Exploring age effects in auditory selective attention with a binaural reproduction method

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Introduction

Communication in noisy situations, such as a scene on a crowded street or in a full restaurant are a great challenge for our auditory attention. With respect to an aging society especially in western civilization, age effects have become of greater interest. There are already several investigations on age effects in auditory attention switching (e.g. [1, 2]). In nearly all investigations elderly subjects perform worse compared to young adults. Usually these investigations work with dichotic reproduction. However, a realistic scene differs enormously from a dichotic presentation of stimuli and therefore auditory selective attention should also be analyzed in a spatial source setup [3]. In previous investigations by Koch et al. [4, 5] as well as Oberem et al. [3] intentional attention switching using spoken digits/number words as auditory stimuli was examined with dichotic- and binaural-listening paradigms. It was found that a required switch of the attention focus yielded in worse reaction times and error rates than a repetition of the target's location.
The present investigation combined the binaural reproduction of stimuli and the analysis of age effects. Based on the findings in the previous binaural-listening experiment, two groups of different age were tested in a binaural listening setup [6].

Method

Subjects

A number of 20 students (18-35 years) and 20 senior citizens (60-75 years) participated in the experiment. Subjects were equally divided into male and female listeners and all paid (8 euro). All younger subjects have normal hearing (within 20 dB). Elderly subjects suffer from a hearing loss in higher frequencies, but were all not provided with any hearing aid (within 30 dB for frequencies of 0.125-2 kHz, within 60 dB for frequencies of 2-10 kHz).

Experimental Task

The developed paradigm, firstly introduced by Koch et al. [4], to analyze the intentional switching in auditory selective attention consists of two simultaneously presented stimuli by two different speakers of opposite sex. One speaker acts as the distractor and the other acts as the target. By a visual cue on a monitor the target-speaker's direction is cued in advance. There are eight different positions equally distributed on the horizontal plane. Speech of target and distractor are never presented from the same direction, but always simultaneously. Hence, there are 56 combinations of the target's and the distractor's position. The used stimuli are spoken digits from 1 to 9, excluding 5. Recordings are anechoic, loudness adjusted and shorten to 730 ms. The listener's task is to categorize the target's speech into two categories (smaller than 5 (<5) vs. greater than 5 (>5)). The two stimulus categories are mapped to two response buttons, held in hand, to be pressed by the left and right thumb. The procedure of a trial is also depicted in Figure 1.

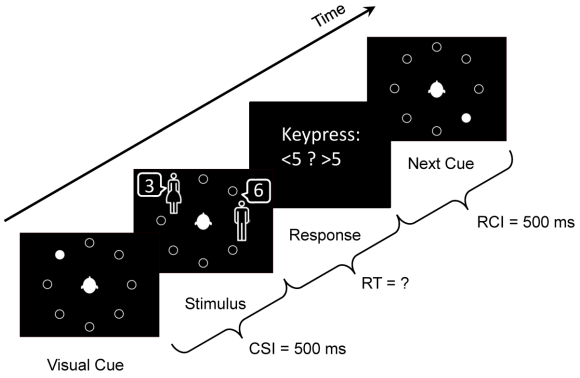

Figure 1: Procedure of a trial with a visual cue indicating the target direction, a cue-stimulus-interval (CSI) of 500 ms, the synchronous presentation of the stimuli, reaction time between onset of stimulus and the response of the subject, and the response-cue-interval (RCI) of 500 ms.

Binaural Reproduction

For the binaural reproduction, head-related transfer functions (HRTFs) of an artificial head (custom-made mannequin produced at the Institute of Technical Acoustics, RWTH Aachen University) were measured in an anechoic chamber. Generated stimuli were presented binaurally via headphones. Open headphones (Sennheiser HD 600) were used for the binaural reproduction.

Results

The collected data is submitted to a 3-way-ANOVA with the variables of age (A), transition (T) and congruency (C). The two age groups are described above. Transition describes the effect whether the targets spatial position is repeated from one trial to another (e.g. front - front) or switched between trials (e.g. left - back). The variable

congruency refers to the stimuli of target and distractor. The variable has two different levels. On the one hand, the two stimuli can be congruent, which is the case when both digits are smaller than 5 or both greater than 5 (e.g. 2 and 4, 6 and 9) and on the other hand, the two stimuli can be incongruent, which is the case when one digit is smaller and one greater than 5 (e.g. 1 and 7, 8 and 3).

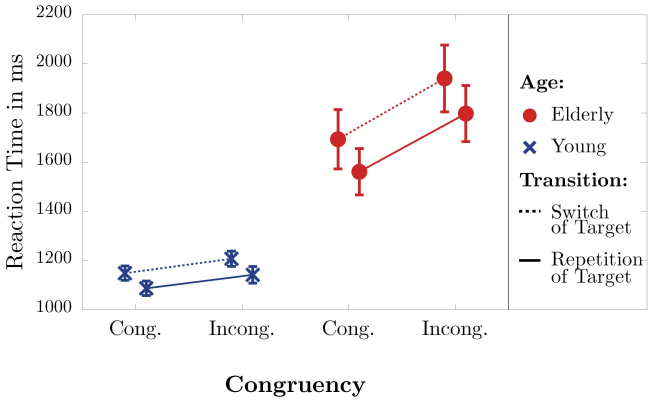

Figure 2: Reaction time (in ms) as a function of room configuration, transition and congruency (RxTxC). Error bars indicate standard errors.

Reaction time

The ANOVA yields a significant main effect of age [A: $F(1,38) = 27.03$, $p < 0.001$] in reaction times. The main effect of transition is also significant [T: $F(1,38) = 20.46$, $p < 0.001$], indicating a higher reaction time for switches than for repetitions (c.f. Fig. 2). However, no significant interaction with age was found [$A \times T$: $F(1,38) = 2.78$, $p > 0.05$]. The third main effect of congruency is also significant [C: $F(1,38) = 33.77$, $p < 0.001$], indicating smaller reaction times for congruent trials than for incongruent trials. The congruency effect was significantly smaller for younger subjects (57 ms) relative to the elderly subjects (242 ms) [$A \times C$: $F(3,38) = 3.68$, $p < 0.001$].

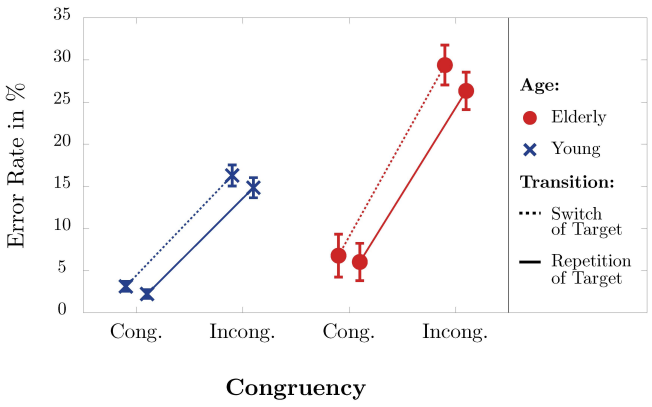

Figure 3: Error rate (in %) as a function of room configuration, transition and congruency (RxTxC). Error bars indicate standard errors.

Error rate

The ANOVA yields a significant main effect of age [A: $F(1,38) = 18.47$, $p < 0.001$] in error rates. The other two main effects are also significant [T: $F(1,38) = 7.86$, $p < 0.05$], [C: $F(1,38) = 127.59$ $p < 0.001$] (c.f. Fig. 3). The interaction of age and transition is as in reaction times not significant [$A \times T$: $F < 1$], but the interaction of age and congruency yields a significant interaction [$A \times C$: $F(3,38) = 7.94$, $p < 0.05$].

Conclusion

The present investigation examined the age effect in an auditory switching task. Younger, normal-hearing adults outperformed older, moderately hearing-impaired adults in almost every condition of the study. Especially, great differences were found in the performance of ignoring the distractor's speech, indicated by the congruency of stimuli. However, the ability to switch attention from one direction to another did not differ significantly correlated with age. In this investigation age was a significant factor although differences in hearing sensitivity across age groups might have contributed to this effect.

Acknowledgement

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