Effects of Long-term Exposure to Noise on Psychophysiological Responses

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소음에 장기 노출되었을 때 나타나는 심리생리적 효과

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Abstracts

It is well known that a long-term exposure to a loud noise environment affects performance, since it distracts attention, and also is able to evoke stress accompanied by negative emotional states. The purpose of this study was to analyze dynamics of subjective and physiological variables during long-lasting (30 min) exposure to intensive white noise (85 dB[A]). Physiological signals on 23 college students were recorded by BIOPAC, Grass Neurodata systems and AcqKnowledge 3.5 software. Autonomic variables, namely skin conductance level (SCL), non-specific SCR number (N-SCR), inter-beat intervals in ECG (RR intervals), heart rate variability index (HF/LF ratio of HRV), respiration rate (RESP), and skin temperature (SKT) were analyzed on 5 min epoch basis. Psychological assessment (subjective rating of stress level) was also repeated on every 5 min basis. Regression and correlation analyses were employed to trace the time course of the dynamics of the subjective and autonomic physiological variables and their relationship. Results showed that intense noise evokes subjective stress with associated autonomic nervous system responses. However, it was shown that physiological variables endure specific changes in the process of exposure to loud white noise. Discussed are probable psychophysiological mechanisms mediating reactivity to long-term auditory stimulation of high intensity.

Introduction

Long-term exposure to an intense noise is stressful to people [8,9,10] and is usually accompanied by negative emotional states and lowered performance on ongoing tasks [3,4,7,12,15]. Studies on nonauditory physiological concomitants of noise were reported by many

research groups [3,4,6,7], but most of these data were published many years ago and were limited by the number of the used autonomic variables [1,5,8,10,11,12]. These studies reported about laboratory field experiments, mostly of relatively short duration, but there are as well field and epidemiological investigations of aftereffects of the noise on phychophysiological parameters, along with considerable suggestive evidence that long-term intense noise impairs health [1,3,4,6,8,9,11,12, 13]. There still exist many unresolved questions regarding bodily changes evoked by the exposure to noise stress and this topic continues to attract an interest of psychophysiologists.

In our previous studies we demonstrated that intense white noise exerts effects on autonomic balance during the performance of mental task with noise background and suggested what autonomic mechanisms were mediating the observed changes of physiological activity under acute stress episodes [13,15], and also identified indicators of attention and emotions during loud affective auditory stimulation [14]. Nevertheless, mechanisms of physiological responses during long-term exposure to noise, more relevant to chronic accumulated stress, might be different from those manifesting during short-term acute stress episodes.

The purpose of this study was to analyze of the dynamics of tonic physiological changes and subjective evaluation of stress evoked by long-term (30 min) exposure to intense aversive auditory stimulation (85dB white noise).

Method

The study was conducted on 23 college students (19-24 years old). However, because if any subject feels that the experiment is too stressful, he/she is free to discontinue it, 8 subjects dropped out. we, as a result, report data here only on 15 subjects who completed experiment.

Physiological signals (ECG, electrodermal activity, skin temperature, and respiration) were acquired by BIOPAC MP100WS, Grass Neurodata System and AcqKnowlwdge 3.5 software. Following physiological variables were recorded: electrodermal activity (EDA), e.g., skin conductance level (SCL), SCR number (N-SCR); cardiovascular activity, namely, inter-beat intervals (RR intervals of ECG), HF (0.15-0.4 Hz) and LF (0.04-0.15 Hz) components and HF/LF ratio of inter-beat period variability (HRV) [2], skin temperature (SKT); and respiratory activity, such as respiration rate (RESP) during the baseline resting state (1 min) and 6 sessions of 5 min long exposure to intensive white noise (85dB[A], delivered via loudspeakers). A subjective rating of experienced stress level (0-100 scale) during test was assessed after each 5 min session.

Results

HF component of HRV (indicator of parasympathetic activity) demonstrated an increase only in earlier two sessions (10 min) and then a gradual decrease thereafter (Fig. 1), whereas LF component of HRV (indicator of mostly sympathetic activity) demonstated an increase during the first 5 sessions reaching the peak at 25 min of exposure to WN (Fig 1). Correlations analysis showed that during first 4 sessions (up to 20 min) HF and LF components (autonomic balance indicator) were featured by highly positive

correlation (correlation coefficients respectively 0.80, 0.59, 0.93, 0.63, all ps <0.01). However at 5th session (25 min) correlation was disrupted (r=0.19, p=0.55) and HF and LF dissociated (Fig 1.) HF/LF ratio of HRV showed this tendency by demonstrating a declination of index across sessions, thus indicating the take over of LF in autonomic balance (Fig 3.). A similar trend was oberved for the correlations between LF and subjective stress ratings.

Changes of HF/LF balance are comparable with RR interval dynamic. Inter-beat intervals were shorter for the first 5 min, then followed by an adaptation (increase 10-15 min) and the second wave of decrease (Fig. 2). A similar two-wave decrease pattern was demonstrated as well by SKT (Fig. 2). Electrodermal activity was also featured by the initial and second phases of acceleration with the peak on the 5th session (N-SCR on Fig. 2). Only RESP and subjective stress ratings demonstrated a gradual increase with time of exposure to the intense noise (Fig. 4).

Discussion and Conclusion

Results of the study demonstrated that during long-term exposure to noise physiological variables are exhibiting a pattern which is typical of most of recorded parameters, namely short-term activation (RR decrease, SKT decrease, N-SCR increase etc.) followed by an adaptation and a subsequent second wave of activation, which resulted in failure to recover in post-stimulation period. As it was clearly seen in RR and HRV dynamics, heart rate acceleration response was manifested at the initial stages of exposure, but then a concurrent activation of parasympathetic and sympathetic inputs resulted in temporal compensation and rebound effect, when RR increased even above the baseline level. These data are comparable with results cited in [6], where loud noise (108dB) produced physiological effects (vasoconstriction, SCL increase etc.) and then these effects seemed to adapt completely within 23-25 min of exposure. However, in our study after 15-20 min of exposure to noise sympathetic activation began to dominate and led to the second peak of transient RR decrease. The domination of sympathetic arousal in the 5th -6th sessions of the experiment was expressed as well in such indicators of sympathetic activity as SKT, LF of HRV and electrodermal activity (N-SCR, frequency of SCR etc.).

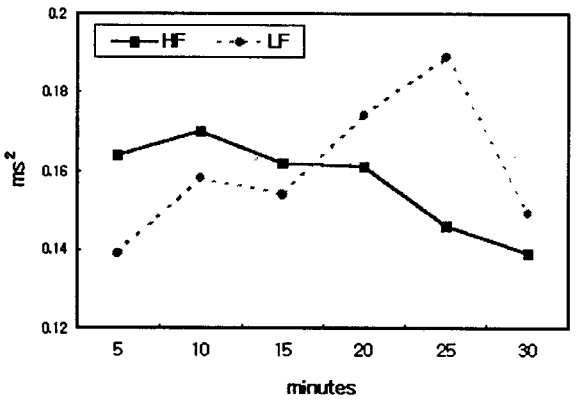

Figure 1. HF and LF components of HRV during 30 min of exposure to 85dB white noise (N=15). Dissociation of HF and LF components begins from after 20 min and reaches maximum at 25 min of aversive stimulation, whereas changes of HF and LF proceeded in parallel at first 15 min of noise.

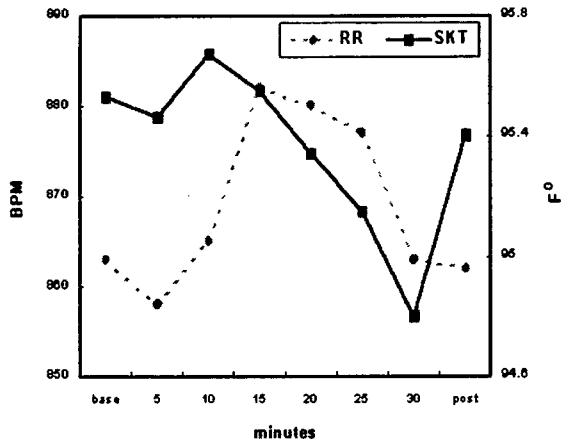

Figure 2. RR intervals of ECG and skin temperature during baseline, 30 min of exposure to 85dB white noise and post-stimulation period (N=15). Changes of both variables has similar profile - first phasic decrease, followed by rebound and short-term over-compensation and second tonic decrease after 10-15 min of aversive stimulation.

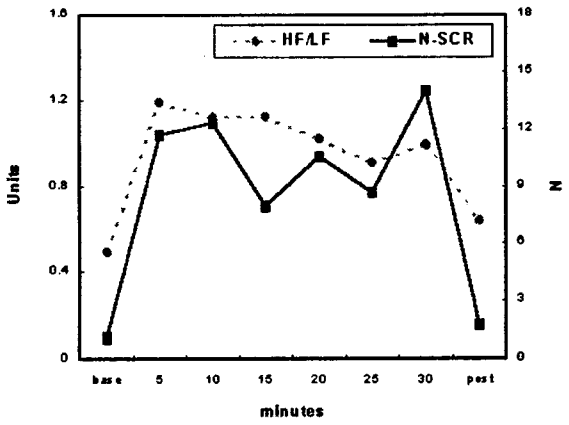

Figure 3. HF/LF ratio of HRV and N-SCR (number of non-specific SCR) - indicator of tonic sympathetic activation - during 30 min exposure to white noise background (85dB). Both curves show initial and second phases of acceleration with peaks centered at 5th and 30th min of auditory stimulation.

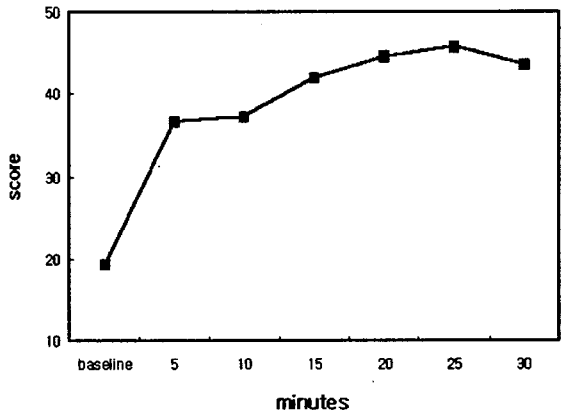

Figure 4. Subjective rating of experienced stress level during 30 min of 85 dB white noise exposure.

Our results are in accord with some of reports about effects of noise stress, such as a rise of activity of some physiological parameters then pronounced decrease followed by a sustained rise [1,5,6, 11], but our data are not matching data where only short-term stress was modeled [6,13,15]. Nevertheless, current experimental manipulation employing a long-term exposure to stressor is closer to traditional understanding of stress response, when long-lasting monotonous aversive stimulation may produce a subjective evaluation of situation as stressful (negative affect) and is accompanied by signs of tonic sympathetic domination manifested in an increase of the activity of physiological parameters, usually considered as sympathetic activation markers. In conclusion it should be stated that a long-term (30 min) exposure to intense noise (85dB WN) exerted influence on psychophysiological variables. The influence was expressed mainly in three-phase curve, namely short-term activation (5-10 min), followed by an adaptation and rebound effect (10-20 min) and the subsequent

second wave of activation (20-30 min, peak at 25 min), suggesting that observed effects are evoked by the prevalence of tonic sympathetic arousal.

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