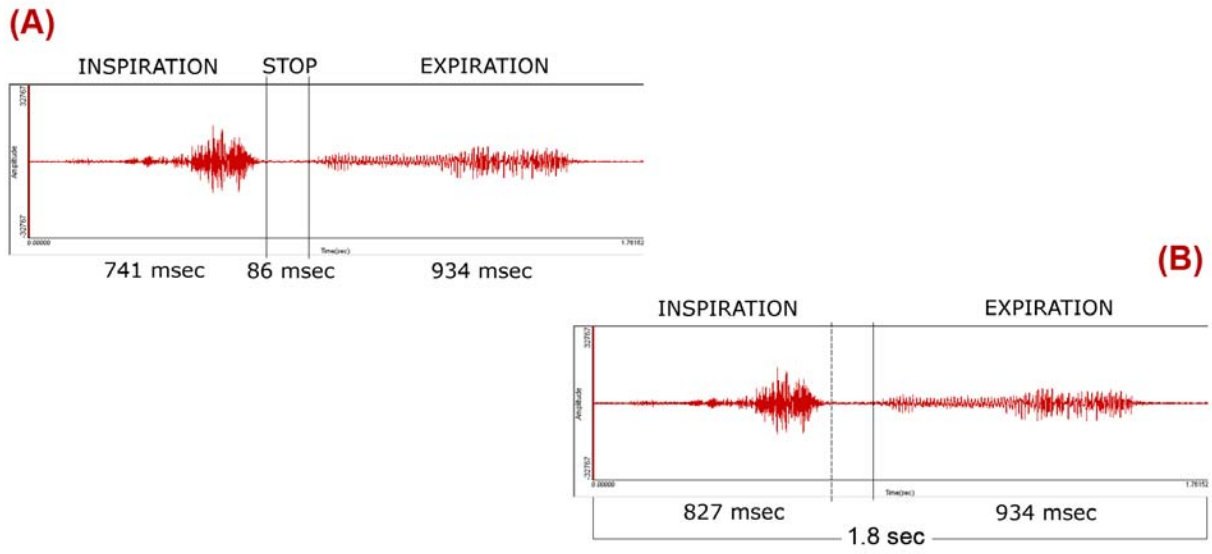
[2] http://www.med.harvard.edu/AANLIB/cases/caseM/mr2tc1_t/025.html
Whole Brain Atlas http://www.med.harvard.edu/AANLIB/home.html

Figure 8. Successive panting motives in dance accompaniment



The narrowband spectrogram demonstrates the sound to be constant: no pauses occur between the motives.
1 panting motive = 1 breathing cycle.
From the perspective of hyperventilation, the lack of a pause appears to be significant: It enables faster breathing per one unit of time.

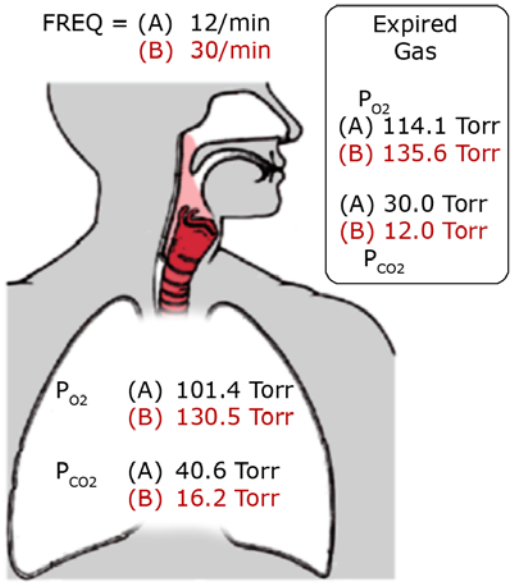
Figure 9. Breathing cycle in dance accompaniment



(A) depicts the oscillogram of one breathing cycle of the bear dance. All stages of the cycle (inspiration, glottal stop and expiration) have been measured separately in milliseconds. (These stages are significant in respect to the imitating timbre).
(B) depicts an oscillogram of the same breathing cycle divided into two stages: inspiration and expiration. The glottal stop (one tenth of the first stage) determines the inspiration, i.e. forms a part of inspiration. This is the turning point of the breathing direction.

The total sequence of the cycle is 1.8 sec.
The average breathing frequency of the bear dance performers is approximately 30 cycles per minute.
In comparison: a normal breathing frequency is 12 times per minute.

Figure 10. Alveolar gas exchange



Hyperventilation reduces the carbon dioxide level in the blood.
In the diagram, normal breathing (A) (freq 12/min) differs from hyperventilation in Nganasan ritual dancing (B) (freq 30/min) by alveolar P_{CO2} tension (respectively 40.6 and 16.2 Torr) and expired gas P_{CO2} content (respectively 30 and 12 Torr). As a result, multiple pathophysiological processes are triggered in the blood and brain that are followed by the clinical symptoms of hypocapnia.

Table 2. Common causes of hypocapnia

Central nervous system	Cerebral	Cardio-vascular	Drugs	Stimulation of chest receptors	Miscellaneous
Pain	Meningitis	Hypoxemia	Progesterone	Pneumothorax/ hemothorax	Mechanical ventilation
Hyperventilation syndrome	Encephalitis	Severe anemia	Methylxanthines	Interstitial lung disease	Heat exhaustion
Anxiety	Tumor	Hyper-ventilation	Salicylates	Pulmonary edema	Recovery phase of metabolic acidosis
Psychosis	Trauma	Right-to-left shunts	Catecholamines	Pulmonary embolism	
Fever			Nicotine	Aspiration Pneumonia	**Religious rituals**

Hypocapnia is a state in which the level of carbon dioxide in the blood is lower than normal; can result from deep or rapid breathing.Table 2 lists the main causes of hypocapnia (c. f. Laffey and Kavanagh 2002).

Implications for musicological interdisciplinarity

- Hyperventilation is a common feature of Nganasan ritual dancing.
- Hypocapnia that is attained as a result of hyperventilation explains certain features of the trance (fainting) pertaining to the Nganasan religious ritual.

- Additional psychoemotional qualities are achieved by providing a special timbre and imitating the movements of the bear. These components are independent of hyperventilation or hypocapnia.
- As these features are universal to human beings, religious rituals worldwide may implement similar physiological mechanisms (hyperventilation, hypocapnia, respiratory alkalosis). This mechanism may explain the essence of trance and therefore it will require further study and experimental investigation.

Acknowledgments.

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