IRRELEVANT SPEECH, ATTENTION AND MEMORY IN PUPILS

E. Boman
University of Gävle, Sweden

Introduction Only recently has behavioural noise research started to relate environmental noise exposure to cognitive performance in children. Since most of the reported studies are cross-sectional, an experimental study, examining how noise influence different aspects of children's memory, was designed. The tests in the battery were arranged to elucidate several cognitive processes. However, for the present paper, the effects of meaningful irrelevant speech on attention, cued recall and recognition from episodic memory and retrieval from semantic memory will be described.

In school irrelevant speech is a dominant noise source. Despite that, the only study found, that examined the influence of acute irrelevant speech on children's long-term memory was Hygge (in press). In a large set of classroom experiments, children aged 12-14, read texts in both silence and noise in their ordinary classroom. The memory test composed cued recall and recognition questions and the children were tested exactly one week later. The results showed that continuous irrelevant meaningless speech, presented at 66 dBA L_{eq}, did not affect recall, nor recognition. However, a number of researchers have examined irrelevant speech on short-term memory on adults, showing pronounced impairment from both meaningful and meaningless speech, particulary on memory tasks with a serial component
(cf. Martin, Wogalter & Forlano, 1988; Oswald, Tremblay & Jones, 2000 and studies reported therein). For more complex cognitive tasks, such as reading comprehension and proofreading the meaning of the speech is of importance (Martin, et al., 1988; Oswald et al., 2000).

Episodic memory refers to the type of long-term memory that allows a person to recollect personally experienced events. It encompasses both the initial acquisition of information (encoding) and the subsequent remembering of the previous experiences (retrieval) (Tulving, 1993). Noise exposure may impair memory both by impairing encoding and retrieval. However, noise research has traditionally relied on memory tests that make explicit reference to a specific learning episode (Meis, Hygge, Evans & Bullinger, 1998), though divided attention at encoding reduces performance considerably but has a much smaller effect on retrieval (Craik, Naveh-Benjamin, Ishaik & Anderson, 2000). This assumption is also confirmed in that chronic noise effects on children's long-term memory seem to be on complex explicit memory material, which are strongly dependent on semantic processing (cf. Meis, et al., 1998). In order not to confound the noise effects on encoding and retrieval, the retrieval phase was always in silence.

If retrieval is successful or not is dependent on which way the event was encoded but also which cues are available during retrieval. It has been suggested that recall involves more effective processing than does recognition, as very few retrieval cues are available during recall (Craik & McDowd, 1987).

The tests in the battery were arranged to elucidate several cognitive processes. A first comparison was that between cued recall and recognition from text reading when exposed to meaningful irrelevant speech during the encoding phase. It was predicted that meaningful irrelevant speech would impair cued recall, but not recognition, since more retrieval cues are provided in recognition compared to cued recall.

Semantic memory encompasses the structured representation of objects, facts and concepts, as well as words and their meaning, with no reference to the time, place and context where the

knowledge was acquired (Tulving, 1993). It was kept open whether decrements in retrieval from semantic memory will occur for children at the age of 13-14 years, since this memory system on one hand is a stable system, which can be assumed to be resistant against noise, and the attentional demands can be regarded as being more automatic than controlled (Craik et al., 2000). On the other hand, is the semantic memory in a developmental stage for this age group, though it reaches its peak in the middle age (Tulving, 1993).
According to earlier findings (Hygge, Boman & Enmarker, 2003) it was predicted that meaningful irrelevant speech would impair attention in a speed to accuracy trade-off (SATO) way, with more lines of the task completed in noise, but at a lower accuracy. It was also expected that impaired attention would act as a mediator for the expected noise effects on episodic memory since divided attention at encoding reduces performance considerably (Craik, et al., 2000).

Methods

Subjects and basic design Sixty-four school children, aged from 13 to 14 (M=13.8) were recruited from local compulsory schools and paid to participate. Equal numbers of boys and girls were randomly assigned to the meaningful irrelevant speech and silent condition. There were 16 boys and 16 girls in each group.

Procedure The experiment was conducted in a climate chamber (4 x 6 m) in which the air temperature (21°C) and light level (900 lux) were controlled. Three to four subjects stayed in the experimental room at the same time, but worked on the tasks individually. They were seated at a row of tables and in front of the subjects there was a computer screen. The tasks were given in the order and time restraints shown in Table 1. Altogether, the experimental session lasted for approximately two hours and the noise exposure during fifty minutes. All sessions were run in the afternoons. At the outset, the pupils were informed that the study was about people's memory. They were told that they would be given separate instructions and time limits ahead of each task. Throughout the experiment the time limits were exactly the same for all subjects. The experimental session was divided into two parts. The difference between the three groups was during part one in which the subjects were exposed to noise in the noise conditions. This design made it possible to analyse noise effects on encoding for episodic memory and performance in semantic memory and attention.

Noise In the noise conditions digital recordings of meaningful irrelevant speech was played back through loudspeakers in front of the room. The equivalent sound level in the noise condition was set to 66 dBA L_{eq} 2 m in front of the loudspeakers. The sound level in the silent group was 38 dBA L_{eq}. The meaningful irrelevant speech recording consisted of background babble (~62 dBA) without any discernible meaning. Segments from a conversation between teenagers, only one person talking at a time, were superimposed on the babble background. The dominant frequency range for the speech was 500-1500 Hz and the recording included both male and female voices.

Dependent measures

Cued recall and recognition of a text The subjects read a text during 15 minutes about an ancient culture. In order to prevent the readers from using their possible knowledge about the culture, imaginary words and names replaced real ones. In about one-hour later text comprehension was tested with cued recall and recognition questions in silence (see Table 1, task 2, 12). The subjects replied in writing to eight cued recall questions and twelve multiple-choice questions.

Word fluency The next test was a semantic memory task that encompassed three ways of assessing word fluency, to generate words, five-letter words and professions starting with a certain letter (see Table 1, task 4). Each task was done during a period of one minute. In this way, noise impact on general knowledge in the semantic memory was tested.

Word comprehension Another semantic memory task was a word comprehension task. The pupils were presented with a list of 30 target words and next to each word there were four other words presented. Among these four words there was one synonym to the target word. This task was also a test of noise impact on the general knowledge in semantic memory (see Table 1, task 5).

Search and memory task (SMT) Attentional performance was measured by a memory-load search task. Subjects were presented lines of random letters with five target letters at the beginning of each line. The task was to memorise the given targets, search through the given line only once, and to mark all the targets found. Each line contained 59 letters, 0-4 of which were targets. Accuracy, percentage of errors of omission, was scored. This task was performed twice during the experiment, in the beginning and as the last task before the silent period (see Table 1, task 1, 7). By administrating the task twice, both initial and accumulated noise effects on attention can be assessed.

Table 1 Chronological Order of Dependent Measures and Time Limits for Each Task

Test No.	Dependent measure	Block	Time min.
Part 1	Encoding and retrieval in silence or road-traffic noise [1]		
1)	**Attention, search and memory task (SMT)**	**Block 1**	**6**
2)	**Reading a text**		**15**
3)	Face and name encoding		2.5
4)	**Word fluency**		**3**
5)	**Word comprehension**		**7**
6)	Encoding of SPTs and sentences		4.5
7)	**Attention, search and memory task (SMT)**	**Block 2**	**6**
Part 2	Retrieval in silence		
8, 9)	Free and cued recall of SPTs and sentences		10
10)	Recognition test of faces and first and family names		12
11)	Cued recall of SPTs and sentences		4.5
12)	**Test of recall and recognition of text in task 3**		**10**

Note. Only the bold typed dependent measures are reported in this article. [1] The actual experiment also included a third condition, road traffic noise, which is not reported here.

Results

Cued recall and recognition of the text in episodic memory For cued recall, the pair-wise difference between performance in the silent condition (M=3.41, SD=2.84) and the meaningful irrelevant speech (M=2.03, SD=2.06) condition was significant, $t(62) = 2.22$, $p < .05$. Thus, noise impaired cued recall of the text in episodic memory in the predicted manner. However, contrary with predictions, the difference between silence (M=8.00, SD=2.21) and meaningful irrelevant speech (M=6.38, SD=2.24) was significant also for recognition, $t(62) = 2.91$, $p < .01$ (see Figure 1, 2).

Word fluency To generate words, five-letter words and professions on a certain letter did not differ between the silent and road traffic noise condition.

Word comprehension The analysis revealed a higher degree of word comprehension in silence (M=18.97, SD=4.73), than in meaningful irrelevant speech (M=15.97, SD=5.46), $t(62) = 2.35$, $p < .05$.

Search and memory task (SMT) In contrast to expectations the predicted speed-to-accuracy trade-off effect was not supported. That is, the pupils did not complete more lines to a lower accuracy during noise exposure.

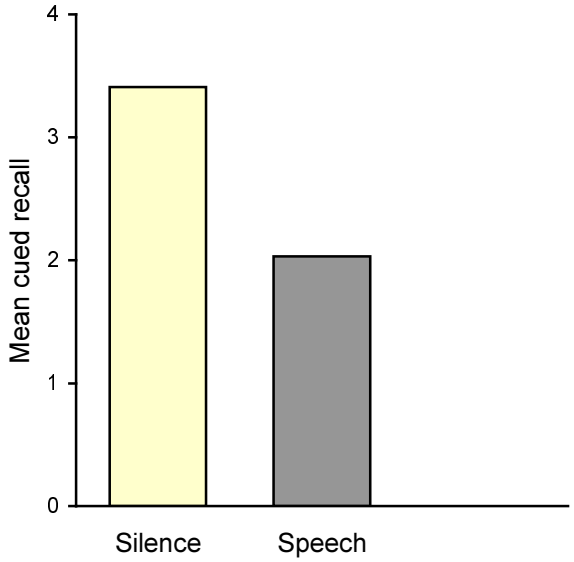

Figure 1. Mean scores on cued recall items of a text in episodic memory

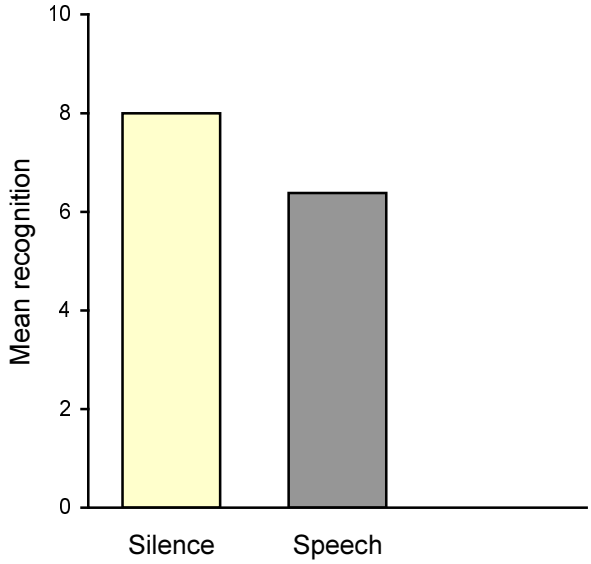

Figure 2. Mean scores on recognition items of a text in episodic memory

Conclusions The most salient finding in this study was the effect of noise on cued recall from text reading, which replicates the results from Hygge (in press) and Hygge et al., (2003). These results are consistent with research on meaningful irrelevant speech effects on reading comprehension and proof reading (Martin et al., 1988) that the extraction of meaning while encoding the text would be less efficient if the noise also is meaningful and to same extent processed semantically. Further, against prediction was the impairment on recognition from text reading. Thus, it can be concluded that meaningful irrelevant speech causes such an inefficient elaboration of the text, so even with the retrieval cues provided in recognition an effect of noise occurred.

For one of the semantic memory retrieval tasks, word comprehension, there was a noise effect. Since the semantic memory is in a developmental stage (Tulving, 1993), this result may indicate that noise with a semantic content might be especially disturbing for this age group.
The lack of noise effect on attention is inconsistent with the explanatory framework that memory performance decline when attention is divided during encoding relative to condition of full attention (Craik et al., 2000).

Key-words: Noise, Meaningful irrelevant speech, Attention, Episodic, Semantic memory

References

Craik, F. I. M., & McDowd, J. M. (1987). Age differences in recall and recognition. *Journal of Experimental Psychology: Learning, Memory and Cognition, 13* (3), 474-479.

Craik, F. I. M., Naveh-Benjamin, M., Ishaik, G., & Anderson, N. D. (2000). Divided attention during encoding and retrieval: Differential control effects? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 2*6 (6), 1744-1749.

Evans, G. W., & Lepore, S. J. (1993). Moderating and mediating processes in environment behavior research. In G. T. Moore & R. W. Marans (Eds.), *Advances in Environment, Behavior, and Design,* Vol 4 (pp. 255-285). New York: Plenum Press.

Hygge, S. (in press). Classroom experiments on the effects of different noise sources and sound levels on long-term recall and recognition in children. *Applied Cognitive Psychology.*

Hygge, S., Boman, E., & Enmarker, I. (2003). The effects of road-traffic noise and meaningful irrelevant speech on different memory systems. *Scandinavian Journal of Psychology, 44,* 13-21.

Martin, R. C., Wogalter, M. S., & Forlano, J. G. (1988). Reading comprehension in the presence of unattended speech and music. *Journal of Memory and Language, 27,* 382-398.

Meis, M., Hygge, S., Evans, G. W., & Bullinger, M. (1998). Dissociative effects of traffic noise on implicit and explicit memory: Results from field and laboratory studies. In N. Carter & R. F. S. Job (Eds.), *Noise Effects '98 – Proceedings of the 7th International Congress on Noise as a Public Health Problem. Vol. 1* (pp.389-394). Sydney, Australia: National Capital Printing ACT.

Nilsson, L.G., Bäckman, L., Erngrund, K., Nyberg, L., Adolfsson, R., Bucht, G., Karlsson, S.,Widing, M., & Winblad, B. (1997). The Betula prospective cohort study: memory, health, and aging. *Aging, Neuropsychology, and Cognition, 4* (1), 1-31.

Oswald, C. J. P., Tremblay, S., & Jones, D. M. (2000). Disruption of comprehension by the meaning of irrelevant sound. *Memory, 8* (5), 345-350.

Tulving, E. (1993). Human memory. In. P. Andersen, O Hvaleby, O Paulsen & B. Hökfelt (Eds.), *Memory concepts 1993: Basic and clinical aspects* (pp.27-45). Amsterdam: Excerpta Medica.