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THE EFFECTS OF AIRCRAFT NOISE ON MEMORY, STRESS AND AROUSAL IN OLDER PERSONS

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ABSTRACT
The aim of the present experiment was to examine memory, stress and arousal in older adults during aircraft noise (66 dBA L_{eq}) exposure. Since the study replicated the design of Hygge's [1] classroom experiment, a comparison with schoolchildren and the older adults of the degree of impairment in long-term memory recall also could be performed. The subjects, 105 senior citizens 66-74 years of age (62 females and 43 males) took part in three experimental morning sessions. The results showed that aircraft noise impaired long-term memory recall, as well as recognition. With regard to long-term memory recall, aircraft noise effect on older adults was stronger than for the schoolchildren. In short-term memory serial recall decrements were found on earlier items. The subjects reported themselves more stressful, but not more aroused, when exposed to noise.

1 - INTRODUCTION
Studies of younger persons have demonstrated that memory performance declines when attention is divided at the time of encoding relative to conditions of full attention [see 1, 2]. However, there are fewer consensus over whether the degree of impairment is similar or even greater for older adults. Experiments of age differences in memory include a large numbers of studies comparing test on recall and recognition memory. The results show age decrements in recall performances, while the results in recognition memory are mixed [3]. The long-term memory recall, but not recognition, was impaired in children at the age of 12-14 years in Hygge's [1] classroom experiments when exposed to aircraft noise at 66 dBA L_{eq}. Hygge [1] did not employ any measures of short-term memory, arousal or stress. Therefore, the older adults in the present study were subjected to a serial recall task, and an arousal and stress questionnaire. In this way the influence of aircraft noise could be assessed, as well as the role played by arousal and stress at information intake.
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2 - METHOD

2.1 - Participants
One-hundred and five senior citizens 66-74 years of age, 62 women and 43 men, took part in the study. The participants were recruited on the criteria that they reported themselves being of normal health for their age and without any hearing impairment.

2.2 - Design
The study replicated the within-subject design of Hygge [1]. All participants took part in four morning sessions, exactly one week apart and always before lunch. The first one was a pre-test under ambient noise (instructed silence condition). The experimental sessions two and three were counterbalanced as

the noise and control (ambient noise) conditions. Participants were randomized on a group basis to the experimental and control conditions. There were four groups of participants: n = 29 (15 women and 14 men), n = 23 (16 women and 7 men), n = 28 (15 women and 13 men), and n = 25 (16 women and 9 men). The long-term memory test was always done in silence. After the two experimental sessions there was an ending long-term memory test-session.

2.3 - Apparatus

In the noise condition, aircraft noise was played back through loudspeakers in front of the experimental room. L_{eq} was set to 66 dBA 4 m in front of loudspeakers. The peaks were ∼78 dBA, occurring at 12 points in time during the 28 min noise exposure. The background noise levels in the control condition were $\sim 42 - 44$ dBA L_{eq}. Before the participants entered the experimental room, a Brüel & Kjær 2219 sound level meter was used to measure the noise levels. In front of the participants there was a computer screen for the serial recall stimuli.

2.4 - Materials and procedure

The texts for the long-term memory assessment were about three cultures taken from Carter [4]. The texts were approximately of the same length, around 6 pages. In the first session all participants read the same text. The two other texts appeared equally often in different conditions and presentation orders. The following-up long-term memory test consisted of six recall items and twelve open-ended items for recognition. The test took part exactly one week apart from the text reading.

In addition to the materials used in Hygge [1], the present study also included a serial recall task, containing fourteen series of nine letters. The letters were presented on a computer screen, clearly visible to all participants, at a rate of 1/s. After each series there was a 10 s pause, after which the participants were instructed to enter the letters in correct order in a reply form. In the experimental sessions, the serial recall task was presented between testing for long-term memory and reading the new text.

The arousal and stress questionnaire taken over from Kjellberg and Iwanowski [5] and Kjellberg and Bohlin [6], comprised of 16 adjectives representing two dimensions of arousal, wakefulness and energy, and one dimension of stress, on rating scales from 0 (not at all) to 5 (very, very much). The participants completed the questionnaires at the beginning and in the later part of each session. Age, gender, education level, medication, former knowledge of the text read, degree of difficulty and effort in the tasks, and the perceived disturbance from the noise while reading and learning were also controlled for.

3 - RESULTS

Analyses of variance (Software SPSS-X, MANOVA) were made on the scores in the control and aircraft noise conditions (within-subject). As a follow-up, ANCOVA was also performed.

3.1 - Long term memory recall

The predictions were stated that aircraft noise would impair long-term memory recall in older adults, and that the recall items would be more impaired in older persons than in schoolchildren. The statistical analysis for the recall items indicated a significant main effect of Noise, F (1,104) = 25.13, p =.000, as shown in the first pair of bars in Figure 1. Figure l also shows the results from Hygge [1] on the recall scores from the aircraft noise in schoolchildren. There was a significant interaction between Age and Noise, F (1,244) = 10.56, p =.001. Thus, the predictions were supported.

3.2 - Long-term memory recognition

It was an open issue if the aircraft noise would impair recognition in long-term memory in older adults or not. As shown by bars in Figure 2 there was a significant effect of Noise, F (1,104) = 10.44, p =.002. Accordingly, recognition was impaired by aircraft noise in older adults.

3.3 - Short-term memory serial recall

To corroborate the findings by Hamilton, Hockey, and Rejman [7] in a serial position recall task, it was predicted that noise would impair memory for items early in the list, but would improve for items late in the list. Aircraft noise did impair serial recall, F (1,104) = 19.05, p =.000. There was also a main effect of Position, exact multivariate F (8,97) = 217.42, p =.000. There was a significant interaction between Noise and Position, exact multivariate F (8,97) = 2.34, p =.024, indicating that noise impaired serial recall only for the items early in the list. This result supported the part of the prediction that stated that aircraft noise would impair the performances on early items, but did not support improvements for later items.

3.4 - Arousal and stress

It was predicted that perceived arousal and stress would be higher in the aircraft noise condition than in the control condition. For the second measurement during the noise and control conditions, the statistical

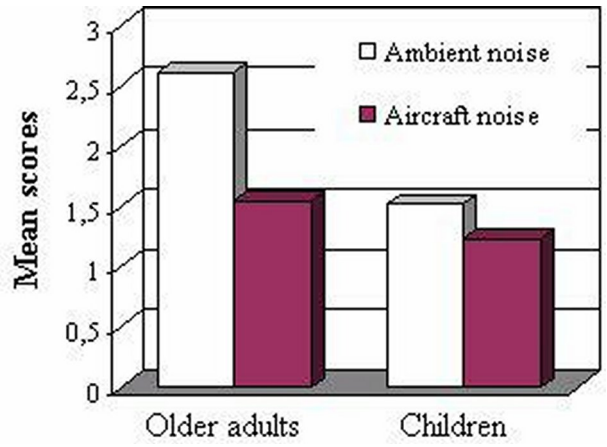

Figure 1: Mean scores on the recall items after learning in aircraft and ambient noise for older adults and schoolchildren.

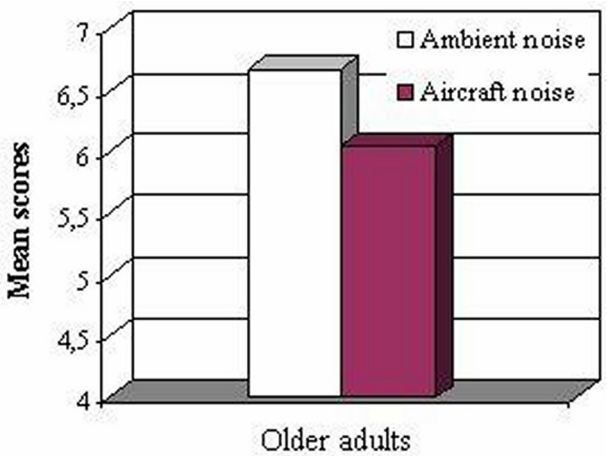

Figure 2: Mean scores on the recognition items after learning in aircraft and ambient noise for older adults.

analyses only showed a significant effect on perceived stress, $M_{ambient} = 2.17$, $M_{noise} = 2.44$, $F(1,104) = 15.76$, $p = .000$. For perceived wakefulness and energy Fs $< .15$. These results were paralleled by the increase in wakefulness, energy and stress from the first to the second measurement within the noise and control sessions. Only the increase in perceived stress in the aircraft noise condition was significant, $F(1,103) = 5.38$, $p = .022$. (Other Fs $< .35$).

Given that the arousal dimension is mainly tapped by the questions on wakefulness and energy, the lack of effects of aircraft noise on arousal was ruled out. However, the significant increase on perceived stress, could mean that the aircraft noise effects on long-term memory recall was largely mediated by perceived stress at the time of learning. To test this hypothesis an ANCOVA was performed for the recall items with perceived stress as covariates. Although the correlation with the covariates was significant, $F(1,103) = 9.88$, $p = .002$, the Noise effect was still highly significant, $F(1,103) = 13.89$, $p = .000$. Thus, the mediating effect of stress was not sufficient in explaining the noise effects.

4 - DISCUSSION

The result showed that memory performance in older adults declined when attention was divided during encoding. Thus, long-term memory recall, as well as recognition, and the short-term memory serial recall were impaired when learning during aircraft noise exposure. With regard to long-term memory recall, the effect of aircraft noise in older adults was stronger than for the schoolchildren. The perception of stress was significantly higher in the aircraft noise condition compared to the control condition. However, stress did not mediate the noise effect on long-term memory recall. Arousal was also ruled out as an explanation of the memory effects. It can be concluded that older adults are cognitively vulnerable when exposed to aircraft noise, and so in a higher degree than children, 12-14 years, are. Further studies will

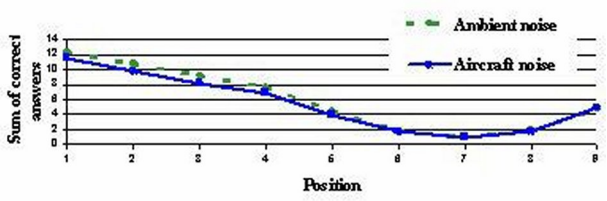

Figure 3: Mean sum of correct answers on the serial position recall in aircraft and ambient noise.

be designed to deepen the age difference findings in long-term memory by tasks with a more distinct division in memory processes and systems.

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