Voice, respiration and brain regulation

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Introduction

- Breathing is a continuous and indeed a fundamental physiological process in life. The respiratory movements in breathing occur as an automatic mechanism responsible for vital behaviors such as gas exchange in the lungs and pH regulation.
- A research at British Library London was made and found 32 references with the search words: Voice AND Respiration AND Brain Regulation – for the latest 5 years. Upon reading the abstracts 0 relevant articles were found. Further research was made through the database PubMed where the search was specified to respiration and voice. Here we found few relevant articles. This shows that the area has not been a major subject in the past 5 years. Further research is necessary.

Anatomical mechanism of the respiratory system

Breathing consists of two phases: Inspiration and expiration. The inspiration is always active while the expiration in rest is passive.

Inspiration:

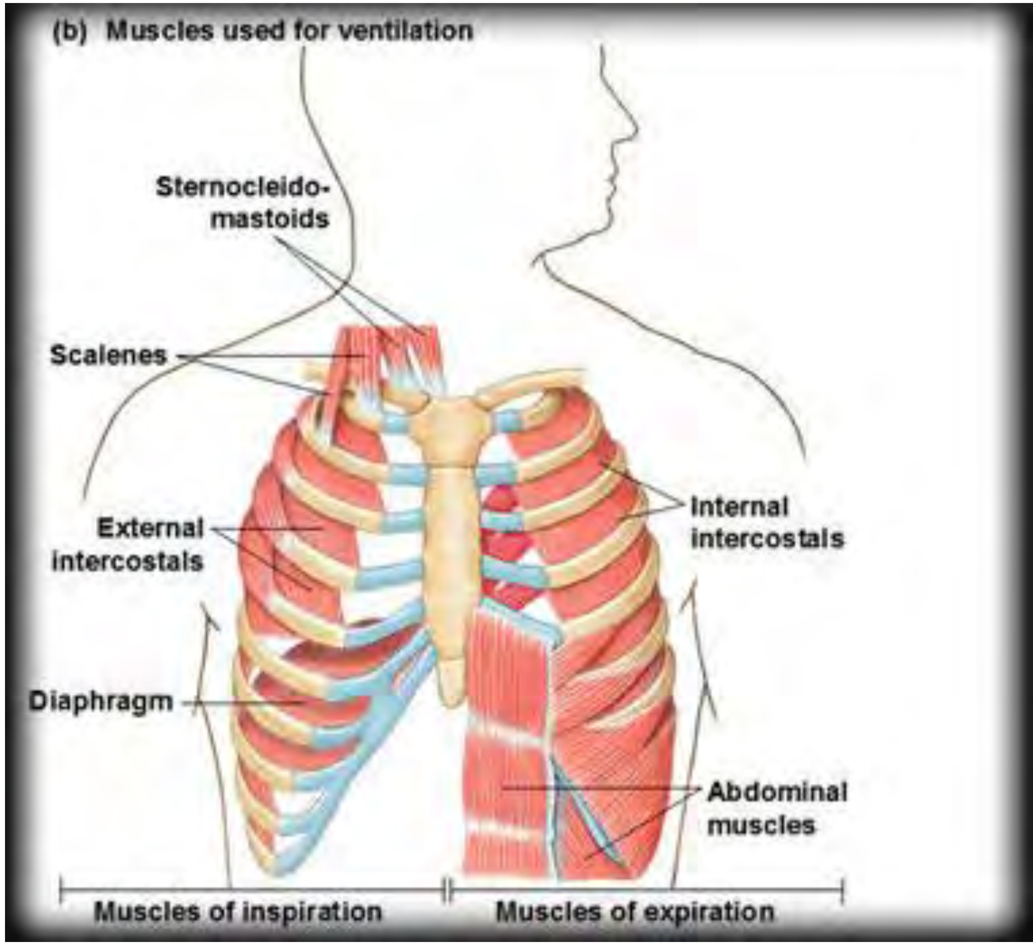
- Diaphragm is responsible for most of the inspiration in rest.
- External intercostals are responsible for deeper breathing.
- Sclaenes and sternocleidomastoids are responsible for deeper breathing too.

Passive Expiration:

- Relaxation of the diaphragm is therefore passive in rest.

Active Expiration, including voicing:

- The internal intercostals
- Abdominal muscles



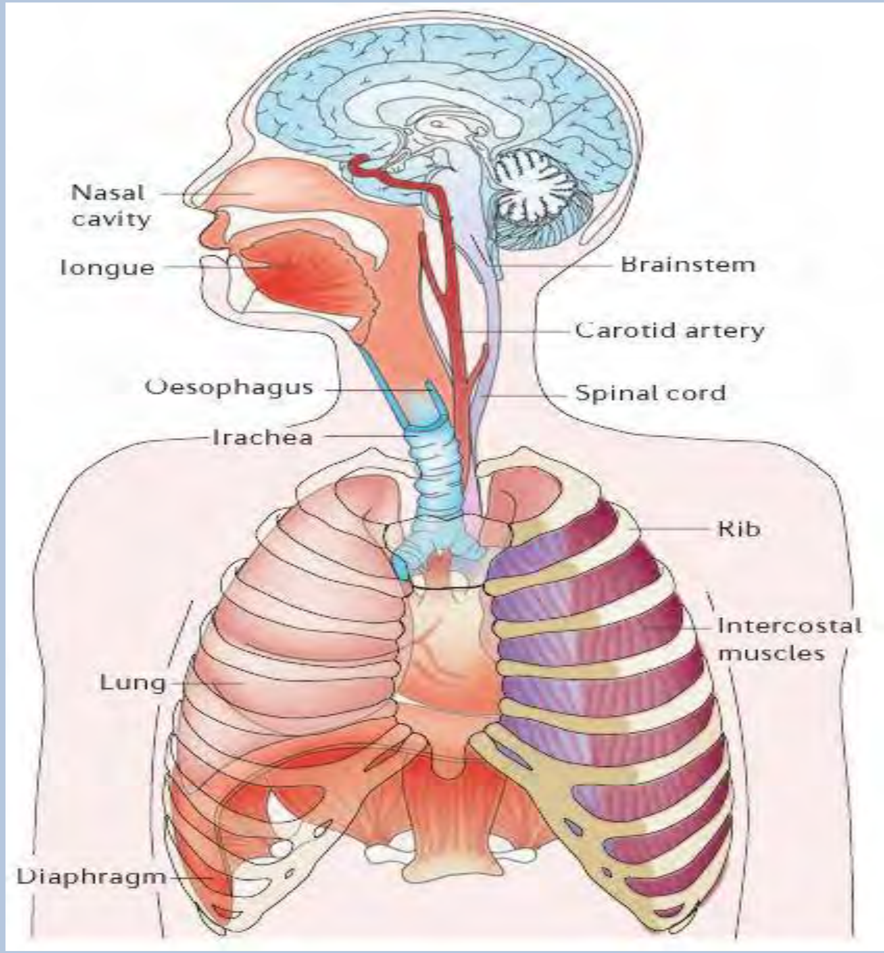
Picture from: https://www.t-nation.com/training/breathe-stupid-breathe

Physiological mechanism of the respiratory system

Rhythmic neural activity is generated and organized as neural circuits in the brainstem driving the continuous respiratory breathing movements in mammals during normal breathing. (ref 1)

This neuronal activity produces a respiratory rhythm which pulsates the breathing mechanism.

regions of the brainstem, including the preBötzinger Complex and the ventral medullary surface[23]. Most recently, Guyenet and colleagues[26,28] presented compelling evidence to suggest that the original view, that central chemoreception is the province of the ventral medullary surface, is correct, and that the retrotrapezoid nucleus (BOX 2) is a critical site.



The restricted scope of this article precludes discussion of topics essential for a comprehensive understanding of the neurobiology of breathing, including chemoreception[23–28], pontine sites and their contributions to respiratory behaviours[29], expiratory pattern generation *in vivo*[7,30],

Physiological mechanism of the respiratory system

This neural circuit in the brainstem is referred to as the respiratory central pattern generator (CPG) responsible of generating rhythmic breathing patterns. (ref1)

CPGs consists of interconnected neurons organized in a network controlling the output of motor neurons. (ref 2 and 3).

These pattern generators can be divided into constitutive pattern generators and conditional pattern generators. A constitutive pattern generator generates persisting patterns of activity throughout a lifetime of an organism.

The respiratory CPG is a constitutive active pattern generator producing automatic movements throughout life. However, the conditional pattern generators generate patterns of activity which are not occurring persistently throughout life, but time limiting movements e.g. locomotion (the act of power of moving from place to place), swallowing and chewing and voicing (ref 3).

Arrangement of the respiratory network within the brainstem and respiration rhythmogenesis

Neural circuits in the brainstem have shown to generate the respiratory motor output leading to breathing during normal breathing.

It is hypothesized that intrinsic rhythmically pacemaker neurons are driving the respiratory rhythm generation (rhythmogenesis) (ref 4-9).

A group of neurons located rostral in the ventrolateral medulla oblongata, the preBötzinger Complex, is hypothesized to be essential for the rhythmogenesis (ref 4-9).

These neurons with respiratory activity in the ventrolateral medulla oblongata are as a collective group called the ventral respiratory group (VRG) (ref 10). The VRG contains different subpopulations of interacting excitatory and inhibitory interneurons which represents the respiratory Central Pattern Generator (CPG) (ref 1).

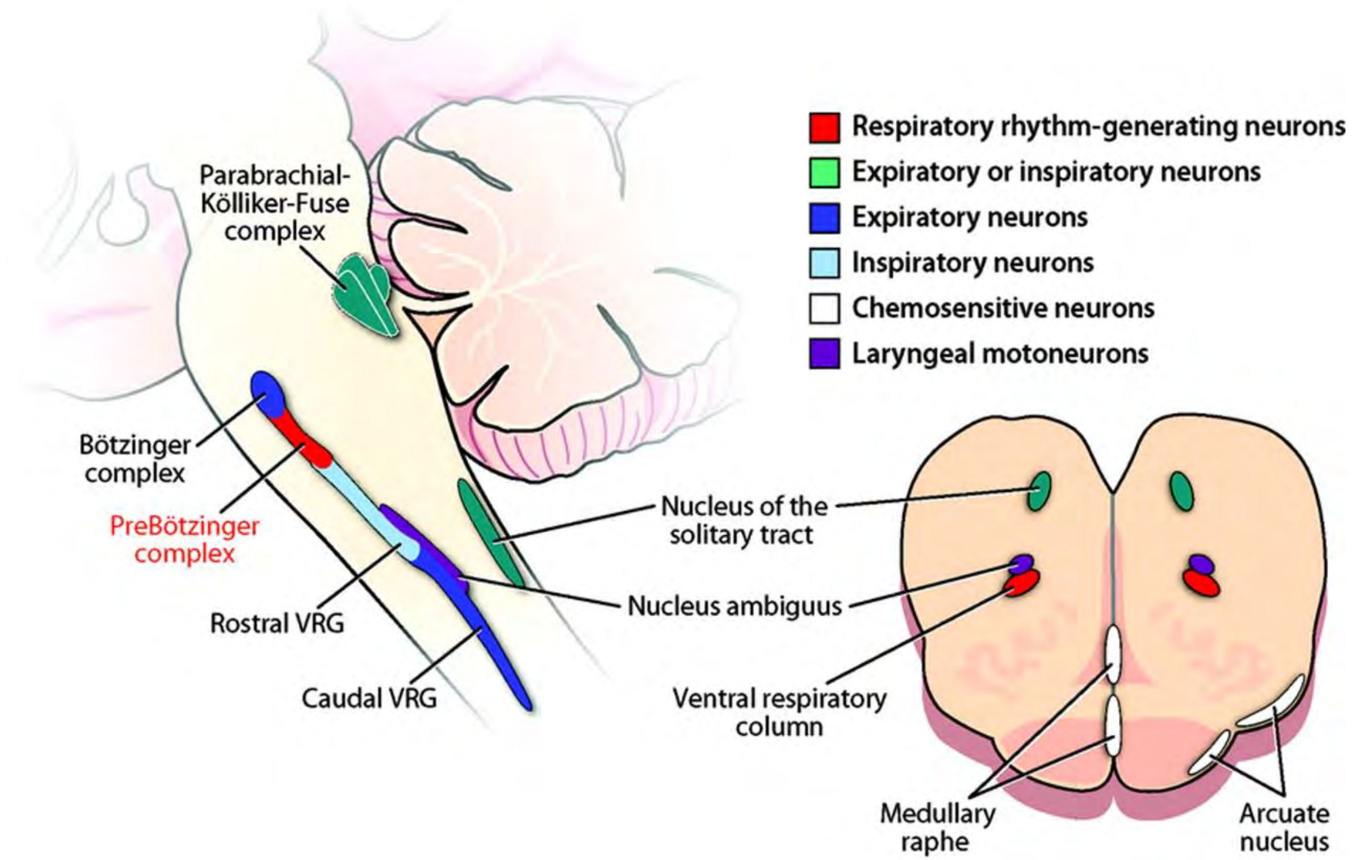
Arrangement of the respiratory network within the brainstem and respiration rhythmogenesis

The preBötzinger Complex is known as a limited portion of the Ventral Respiratory Group (VRG) consisting of a heterogeneous group of neurons that might generate respiratory-related outputs (ref 10).

The preBötzinger Complex has been proposed to be responsible for generating the inspiratory rhythm while other regions of the VRG, such as the Bötzinger complex and the retrotrapezoid nucleus/parafacial respiratory group, generates the expiratory activity (ref 5). Perturbations and ablations of neurons in the preBötzinger Complex have shown to alter and eliminate the respiratory rhythm of neonatal rats (ref 8, 11-14).

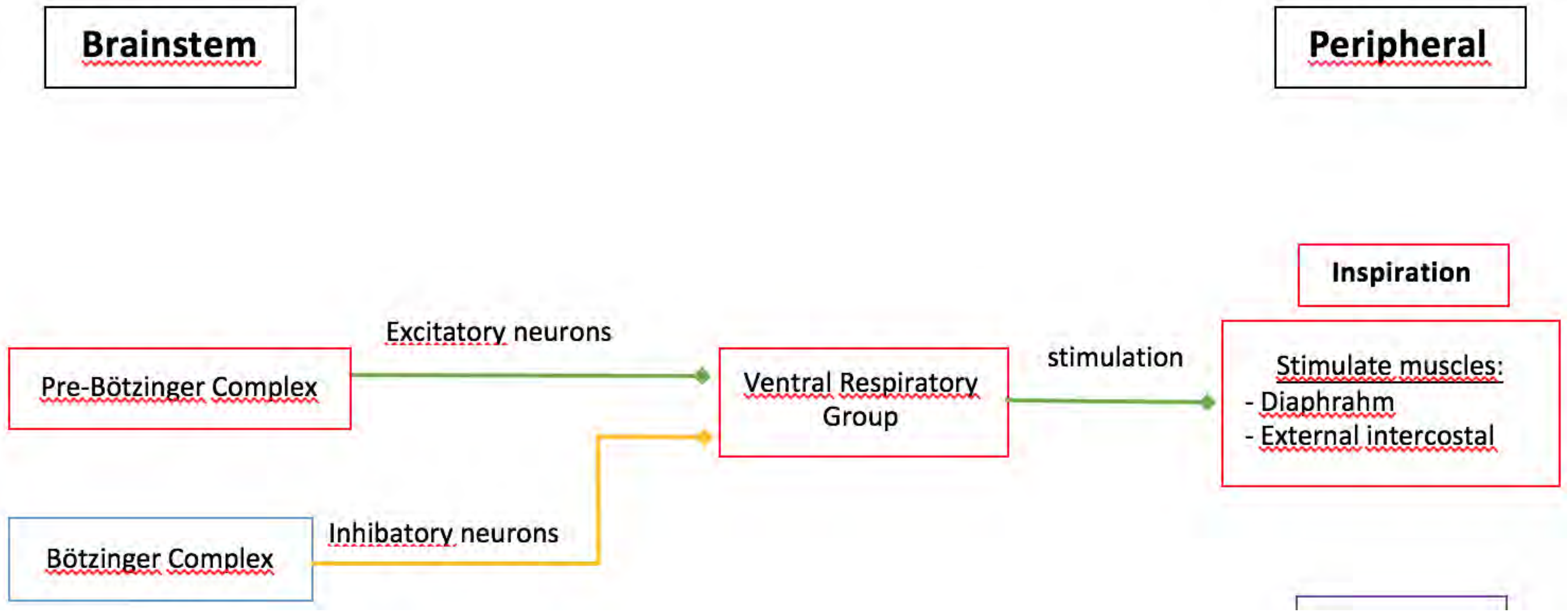
An intact preBötzinger complex has therefore proven to be essential for generating normal respiratory rhythm in mammals.

Brainstem and the prebötzinger complex



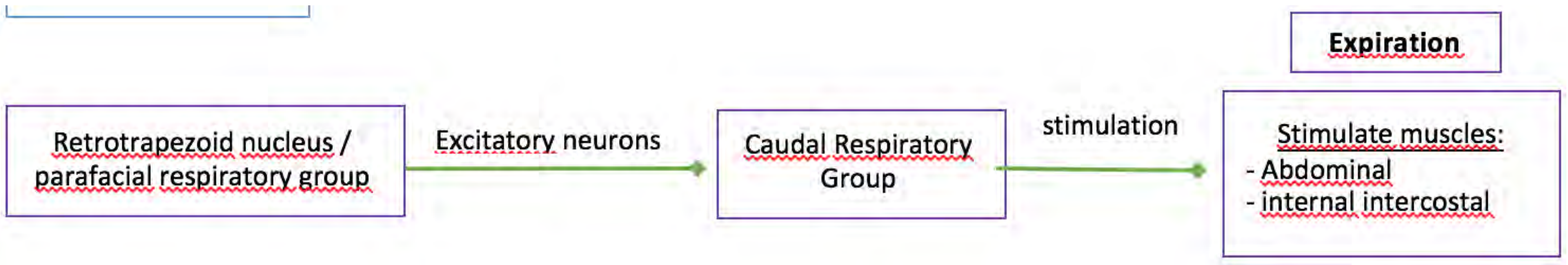
Picture from: http://www.neurology.org/content/68/24/2140/F1.large.jpg

Synapses between brainstem and the respiratory organ during inspiration.



Central rythm generation of respiration, overview in mammals.

Synapses between brainstem and the respiratory organ during active expiration.



Central rythm generation of respiration, overview in mammals.

Respiratory cycle

During a respiratory cycle consisting of inspiration and expiration the Central Pattern Generator (CPG) generates only the inspiratory phase while the expiratory phase is passive during quiet breathing (ref 3).

Voice and respiration

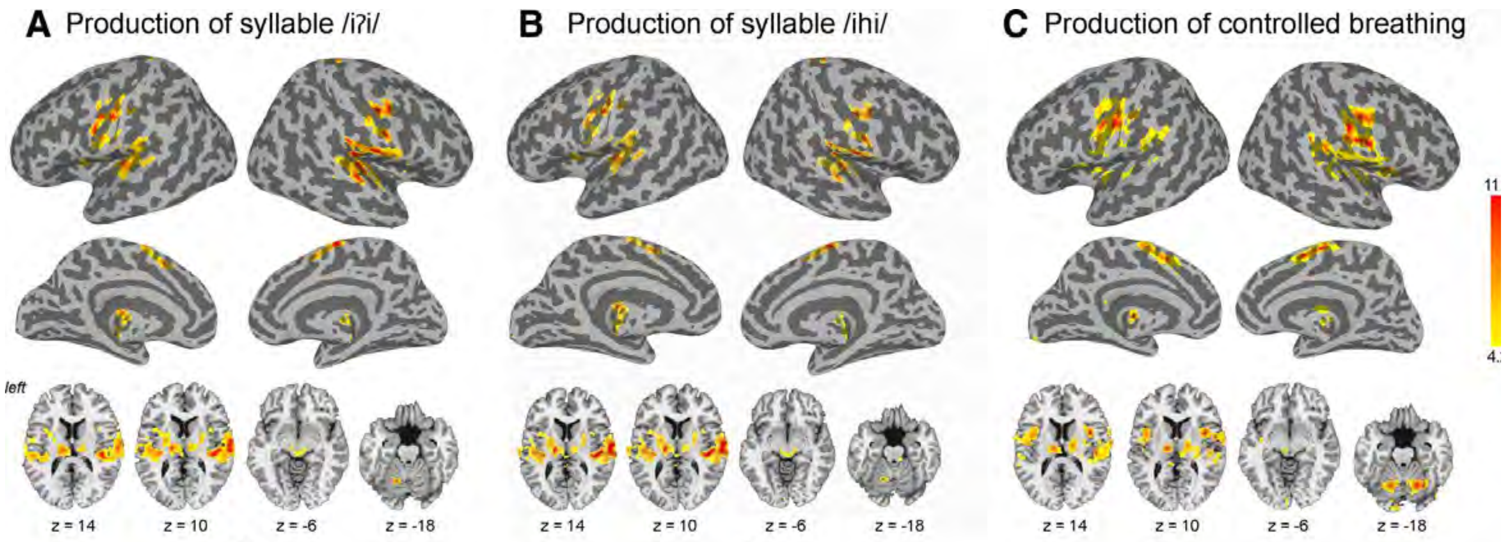
- Voice plays an important role in human communication. The genetically determined vocal reactions are controlled by the lower brain stem. Breathing control is very important to precise control of vocal fold movement.

- Prolonged controlled expiration is necessary to maintain adequate subglottic air pressure to start and sustain voice production. (ref 15)

- The involvement of the voluntary control over respiration must be studied in order get a better understanding of phonation for speech. (ref 16)

Brain activity during production of syllable´s and during production of controlled breathing.

There are similar positive functional connections of the left laryngeal motor complex during voluntary voice production (i.e., both syllables /i?i and /ihi/) and during controlled breathing.



Brain activity during production of syllable´s and during production of controlled breathing.

Positive functional connections of the left laryngeal motor complex during voluntary voice production (i.e., both syllables /i?i and /ihi/) and during controlled breathing are: Ventrolateral prefrontal cortex, Insula, thalamus, caudate nucleus, putamen, cerebellum.

Functional connections of the right laryngeal motor complex during voice production were comparable to networks of the left laryngeal motor complex, but involved less brain regions, while the few positive connections of the right laryngeal motor complex during breathing were observed with the right dorsolateral prefrontal cortex, posterior cingulate cortex and left putamen.

In conclusion these findings shows a left hemispheric lateralization of the functional networks during syllable production, but not during controlled breathing which has a more symmetrical bilateral brain activity. (ref 15)

Phonetograms and Air-flow meassurements as looked on traditionally

Multivariate statistical analysis in 16 male brain injury (SAS Statistics).

Figure from:

- Pedersen M (1995) Stimmfunktion vor und nach Behandlung von Hirngeschädigten. Mit Stroboslopie, Phonetographie und Luftstromanalyse duchgefürht. Sprache, Stimme, Gehöhr 19: 84-89.
- Pedersen M, Mahmood S, Jønsson A, Mahmood MS, Akram BH, Agersted AA (2016), Functional eamination of voice, a review. Health Science Journal vik, 19 No. 4:20

	Average	SD	Correlation	Of interest
Age	35 years		14 (-48)	15 (-44)
Peakflow	7739 ml/s	1802	4 (.43)	5 (.47)
vital capacity	4052 ml	947	4 (.88)	10 (.70)
Maximal phonation time	3170 ml	989	5 (.48)	10 (.57)
Phonation	17 s	9	6 (-.47)	8 (-.69)
stability of the fundamental frequency	13.00%	9.9	11 (-.43)	
Stability of SPL	0.4dB	0.2	12 (-.42)	
Average air flow velocity			9 (.96)	11 (-.15)
Phonation quotient	275.8 ml/s	33		11 (-15)
Quotient of air consumption (average wind velocity / phonation quotient)	77.50%	10.10%	11 (.31)	
Phonetogram areal in half tones x dB	224	177	1 (.67)	12 (.49)
Maximal dynamics	19.5dB	5.4	15 (.60)	14 (.51)
lowest tone of phonegram (geometric average)	106Hz	18	14 (-.45)	
Half tones of phonetogrammes	24	8	15 (.95)	
highest ton of phonetogrammes	438 Hz	166		
(p < 0.05 über .51; P <0.01 über 0.60				

Thank you for your attention!

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