IMPACT OF AUDITORY ATTENTION ON THE EFFERENT AUDITORY SYSTEM IN THE ABSENCE OF REAL AUDITORY TARGETS

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1. Introduction

Attentional processes have been reported to modulate the efferent (descending) auditory system. These effects have been indirectly assessed by examining their impact on the contralateral suppression on otoacoustic emissions (OAE). OAEs are low amplitude acoustic vibrations arising from outer hair cells' (OHC) active and passive mechanisms. In healthy ears, they can be recorded in the ear canal in response to acoustic stimulation [1]. For the visual system, attending to visual tasks (such as counting visual events) leads to an increase in contralateral suppression (decrease OAE amplitude) relative to non-attending tasks [2, cf. 3]. In terms of auditory attention, attending to stimuli in the contralateral ear has also been shown to increase contralateral suppression, while attending to stimuli in the ipsilateral ear decreases contralateral suppression [4]. However, given that both visual and auditory attention impact on OAE amplitudes, it remains unclear whether these effects are modality-specific or a result of generalized attentional processes. In the present study, we investigated whether auditory attention, compared to visual attention, differentially modulates activity in the auditory efferent system. We used a well-reported procedure for assessing efferent system modulation, which involves the presentation of noise in the contralateral ear and measuring OAE in the ipsilateral ear (CS-OAE paradigm; [5]). The presentation of noise in the contralateral ear alters ipsilateral OHC motility via the crossed afferent pathways and the medial olivocochlear (MOC) fibers [6,7]. For the present study, we hypothesize that auditory attention will increase contralateral suppression of OAEs relative to visual attention. This will support the influence of a modality-specific attentional process, as opposed to a more generalized attentional mechanism.

2. Methods

2.1 Subjects

16 right-handed native English speakers (M (S.D.) = 22.0(3.16) years; Males: 4, Females: 12) with no history of speech, language, learning, neurological, or otological issues, or noise exposure in the last 24 hours prior to the experiment participated. All participants had ontologically normal ears and exhibited ear canal pressure values between -100 and +50 daPa, middle-ear compliance values between 0.3 and 1.6mL, and acoustic reflex thresholds ≥ 65 dB SPL. The study was approved by the University of Toronto's Health Sciences Research Ethics Board and participants provided informed consent prior to the start of the study.

2.2 Stimuli and Procedures

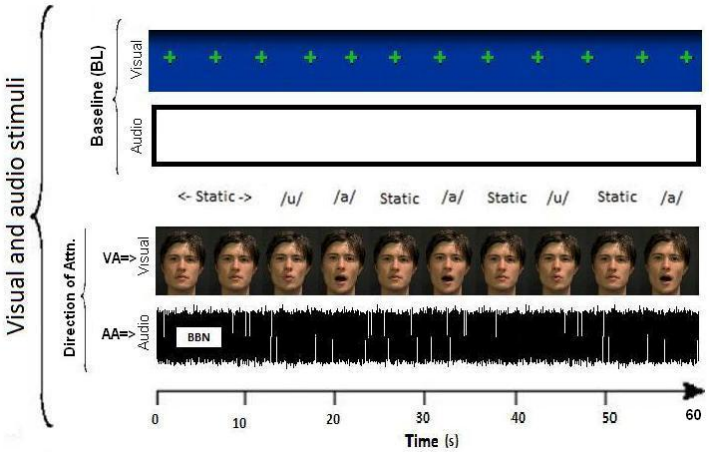
We used Transiently-Evoked OAEs (TEOAEs) elicited with linear clicks at 60 dB peak SPL (click duration of 80μs, click interval of 21.12 ms, total clicks = 1040, high and low pass filtered between 750 and 6000 Hz respectively with a recording window between 2.5 to 20.0 ms). TEOAEs at 2kHz centre frequency were recorded via Vivosonic Integrity 4.5.3, with artefact rejection threshold of 45 dB SPL and whole wave reproducibility ≥ 70%. A SNR criterion of 3dB was used as the detection threshold for TEOAEs. The study was conducted in a standard sound attenuated booth with a two-way observation window separating the control and test room. The experimenter in the control room provided all instructions for different task conditions and controlled the stimuli presentation via a laptop computer. The second experimenter sat next to the participant and carried out all TEOAE recordings, including probe fit monitoring on a trial-by-trial basis.

TEOAEs were recorded under 3 task conditions (Figure 1). In the baseline (BL) condition, participants focused their attention on a "+" symbol displayed on a computer monitor without any contralateral noise. In the other two conditions, the participants were presented with continuous contralateral broadband noise (BBN), generated by a Grason-Stadler 61 (GSI-61) audiometer and delivered in the left ear at 55 dB SPL via a ER-3A insert earphone. While BBN was presented, participants observed facial speech gestures related to productions of vowels /a/ and /u/ under two instructions: (a) to visually count the number of /a/ productions only and ignore BBN (visual attention to face condition; VA) and (b) to listen carefully and detect target sound /a/ embedded in BBN (auditory attention sham condition; AA). These "sham" trials did not have any acoustic targets and probed the effect of auditory attention even when there was no real target. There were 5 trials per block: the first block was always BL trials, followed by VA or AA trials, with the order of the latter two counterbalanced across participants. Trials within each block were also randomized and each trial lasted approximately 60 seconds.

3. Results and Discussion

The mean of the VA block (or AA block) was subtracted from the mean of the BL block within a participant to derive a score representing change from baseline (ΔVA and ΔAA)

Figure 1. Task conditions: (a) Baseline (BL) condition: no contralteral BBN, (b) VA condition: contralateral BBN + attention (attn.) directed to visually observing speech gestures related to productions of vowels /a/ and /u/ (c) AA condition: contralateral BBN + attention directed to auditory stimuli.



ΔVA Mean (S.D.) = 2.19 (1.98) dB SPL and ΔAA Mean (S.D.) = 1.88 (1.82) dB SPL. The mean difference between the two conditions yielded a moderate positive effect size (Cohen's *d* adjusted for repeated measures = 0.52). 75% of the participants tested (12 out of 16 participants; exact binomial test significant at one-tailed p = 0.03) exhibited an increase in suppression of 0.31 dB SPL in the auditory attention (AA) task relative to the visual attention (VA) task. These effects are similar to those reported in the literature, wherein auditory attention to stimuli in the contralateral ear increased OAE suppression [4]. Our results show that these effects are obtainable even in the absence of real auditory targets (i.e. without stimulus confound). Such small differences (~0.35dB) found across attentional task conditions are not unusual and have been reported in other studies [8,9]. Given that VA and AA conditions only differed in instructions of directing either visual or auditory attention, the differences observed between conditions possibly suggest a modality-specific rather than a generalized attentional modulation of the efferent auditory system.

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