Influence of Short Term Noise on Concentration and Human Performance

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Introduction

Over the years, a large number of studies, to mention just a few [1-5], have proved the relationship between exposure to noise and its profound effects on human health, both short term and long term. It has been well established that short-term exposure to noise causes fatigue, insomnia, headache, loss of concentration and the occurrence of negative emotions. In order to examine certain aspects of this problem, a subjective testing has been made with the emphasis on the ability of human beings to maintain concentration and to perform well in a noisy environment. The test itself included the evaluation of the subjects' psychophysical state before and after completing the required task in order to examine the changes in psychophysical state caused by exposure to noise. In the central part of the test the subjects were asked to solve a simple task that did not require any specific knowledge, only a certain amount of concentration. Simultaneously, the subjects were exposed to four types of artificially generated noise. The type of noise varied from group to group and the loudness of the signal varied from one test séance to the next. The results of the tests reveal that the subjects were able to maintain their concentration and a certain level of performance when exposed to short-term noise, although they experienced significant changes in their psychophysical state.

Experimental setup

General idea and noise signal types

Up to this date extensive research has been made on human ability to perform in a noisy environment. As a part of our own research, a subjective testing has been made in order to examine human ability to stay focused on a specific task that requires concentration while exposed to several different types of noise at several different loudness values. To be specific, four groups of test subjects were formed and each of them was exposed to a specific type of noise, as follows: sinusoidal signal at a frequency of 1 kHz, the pink noise signal, the narrow band noise centered at 1 kHz with a ⅓-octave bandwidth and the 1-kHz sinusoidal carrier signal 100 % amplitude modulated with a 1 Hz sinusoidal signal. Prior to tests in noise, the reference test was made in quiet for each group. After that, four tests were made with each group in noise with levels corresponding to subjective loudness of 8, 16, 32 and 64 sones.

The structure of the test

The test itself consisted of three parts. In the first part the subjects were asked to evaluate their initial psychophysical state. The adjectives describing the psychophysical state were chosen as follows: apathetic, tired, aggressive, frustrated, irritated, exhausted, queasy, sleepy, angry and tense. The grade range was set from 1 to 7, with verbal explanations as follows: 1 - not at all, 2 - very little, 3 - little, 4 - moderate, 5 - strong, 6 - very strong and 7 - unbearable.

In the second part of the test the subjects were exposed to noise of certain type and level, as described before and were given a task that did not require any specific knowledge, but only the ability to concentrate in a noisy environment. To be more precise, the task consisted of 8-way word puzzle and the goal was to find all the words hidden in the puzzle. Five different versions of this task were created in order to ensure that each subject gets a different task each time. An example of the task is shown in Figure 1.

Figure 1. An example of the task given to the subjects

The time required for completing the task was set to thirty minutes, although the subjects were quite able to complete the task in a lesser amount of time.

The third part of the test was identical to the first one, demanding that the subject their psychophysical state once again, after being exposed to noise. Additionally, the subjects had to evaluate how much the noise they were exposed to annoyed them during the completion of the task. The subjects answered that particular question by giving grades from 1 to 7, having the same verbal explanations as described earlier.

Observed parameters and results

In the analysis of the data obtained from these tests attention was paid to three parameters: the time required for completing the task, the final grade of annoyance and the grade difference calculated as the difference between the

final and the initial grades of psychophysical state, all calculated as the average for each group and each test.

The average completion time is shown in Figure 2 for all four groups of subjects (and all four test signals, consequently) as a function of noise loudness. Additionally, the average completion time is shown for reference test made in quiet.

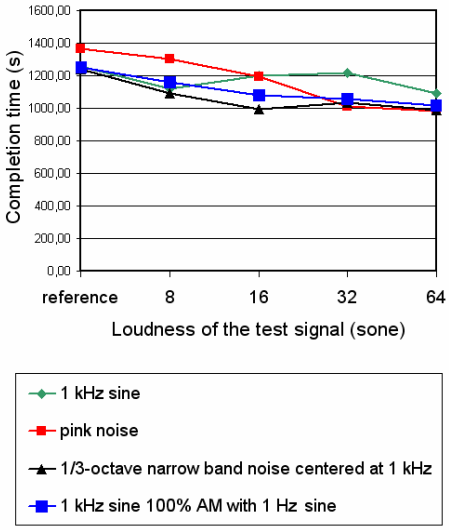

Figure 2. Average completion time

As expected, the average completion time reaches its maximum value for the initial reference testing for all four groups. The reason for this is that the test subjects who participated in these tests do not enjoy solving enigmatic puzzles such as the task given on this test, so for most of the subjects this particular test represented the first encounter with a problem of this type after a long time. As the tests progressed, the average completion time was maintained in a relatively narrow range expected for solving the task of this size and difficulty.

Average grades of annoyance are shown in Figure 3 for all four groups as a function of noise loudness.

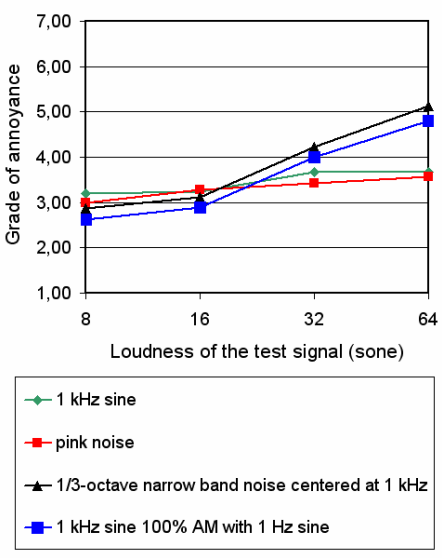

Figure 3. Average grades of annoyance

The results shown in Figure 3 show that the annoyance by noise, as graded by the test subjects, tends to increase with the increase of loudness of the noise, as expected. However, this increase of annoyance is somewhat smaller than expected in case of the sinusoidal and the pink noise signal. In our opinion, the reason for this is the true stationary character of both noise signals, which allows the subjects to disregard it while attempting to solve the task given in the test. On the other hand, the increase of annoyance is much greater for the remaining test signals, namely, the narrow band noise centered at 1 kHz with a ⅓-octave bandwidth and the 1-kHz sinusoidal carrier signal 100 % amplitude modulated with a 1 Hz sinusoidal signal. A possible explanation for this is that at high loudness values the nonlinearity of the human hearing system becomes evident. As a consequence of this nonlinearity, new frequency components are generated that did not exist in the original signal. These new components have frequencies equal to the difference of frequencies of each two components in the original spectrum. Since the bandwidth of a ⅓-octave band centered at 1 kHz is equal to 231 Hz, the highest frequency of a newly generated component is equal to this particular value. All other new components are generated below this frequency and the energy of this 'difference' spectrum increases with the decrease of frequency. These low frequency components are particularly unpleasant to listen to, causing physical discomfort even at levels that are well below the threshold of pain.

The 1 kHz sinusoidal signal amplitude modulated with 1 Hz sinusoidal signal is not a true stationary signal, meaning that its loudness is a function of time. The subjects exposed to this particular type of noise, by their own admission, had trouble maintaining their concentration due to that fact. The grades of annoyance these subjects have given reflect this phenomenon.

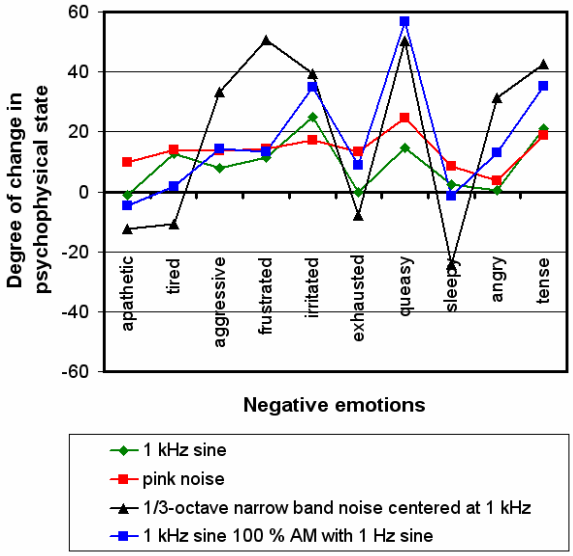

Figure 4. Weighted and averaged grade differences

The grade difference between the initial and the final psychophysical state reveals that all the subjects, being exposed to any kind of noise signal used on the test, experienced the most increase in feelings of queasiness,

tension and irritation. Figure 4 shows the degree of change in psychophysical state experienced by the test subjects for all four test groups, derived from grade differences weighted using the loudness of the signal as the weighting factor and averaged over all four tests for each noise signal, i.e. each test group. Positive values indicate the strengthening of listed emotions. A possible explanation for the results shown in Figure 4 might again be found in the properties of noise signals described above. Furthermore, these results could be used as an indication of overall annoyance shown in Figure 3.

Taking into account all three parameters, the conclusion can be made that the subjects were able to maintain the level of concentration required to complete the task when exposed to noise of different types and levels. Furthermore, noise level was increased as the tests went on, resulting in the increase of grade of annoyance, as shown in Fig.2. However, the average time required to complete the given task was either decreasing or maintained its value as the tests progressed. Finally, the conclusion can be drawn that the subjects are quite capable of completing the task when exposed to particular types of noise used in this test although the exposure to noise evokes significant changes in their psychophysical state. Furthermore, the increase in noise level has emphasized these changes, but did not affect the time required to complete the task. By their own admission, as the noise level increased, the subjects made even more effort to complete the task in as short time as possible.

Conclusion

Up to this date, a large number of interdisciplinary research studies have confirmed the effects of both short-term and long-term exposure to elevated noise levels. These effects range from short-term changes in the psychophysical state, which include the occurrence of certain emotions that can be considered as negative, as well as the changes in blood pressure and heart rate as the most common markers of physical state. Long-term effects of exposure to noise range from hearing loss in different forms and degrees to the wide variety of stress related illnesses.

The results of subjective testing described above confirm that humans can maintain concentration required for performing a given task when exposed to elevated levels of unwanted noise for a short period of time. However, maintaining concentration requires a certain amount of effort resulting in changes of psychophysical state of the subjects, namely, the increase of negative emotions like queasiness, tension and irritation.

References

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