

Pericranial Motor Components of the Orienting Response

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Introduction

The orienting response (OR) can be defined as a complex of changes in brain activity and peripheral reflex responses to unexpected, novel changes in the environment (Sokolov, 1963). The OR would be directed to an aspecific enhancement of the sensitivity of sensory modalities, including that of the peripheral receptors, resulting in facilitation of the uptake, transmission, and analysis of environmental information.

The current study was undertaken to examine whether novel, unexpected stimuli elicit physiological and behavioral changes which might be related to the hypothesized sensory function of the OR in the auditory domain. We focused on two physiological response systems that might have a functional role during stimulus intake: respiration and activity of pericranial muscles innervated by the trigeminal and facial nerves. In several studies (e.g., Barry, 1977), it has been observed that during orienting, breathing is partially inhibited, probably reducing disturbing respiratory sounds. Stekelenburg and Van Boxtel (2001) found evidence for a similar functional role of inhibition of pericranial muscle activity during auditory stimulus intake. They observed that inhibition of activity in the muscles of the lower part of the face and the masticatory apparatus increases the perceptual sensitivity to external auditory stimuli. This was explained by a decrease of the internal auditory noise produced by these muscles themselves. Indirectly, pericranial inhibition might also be expected to be accompanied by relaxation of middle ear muscles, producing lower auditory thresholds, especially for low-frequency sounds. Consequently, if the primary function of the OR would be to increase the sensitivity of the sensory systems, we may predict inhibition of pericranial muscle activity and respiratory activity during the course of the OR.

Experiments 1 & 2

In the first experiment, a series of different, complex, novel auditory stimuli of low intensity was presented. Participants were engaged in a primary reading task and were not informed that stimuli were presented occasionally. In the second experiment, we investigated whether inhibitory muscular and respiratory responses would show rapid habituation with repeated presentation of the same auditory stimulus.

Participants

Exp. 1: 22 healthy volunteers; Exp. 2: 28 healthy volunteers

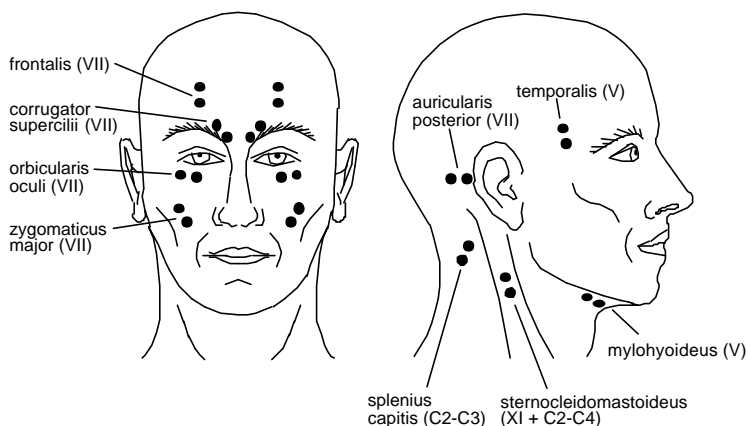
Stimuli

Exp. 1: 21 different environmental sounds (duration varying between 4.2 and 9.2 s; stimulus intensity varying between 28 and 32 dB (A); rise and fall times 100 ms) presented through a hidden loud-speaker located to the left of the participant. ISI varied between 50 and 100 s.

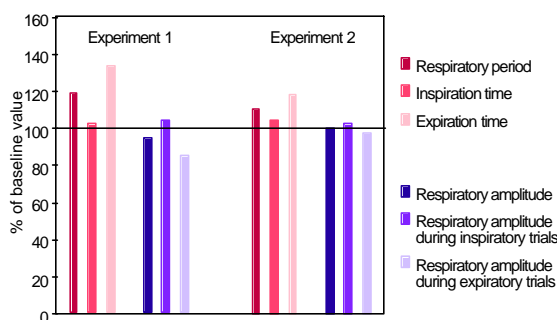
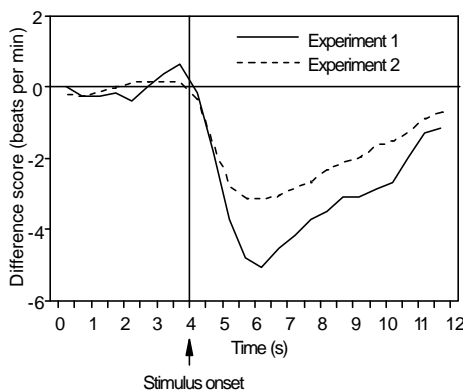
Exp. 2: a subset of 7 different stimuli was taken from Exp. 1. Each stimulus was presented 6 times in succession, resulting in 7 blocks of 6 identical stimuli.

Recordings

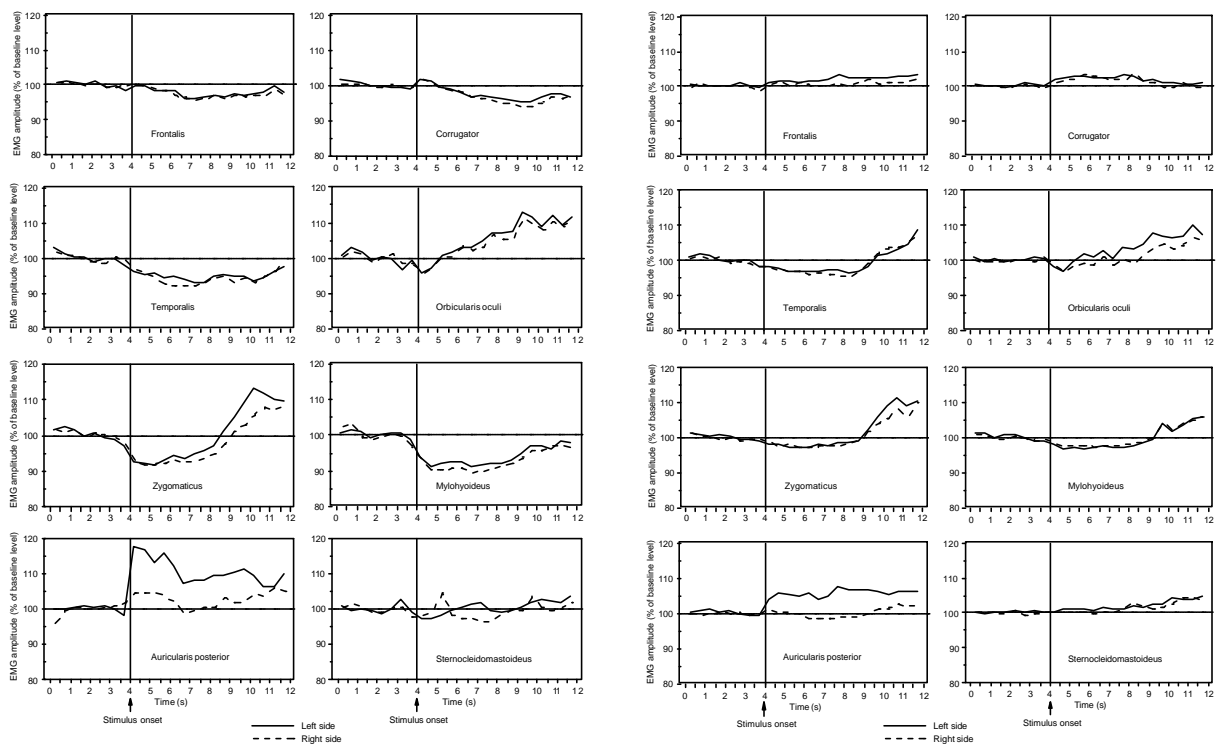
- Heart rate (Exp. 1 and 2).
- Skin conductance response (SCR, Exp. 2).
- Respiratory period (with separate analysis of inspiration time and expiration time) and respiratory amplitude.
- Bilateral electromyogram (EMG) of frontalis, corrugator supercilii, temporalis, orbicularis oculi, zygomaticus major, mylohyoideus, auricularis posterior, and sternocleidomastoideus.



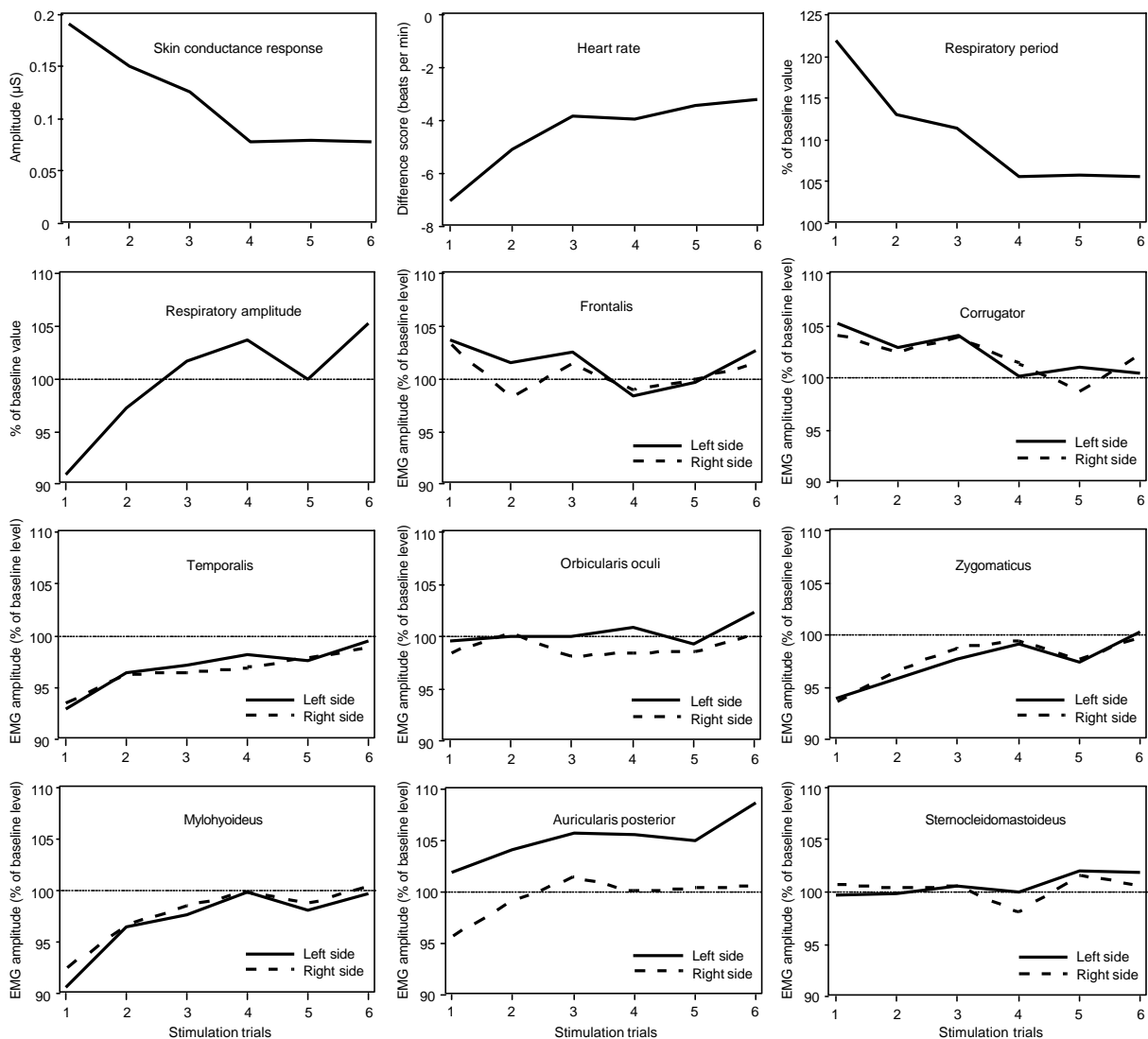
Placement of electrodes for surface EMG recordings. Roman numerals indicate muscular innervation by cranial nerves and cervical spinal nerves.



Mean heart rate responses and mean responses in respiratory period and respiratory amplitude to auditory stimuli in Experiments 1 and 2.



Mean EMG responses on the left and right side of the head to auditory stimuli in Experiment 1 (left) and Experiment 2 (right).



Ordinally averaged responses in skin conductance, heart rate, respiratory parameters, and EMG activity to repeated presentations of the same auditory stimuli in Experiment 2.

Summary of results

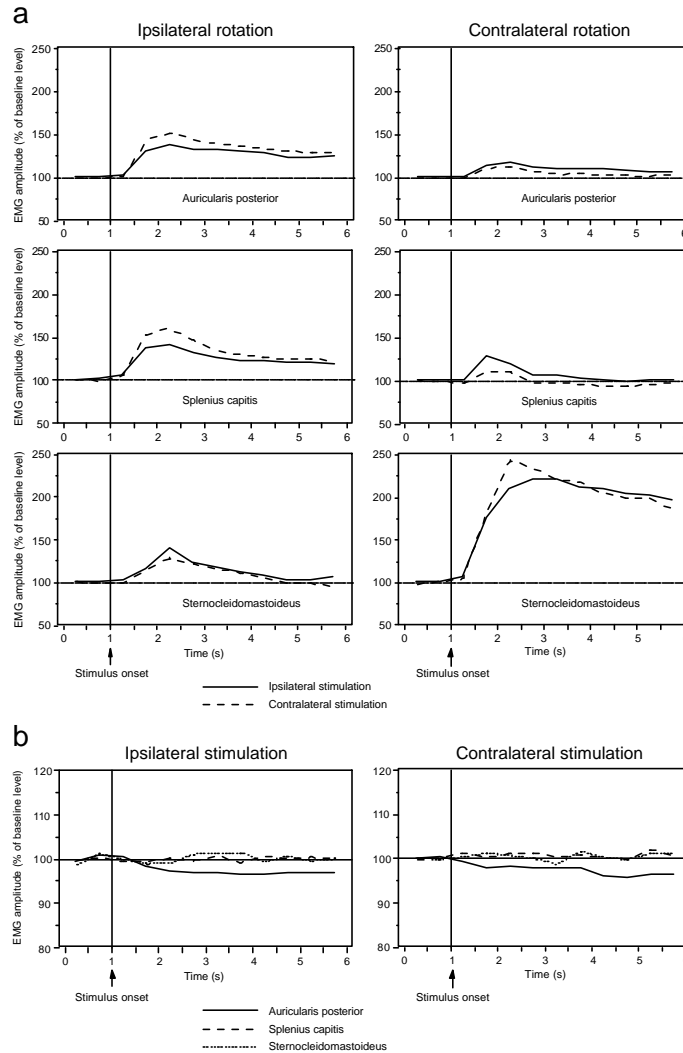
Complex, unexpected, novel auditory stimuli elicited:

- Heart rate deceleration and skin conductance responses.
- Prolongation of respiratory period, in particular of expiration time.
- Reduction of respiratory amplitude when stimulus onset fell in the expiratory phase.
- Consistent inhibition of EMG activity of temporalis, zygomaticus, and mylohyoideus.
- Facilitation of EMG activity of auricularis posterior only on the side of stimulus presentation.

SCR and the inhibitory heart rate, respiratory, and EMG responses habituated when a novel auditory stimulus was repeatedly presented.

Experiment 3

We suspected that the enhanced EMG activity in the auricularis posterior muscle on the ipsilateral side to stimulus presentation was not an effect of stimulation side but an artifact related to (a slight) rotation of the head toward the stimulation. The electrodes on auricularis posterior might pick up activity of the splenius capitis muscle that is involved in ipsilateral head rotation and has its insertion on the mastoid process and occipital bone. A third experiment was conducted to disentangle the effects of stimulation side and head rotation on the EMG response of the auricularis posterior muscle. Eight participants deliberately performed ipsilateral or contralateral head rotations or kept their gaze fixed during unilateral stimulus presentation to test whether ipsilateral stimulus presentation or ipsilateral head rotation were crucial for bringing about this EMG response.



(a) Mean EMG responses to auditory stimuli presented ipsilaterally or contralaterally relative to the EMG recording side combined with ipsilateral or contralateral rotation of the head. (b) The same during absence of head rotation.

The results of Exp. 3 indicate that the unilateral facilitation of auricularis posterior EMG was caused by crosstalk of splenius capitis EMG activity associated with ipsilateral head rotation. When rotation was prevented, bilateral EMG inhibition was observed in auricularis posterior.

Conclusion

The results suggest that involuntary orienting to nonsignal stimuli elicits a somatic and autonomic response pattern with sensory utility. Inhibition of lower facial and masticatory muscle activity and respiratory activity might quiet down somatic noise interfering with the detection and identification of the OR-eliciting stimulus.

References

Barry, R. J. (1977). Failure to find evidence of the unitary OR concept with indifferent low-intensity auditory stimuli. *Physiological Psychology*, 5, 89-96.

Sokolov, E. N. (1963). *Perception and the conditioned reflex*. Oxford: Pergamon Press.

Stekelenburg, J. J., & Van Boxtel, A. (2001). Inhibition of pericranial muscle activity, respiration, and heart rate enhances auditory sensitivity. *Psychophysiology*, 38, 629-641.