Effects of irrelevant speech and traffic noise on speech perception and phonological short-term memory in children aged 6 to 7 years

Maria Klatte[1], Helga Sukowski[1], Markus Meis[2], August Schick[1]

[1] *University of Oldenburg, Dept. of Psychology, D-26111 Oldenburg, Email: maria.klatte@uni-oldenburg.de*
[2] *Hearing Center Oldenburg Ltd.*

Introduction

The ability to listen effectively is of major importance for children's cognitive and social development. Unfavorable listening conditions such as reverberation and noise disrupt children´s listening performance more than adults' [1]. In order to achieve adequate listening conditions for children, it is necessary to know (i) which sound qualities determine the disruption of children's listening performance, and (ii) what kinds of listening tasks are especially sensitive to disruption by noise.

Within the Research Network "Quiet Traffic", we are currently examining the effects of different kinds of train noise on listening tasks which require identification, storage and mental processing of speech in first-graders. Irrelevant background speech is also included as a sound condition, since it is known that task-irrelevant background speech disrupts phonological short-term memory ("Irrelevant Sound Effect" (ISE)). The ISE is a very robust effect that has been documented in numerous studies using visual as well as auditory presentation of the items to be remembered [2]. Since the experiment was still running at the time of the DAGA, only the results concerning the effects of irrelevant speech will be presented in this paper.

Method

Subjects

23 first-graders (9 male, 14 female) of an Oldenburg elementary school took part in this experiment. The children aged 6 to 7 years, with a median age of 7 years 1 month.

Tasks

Three listening tasks varying in complexity were used in this study.

(1) Identification of single words: In each trial, 3 pictures representing similar-sounding words were presented to the children (e.g. "Arzt", "Axt" and "Ast"). The pictures were accompanied by a spoken word representing one of the three objects (e.g. "Arzt"). The children had to mark the picture representing the word in prepared response sheets.

(2) Phonological short-term memory: In each trial, a pair of nonwords was presented to the children with an interstimulus-interval of 3 seconds. The nonwords consisted of CV-syllables and varied in length between 3 and 5 syllables. In half of the pairs, the same word was repeated, in the other half, the second word of the pair was changed (e.g. "giboda-guboda"). Response sheets were prepared in which each trial was represented by a box with two identical cars ("same") and a box with a car and a bicycle ("different").

(3) Carrying out oral instructions: In this task, verbal instructions were presented to the children, which had to be carried out on prepared response sheets (e.g."Put a cross under the book that lies next to the chair.") Scoring was based on the number of elements correctly solved in each sentence.

Sounds

The speech material was produced by a trained speaker and recorded on DAT-tape via a dummy head in a soundproof laboratory.

A 15-second episode of Danish speech produced by a female speaker was used as irrelevant speech. The record contained no reverbaration and no remarkable changes in loudness and intonation. None of the children could speak or understand Danish.

The words, nonwords and sentences were mixed with the Danish speech with a signal-to-noise ratio of + 5 dB(A). For the identification task, a 3-second episode of the Danish speech was used. The target word started 1 second after onset of the Danish speech. The instructions and nonword pairs were mixed with parts of the 15 seconds episode corresponding to the length of the individual items. For the control condition, the sounds were mixed with low-intensity, continuous broadband noise in the same way, but with an S/N of + 26 dB(A). Noise was used instead of silence in order to avoid an "unnatural" silence in the sound cabin and to minimize potential effects of sounds produced by the children themselves (hustling, rustling, scraping one´s feet etc.).

Procedure

The children were tested in groups of 4 in a sound-attenuated laboratory equipped with school furniture appropriate for this age group. Sounds were presented via open headphones (Sennheiser Elektrostaten HE60/HEV70)) with a signal level of 62 dB(A) Leq. Each trial started with a warning signal consisting of two tones ("ding-dong").

In each task, pictures of the children´s response sheets were shown on a 50'' plasma screen located in front of the room. In each trial, a red arrow marked the appropriate line in which the children had to put their answer on the sheet (see Figure 1). The presentation of the pictures and sounds was controlled using standard presentation software (Microsoft PowerPoint XP).

The effect of sound condition on performance was tested via a repeated-measurement design. Two parallel versions of each task were constructed. For each task, half of the children received version 1 with noise and version 2 with irrelevant speech, the other half received version 2 with

noise and version 1 with irrelevant speech. The order of the sound conditions was randomized from trial to trial.

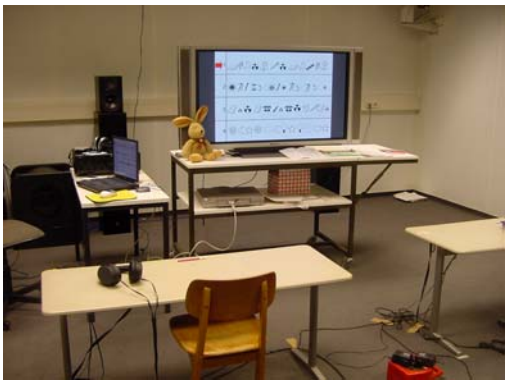

Figure 1: The soundproof laboratory. The slides shown on the plasma screen correspond to the answer sheets used by the children. A red arrow indicates the line representing the actual trial.

Results

Identification of single words

One of the children was late at the time of testing and could not participate in this task. Analysis is thus based on a total of 22 children.

The children reached a high level of word identification performance irrespective of sound condition (see Figure 2). Mean error rate was less than 1 in both sound conditions. There was no significant difference between the means. The children were obviously able to identify the target phonemes correctly in the presence of irrelevant speech.

Phonological short-term memory

As can be seen in Figure 2, phonological short-term memory was severely disrupted by irrelevant speech. Mean number correct was 8,74 (out of 10) in the noise and 6,65 (out of 10) in the speech condition (notice that guessing probability in this task is 5 items correct). Statistical analysis proved a highly significant difference between the means ($T(22) = 8{,}07$; $p<0{,}000$).

Carrying out oral instructions

Performance in this task was significantly affected by irrelevant speech. The children achieved about 10 percent less of the available points when the instructions were accompanied by irrelevant speech.

Discussion

Irrelevant speech of moderate intensity disrupts children´s short-term memory and sentence perception. Obviously, this effect does not result from masking, since irrelevant speech had no effect on a task requiring phoneme identification. As can be seen in Figure 2, the disruption was more pronounced in the short-term memory task than in the oral instructions task. Therefore, the effect should be interpreted as an "Irrelevant Sound Effect". Irrelevant speech has automatic access to phonological short-term memory and interferes with the phonological codes of the items to be remembered.

The disruption of the oral instructions task may also result from interference in short-term memory, since the children

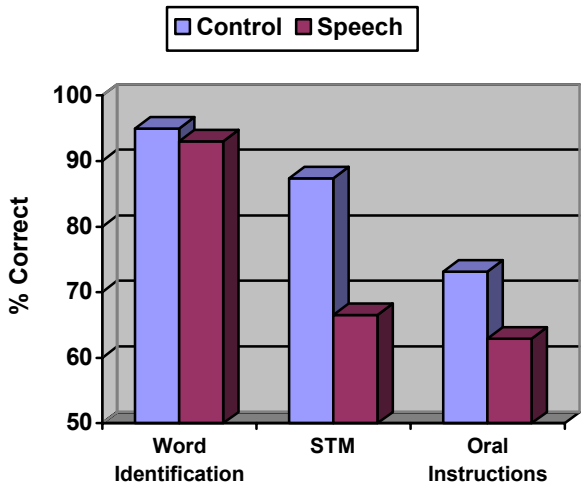

Figure 2: Effects of irrelevant speech on children´s performance in word identification, short-term memory (STM) and carrying out oral instructions.

had to memorize the instructions while carrying them out. In a recent study using the standard irrelevant sound paradigm (memorizing visually presented digits), children were much more affected by irrelevant sounds than adults [3]. The experiment reported here gives further evidence for the pronounced susceptiblility of young children for sound-induced disruption of short-term memory. This finding deserves further attention since, whereas phonological short-term memory does not play a dominant role in adult's everyday cognition, it is of major importance in cognitive development. The ability to hold nonwords in short-term memory is a predictor of children´s language and reading development [4]. Accordingly, standardized tests of language and reading development often include short-term memory tasks as subtests. Regarding the magnitude of the irrelevant sound effect in children reported so far, it is reasonable to assume that permanent exposure to irrelevant sounds might have harmful effects on children's language and reading acquisition. Further research is needed to test for this hypothesis.

References

[1] Johnson, E.C. (2000). Children´s phoneme identification in reverbaration and noise. Journal of Speech, Language, and Hearing Research 43, 144-157.

[2] Larsen, J.D. & Baddeley, A.D. (2003). Disruption of verbal STM by irrelevant speech, articulatory suppression and manual tapping: Do they have a common source? Quarterly Journal fo Experimental Psychology 56A, 1249-1268.

[3] Elliott, E.M. (2002). Irrelevant Speech Effect in children. Memory & Cognition 30(3), 478-487.

[4] Baddeley, A.D. (2003). Working memory and language: An overview. Journal of Communication Disorders 36, 189-208.