EFFECTS ON SPATIAL SKILLS AFTER EXPOSURE TO LOW FREQUENCY NOISE

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A study of spatial skills was conducted with 27 male and 27 female participants. The aim of the study was to examine the post-exposure effect of a complex low frequency noise (21 Hz) on a mental rotation task. It was hypothesised that reaction time and number of errors would increase after 20 minutes exposure to noise, and that persons exposed to more intense noise would exhibit greater impairment. Three groups of participants were exposed to a quite control condition and a noise conditions (either, 77, 81 or 86 dB (A)). After each exposure, subjects completed a mental rotation task where the stimulus consisted of one of three letters presented in five different rotations, showed either normally or mirrored. The participants were asked to respond as quickly and accurately as possible, affirmatively if the letter presented wasn't mirrored and negatively if mirrored. Statistical analysis revealed that the medium intensity level generated post-exposure effects when comparing noise and a quite condition.

Many people are exposed daily to unwanted noise in their working environment. One of the primary effects of this noise is loss of attention during a cognitive activity, such as disruptions during reading or writing. Sounds often seem to influence our awareness. Research in this area has been focused on effects during exposure, both in terms of physiological and cognitive functioning.

For instance, studies have demonstrated the negative influence of noise on focused attention tasks and reduced hit-rate on detection tasks (Smith, 1988, 1991). Other researchers have studied interactive effects of multiple stressors on cognitive performance. For example, students who have to cope with demands of exams and papers at the end of their semester had greater psychophysiological stress and significant slower reaction times when they executed a dual task during a noise condition (Evans, Allen, Tafalla, & O´meara, 1996). Gomes, Martinho Pimenta and Castelo Branco (1999) found similar results that showed memory impairment after exposure to low frequency noise.

However, less is understood about post-exposure effects from noise. Glass & Singer (1972) were among the first to demonstrate post-exposure effects on mental performances. They found that predictability and the individual's possibility to control the noise reduces these effects. Cohen Evans, Krantz and Stokols (1980) investigated these effects in school children, and the results showed that children from noisy schools are more likely to fail on cognitive tasks and appear to give up before they complete their task than children from quiet schools. Haines and colleagues (Haines, Stansfeld, Job, Berglund & Head, 2001a, 2001b) revealed the same effects in studies on school children who had been exposed to aircraft noise from a local airport. Aircraft noise had an impairing effect on reading comprehension, higher levels of annoyance and perceived stress. Another study conducted in the field by Lindström and Mäntysalo (1981) indicated similar results when measuring after-effects from industrial noise, before, in the middle and after a work-shift on a reaction time task. Results indicated a trend towards decrements in reaction time after being exposed to noise during the work-shift.

Post-exposure effects generated from noise on cognitive functioning need to be more closely examined. Large numbers of people regularly work in environments with intermittent exposures to noise of varying intensity and duration. Thus it is important to understand not only the effects during exposure, but also following or in between. The aim of the study was to examine the post-exposure effect of a low frequency noise on spatial skills.

We hypothesized that reaction times and number of errors would increase after exposure to noise and that participants exposed to more intense noise would exhibit greater impairment.

METHOD

Subjects

Fifty-four participants, (27 men and 27 women) with a mean age of 25 years (ranging from 19 to 30), participated in the study. Each participant was tested individually and was reimbursed 300 Swedish crowns (approximately 30 USD) for their participation. Hearing tests were conducted, to ensure the identification of any participants with hearing impairment.

Physical stimuli

The noise condition consisted of a sound from a helicopter played at 21 Hz and was emitted from a loudspeaker positioned 60 cm behind the participants. The noise was registered with an integrating sound level meter (Brüel & Kjær 2237). The quiet condition consisted of the background noise in the laboratory, which remained steady at 60 dB(A).

Procedure and task

The spatial test was a part of a larger data collection material, but the following presentation focuses on post-exposure effects from noise on a mental rotation task.

The subjects received both written and verbal instructions about the tests and procedures and a written consent was collected. The study applied a mixed model design where the participants were randomly assigned to one of three groups: low-intensity exposure (77 dB (A)), medium-intensity exposure (81 dB (A)), and high-intensity exposure (86 dB (A)). All participants were tested in both noise and quiet conditions.

The participants were instructed to sit in an upright position. A familiarizing phase started the session. The mental rotation task was introduced and all subjects were allowed to practice the test until they had successfully completed 10 trials without error. Feedback was provided on the screen during the practice session indicating if the participant had responded correctly. The participants were also briefly presented to the noise stimulus. The experimental test session started with exposure from noise or a quiet condition for twenty minutes, the order of which was randomized over participants. During the exposure they completed an unrelated task.

After each exposure a mental rotation task was conducted for five minutes. The task consisted of three letters that were presented either normally or mirrored and rotated at one of the positions (0°, 60°, 120°, 180°, 240° or 300°) on a monitor. The participants had two hand-held, thumb-operated response buttons, one marked YES and one NO. The subject's task was to respond as quickly and accurately as possible pushing the "YES" marked response button if the letters were normal and rotated and the "NO" marked response button if the letters were mirrored and rotated. Half of the participants had the YES button in their significant dominant hand and the other half in the non-dominant. Reaction times and numbers of errors were measured as dependent variables. After the mental rotation task the participants had a five minutes break.

RESULTS

Reaction time data was transformed logarithmically to adjust for the negative skewing. For the following analyses, a difference ratio was calculated where mean for reaction times in the noise condition were divided with the mean for reaction times in the quiet condition. A value of one would represent the case were there was no change in the reaction times during the noise condition compared to the quiet condition. For the statistical tests, an alpha level of .05 was used.

Analyses of the number of errors committed in each condition revealed no statistically significant effects. Reaction time data were first analyzed for significant differences between the quite and noise condition by testing each group difference ratio with the hypothesized result of one using one-sample t test. The results showed that there were significantly slower reaction times in the noise condition for the participants in the medium intensity group (t = 2,151, df = 18, $p < .05$). Neither of the other intensity levels generated any significant effect, when comparing noise and quite condition, see Figure 1.

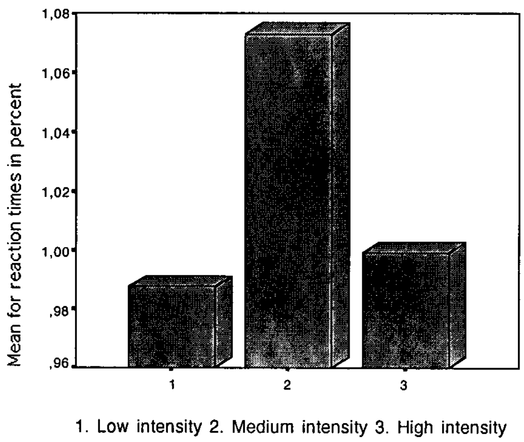

Figure 1. Reaction times difference ratios for the low, medium and high intensity group.

DISCUSSION

The results from the set up for this experiment showed a post-exposure effect, generated from noise in a level of 81 dB(A). The participants exposed to this intensity level seemed to be more sensitive for noise exposure, and they were thus significantly slower in the mental rotation task after exposed to noise compared to the quite condition. The reason for this level should generate these effects is difficult to explain. The fact that there was no significant differences in the number of errors made between a quite condition and the noise condition for any of the groups indicate that the observed differences in reaction times wasn't a result of different strategies in speed/accuracy tradeoff. In any case, the result seen here indicates that there is not a simple relationship between the intensity of exposure and the effect on a cognitive task. The predictability of the noise and individuals possibility to control the noise has in earlier experiments shown to be variables that influence after-effects generated from noise (Glass & Singer, 1972). Noise with a more informative character and more complex cognitive tasks has also shown to have stronger predictability for after-effect. Further investigations where these factors are included in the design might help to better understand the after-effect of noise exposures.

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