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Effects of noise on selective attention: The role of introversion and extraversion

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ABSTRACT

Background: Extrovert and introvert subjects' attention levels are affected by exposure to noise. The aim of this study was to investigate the effects of stress (noise) on selective attention of university students.
Methods: Exposure to 80 dBA noise was used as a stimulus condition in this study. Eysenck Personality Questionnaire (EPQ) was used for determining personality trait such as extraversion-introversion, stability, and instability. Weinstein's noise sensitivity scale and the ISO15666 standard were used to assess noise sensitivity and noise annoyance, respectively. In order to assess the continuous selective attention, DUAF test was used. Participants were asked to expose to 80 dBA noise at 4000 Hz frequency for 2 h and perform DUAF test before and after noise exposure.
Results: The results among introvert subjects indicated that the only statistically significant difference was reported for the mean time spent on incorrect answers ($p = 0.018$). For extrovert subjects, there were significant differences in the mean number of correct answers ($p = 0.005$), the mean number of incorrect answers ($p = 0.002$), the mean time spent on correct answers ($p = 0.008$), and the mean time spent on incorrect answers ($p = 0.001$).
Conclusion: The results of this study indicate that stress (noise) improves selective attention in extrovert subjects.

1. Introduction

Noise as an unpleasant sound is thought to adversely affect human performance [1,2]. Some subjects in specific stimulus situations can have good performance, while other subjects show poor performance. Individual differences in arousal are more important factors involved in this issue. The personality trait such as extroversion and introversion can explain the difference in performance between people in similar situations [2]. Introversion-extroversion personality attributes affect mental performance during exposure to noise. The effects of noise on mental performance with regard to personality trait indicate higher levels of psychophysiological activity in introverts than in extroverts; therefore more adverse reactions to noise are seen in introverts [3]. Arousing test situation may influence the strength of the relationship between intro-extroversion and neuroticism [4]. In 2015, Jafari and Kazempour reported decreased attention and increased levels of tiredness in low frequency noise (LFN) exposed subjects [4]. The findings of Belojevic et al. (2001) showed that the most important risk factor for working in noisy environments with high mental load tasks was introversion [3]. Extroversion and introversion may be related to the processing of positive and negative emotional information, respectively. In the comparison of introversion and extroversion under the conditions of low and high noise, the results have shown that high-intensity noise may affect performance of introverts; while, the performance of extroverts is affected by high and low-intensity noise [5].

The active process of cognitive selection is called "attention" [6]. Attention in everyday activities including perceptive functions, physical movements, emotional activities, and cognitive functions plays an important role. When the processed quantitative information is limited, the attention system directs behavior based on the temporal and geographical characteristics [7]. The most appropriate classifications of attention include maintained attention, divided attention, alternative attention, and selective attention.

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Among four types of attention, selective attention may be an important part of cognitive functioning [6,8]. Selective attention is a mechanism of information perception and entirely avoiding interference of information unrelated to the tasks and selecting information relevant to the goal [9,10]. Selective attention means internal concentration on a certain stimulus of a single goal among multiple outside stimulants. In selective attention, a certain goal is sought and it is accompanied by a higher motivation and alertness of the individual [11].

Regarding selective attention, when a task is repeated, maintaining the individual's attention is more important. Despite alertness, continuous attention is defined as a selective awareness of a stimulus which is often present. In order to measure continuous attention, the main aspects of the general ability or tendency to perform a task in an optimal manner are investigated [11].

Previous research findings demonstrated that noise exposure can result in changes of the subjects' attention. Changes in subjects' attention were dependent on a task difficulty level, salience of cues, and the nature of task. It has been suggested that the breadth of attention did not change during exposure to noise in subjects in some situations [12]. The results of a systematic review undertaken to investigate the effects of noise and music on human and task performance indicated the effects of exposure to noise on human performance in cognition, concentration, and attention-demanding tasks. Noise exposure in workplaces was associated with higher levels of psychosocial job stress [13].

Although there are a lot of studies on the impact of stress on selective attention, there has been little discussion about the influence of stress on auditory selective attention. Therefore, the main objective of the current study was to investigate the effects of stress (noise) on selective attention of the participants (university students).

2. Material and methods

2.1. Study design and participants

The study was designed as an experimental study. Stress (noise) was considered as an independent variable and selective attention was observed as the dependent variable. Selective attention was measured in the four forms including the mean number of correct answers, the mean number of incorrect answers, the mean time spent on correct answers, and the mean time spent on incorrect answers.

The study was conducted on students at different levels of educational programs in acoustic room in the school of public health, Iran University of Medical Sciences, in 2016. The study subjects were comprised of 14 female and 14 male university students who met the following entrance criteria: normal sense of hearing (hearing loss less than 20 dB) and no sensitivity to noise. Therefore, audiometry was conducted for the selection of subjects before the experiment began. Two students were excluded from the study according to the inclusion criteria. Frequency exe software was used to emit noise at 80 dBA for 2 h.

2.2. Study procedure and tools

Noise discomfort and sensitivity were assessed by standard questionnaires. The hearing status of individuals (no hearing loss), history of head injury, history of injury to the visual system, history of taking medication with effect on the visual system, alertness, and attention, history of addiction, and history of neurosis were investigated using cognitive questionnaire.

The Eysenck personality questionnaire was introduced in 1975. The questionnaire includes 57 questions that have been used to assess the levels of extroversion and introversion in individuals older than 16 years. There are no limitations in using the Eysenck personality questionnaire. The questionnaire was usually completed within 10 to 15 min. The questionnaire has four scales including E (extroversion scale), N (neuroticism scale), P (psychoticism scale), and L (lie scale). The reliability test indicated that the internal consistencies of scales based on test-retest procedures ranged from 0.80 to 0.90. The reliability of scales of the Eysenck personality questionnaire was reported in the study in Iran (range: 0.56–0.78) [14,15].

Noise sensitivity was determined using the Weinstein's-noise sensitivity scale [16]. Weinstein's noise-sensitivity scale includes 21 questions scored on a 6-point (in the range 0–5) Likert scale ranging from strongly agree to strongly disagree. Internal consistency (Cronbach's alphas) of Weinstein's noise sensitivity questionnaire in a study of three students and three adults ranged from 0.84 to 0.87. The Cronbach's alpha and test-retest reliability were 0.76 and 0.75, respectively, in the other study used this questionnaire [17].

Noise annoyance was measured using 11-point numerical scale recommended by the ISO15666 standard [18] and participants were asked to answer the following question both before and after the test: "how much noise annoys you when you are here".

2.3. Assessment of selective attention

In order to assess selective attention, DUAF test was used. The test was applied to assess selective attention, concentration ability, general performance, and commitment. The test is also applicable to individuals older than 15 years. The test may be applicable in clinical psychology, occupational and organizational psychology, medicine and pharmacology, aviation psychology, neuropsychology, traffic psychology, and performance-oriented aptitude diagnostics.

The DUAF test from the Vienna Test System software was used. In each test, seven white triangles appeared on a black background on a monitor screen whether the tip of the triangles is upward or downward. Subjects were asked to press the green button as fast as possible if they observed downward triangles (three triangles among seven upward and downward pointing triangles). Each press of the button for answers, whether correct or incorrect, was signaled to produce a short beep tone. The total duration of each test (instruction and practice phases) was approximately 20–30 min.

DUAF test is types of time-limit test. The identification time for each shape was 1.8 s. The next shape will be displayed automatically after this time whether or not the answer is present. The distance between the observer's eyes to the screen was 60–70 cm. The shorter distance causes a reduction in visual field and increases in eye strain. There were 297 shapes in each set. Depending on the test form and differences between samples, the reliability values of test ranged from 0.654 to 0.99. Selective attention test consists of instruction and practice phases as well as the actual test phase.

Participants were asked to expose to 80 dBA noise at 4000 Hz frequency (the ear is most sensitive to sounds between 3000 and 4000 Hz [19]) for 2 h and perform DUAF test before and after noise exposure. To reduce possible learning effects, the DUAF test was performed twice with an interval of 20 min between each test before noise exposure.

Data were analyzed using SPSS software version 16 (SPSS Inc., Chicago, IL, USA).

3. Results

The mean age of subjects was 23.3 ± 2.25 years (in the age range of 21–26 years). The average hearing threshold levels for both ears of studied subjects at all frequencies was 7.45 dB (in the range of 2.63–12.5 dB) which shows normal hearing.

Table 1 presents the functional variables (for assessing selective attention) related to DUAF test including the mean number of correct answers, the mean number of incorrect answers, the mean time spent on correct answers, and the mean time spent on incorrect answers in terms of introversion versus extroversion before and after noise exposure. Comparisons of functional variables among introvert and extrovert subjects before and after noise exposure did not reveal any significant differences between the studied groups ($p > 0.05$). There was only a significant difference in the mean time spent on incorrect answers between extrovert and introvert subjects ($p = 0.014$).

Fig. 1 compares the functional variables between introvert and extrovert subjects. The results of paired *t*-test among introvert subjects indicated that the only statistically significant difference was reported for the mean time spent on incorrect answers ($p = 0.018$). For extrovert subjects, there were significant differences in the mean number of correct answers ($p = 0.005$), the mean number of incorrect answers ($p = 0.002$), the mean time spent on correct answers ($p = 0.008$), and the mean time spent on incorrect answers ($p = 0.001$).

The effects of noise exposure on functional variables were investigated using analysis of covariance (ANCOVA). First, the homogeneity of the slopes of the regression lines was studied. The results revealed that ANCOVA assumptions were satisfied (homogeneity of the slopes of the regression lines: $p > 0.05$; a linear relationship between the independent and dependent variables, the parallel slope of regression lines, and the homogeneity of error variances: $p > 0.05$). Thus, ANCOVA was used to compare variables after exposure to noise (Table 2).

The results of ANCOVA indicate that there were significant differences in the mean number of incorrect answers between the introvert and extrovert subjects ($B = -6.96$, $P = 0.013$). After adjusting the number of subjects' incorrect answers before exposure to noise, the findings revealed statistically significant differences in the number of incorrect answers between the two groups. Also, there were significant differences in the mean time spent on incorrect answers between the introvert and extrovert subjects ($B = -0.06$, $P = 0.035$). In other words, extrovert subjects spent less time answering the tests than introvert subjects under stimulus conditions. No significant differences in the mean number of incorrect answers and the mean time spent on incorrect answers were found between stable and instable types.

4. Discussion

Selective attention refers to a process which allows people to select and concentrate on special inputs for later processing. This process is accompanied by ignoring (inattention and disregard) other information. This level of attention is referred to the capacity for maintaining a set of behaviors and cognitions where the stimuli are mandatory. It would mean paying more attention to the negative stimuli. This paper was aimed at studying the effects resulting from noise stress with regard to personality traits on selective attention.

Some previous research has emerged that offers contradictory findings about the effects of the noise on selective attention and there was no logical relationship. The results of some research indicated that stress not only fail to improve selective attention, but also distract selective attention and lead to greater distraction [11]. Other findings revealed that selective attention improved under stress because of the effects of goal shielding and lower processing of irrelevant information. Stress has effects on selective attention [20].

The findings of the current study are not consistent with attentional control theory (ACT) which showed that negative emotional states such as mental stress and high anxiety level causes reduced attention. The theory indicates that deviated stimulus causes a higher level of distraction under stressful conditions during performance of strange and passive tasks. The current study found that a lower processing of irrelevant information during stressful conditions leads to mitigation of the effects of deviated stimuli and improvements in selective attention. The findings of the current study are consistent with goal shielding theory. The theory suggests that stress leads subjects to focus on the relevant information and this can reduce attention to irrelevant information [20,21].

Comparisons of functional variables (related to assessing selective attention) among introvert and extrovert subjects before and after noise exposure failed to show any significant differences between the two study groups. There was a significant difference in the mean time spent on incorrect answers between the extrovert and introvert subjects. These difference were borderline significant for annoyance between introvert and extrovert subjects (0.060) and extrovert subjects were less annoyed than introverts. Some findings suggested that extrovert subjects have more noise tolerance than introvert subjects. The other researcher additionally linked these ideas to Russian ideas which have proved stronger nervous systems in extrovert subjects than in introvert subjects. Anxiety/neuroticism may act as a mediator in extroversion-performance. Subjects with the strong nervous system were more willing to learn under distracting conditions. The other findings by using a special technique indicated that the selected level of noise

Table 1
Statistical analysis of functional variables between introvert and extrovert subjects before and after noise exposure.

Case Summaries				
		Introvert subjects Mean ± SD	Extrovert subjects Mean ± SD	P Value
Before	Mean number of correct answers	258.10 ± 16.36	259.18 ± 28.70	0.444
	Mean number of incorrect answers	15.70 ± 5.77	23.06 ± 23.36	0.874
	Mean time spent on correct answers	0.72 ± 0.066	0.71 ± 0.080	0.368
	Mean time spent on incorrect answers	0.77 ± 0.074	0.77 ± 0.083	0.845
After	Mean number of correct answers	264.70 ± 11.27	267.25 ± 17.18	0.170
	Mean number of incorrect answers	16.50 ± 8.20	15.25 ± 18.79	0.131
	Mean time spent on correct answers	0.69 ± 0.043	0.68 ± 0.069	0.397
	Mean time spent on incorrect answers	0.76 ± 0.042	0.68 ± 0.099	0.014*
Sensitivity		75.10 ± 18.70	68.56 ± 10.12	0.291
Annoyance		7.00 ± 2.10	5.93 ± 1.34	0.060

* Significant relationship at $p < 0.05$.

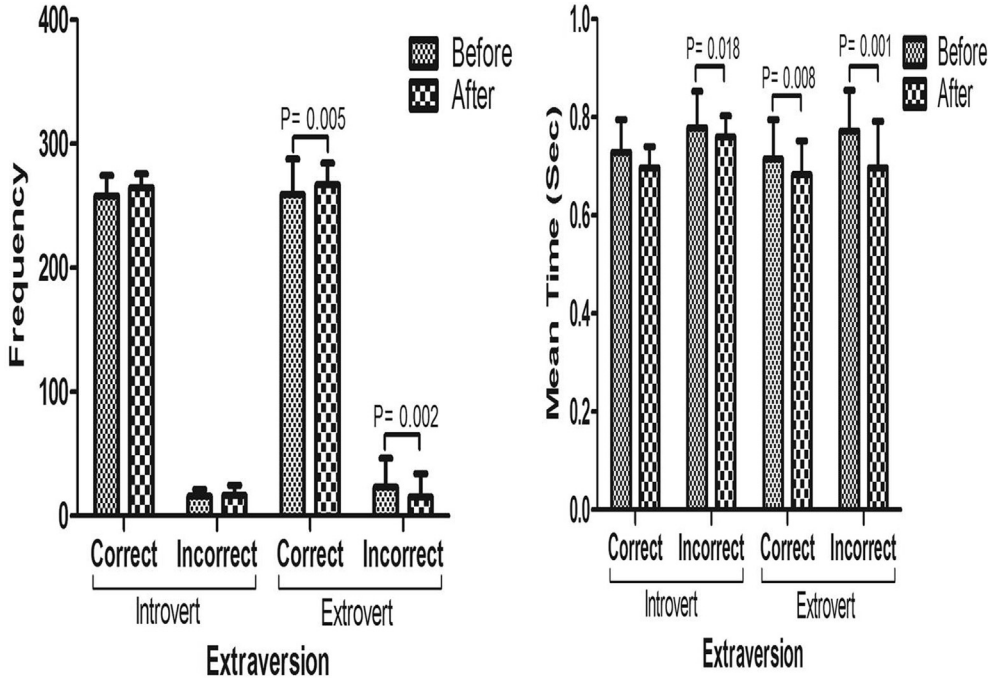

Fig. 1. Comparisons of functional variables between introvert and extrovert subjects.

Table 2
ANCOVA comparisons of functional variables between introvert and extrovert subjects.

	Mean number of incorrect answers[a]			Mean time spent on incorrect answers[b]		
	B	t	P value	B	t	P value
Constant	4.530	1.786	0.088	0.337	2.390	0.026
Introvert-Extrovert (Extrovert)	−6.962	−2.714	0.013	−0.060	−2.257	0.035
Stable and instable (Instable)	−0.308	−0.118	0.907	0.026	0.888	0.385

[a] Adjusted by the mean number of incorrect answers.
[b] Adjusted by the mean time spent on incorrect answers.

was higher for extrovert subjects than introvert subjects by allowing subject to adjust the noise level [22]. This result may be explained by the fact that there are differences in the level of arousal between introvert subjects and extravert subjects.

No significant differences in the mean number of correct answers were found among introvert subjects before and after noise exposure. There were significant differences in the mean number of correct answers among extrovert subjects before and after noise exposure ($p = 0.005$). In other words, reiterating the incorrect answers resulting from either increased focus or high stimulation led to better performance of extrovert subjects under stressful conditions (exposure to noise). Disregarding the negative options and focus on positive versus negative information are important parts of personality dimensions of extroversion. Personality trait (extroversion) may act as a mediator in the effects of stress on selective attention.

According to the findings, extroversion led to decrease in the adverse effects of stress on selective attention. The results of some studies showed that an increase in the background noise echo could improve cognitive task performance in extrovert subjects [23,24]. Researchers showed that the effect of noise levels on performance was affected by personality differences. Belojevic (2003) suggested that extroverts often quickly adapted to boring activities [22]. Other findings revealed that the levels of arousal were lower in extrovert subjects than in introvert subjects. There is a need for higher levels of arousal in extrovert subjects because the lower excitement level was reported in extroverted personality types. Since higher levels of arousal were needed in extroverts, at higher sound levels, the mean number of correct answers was increased with increasing the levels of stress. The findings of the current study are consistent with previous findings [11].

There were no significant differences in the mean time spent on correct answers before and after noise exposure between extrovert and introvert subjects ($p = 0.261$). There was a significant difference in the mean time spent on correct answers before and after noise exposure among extrovert subjects ($p = 0.008$). The difference in the mean time spent on incorrect answers before and after noise exposure was significant between extrovert and introvert subjects ($p = 0.018$). According to previous research, the response time (ms) was faster in performing a second than in performing the first task. Stress can improve the performance of the second task and results in a faster response [24,25].

Results of covariance analysis indicated that, after moderating the effects of the number of incorrect answers before noise exposure, there was a significant difference in the average number of answers between extrovert and introvert subjects after noise exposure. The average number of incorrect answers was higher in introvert subjects than in extrovert subjects. Stability or instability attributes had no impact on the average number of incorrect answers.

Findings have shown that introvert subjects are more sensitive to noise than extrovert subjects [10]. Noise-sensitive subjects show higher stimulation during exposure to noise which leads to increases in incorrect answers and decreases in mental perfor-

mance. The results of some studies revealed the relationship between personal traits and noise annoyance [26].

The results of covariance analysis showed that, after moderating the effects of the mean time spent on incorrect answers before noise exposure, there was a significant difference in the mean time spent on incorrect answers between the two study groups after noise exposure ($p = 0.035$).

Introvert subjects spent less time (0.06 s) than extrovert subjects for repeating incorrect reactions. The percentage of correct answers and rate of performance were lower for introvert subjects than extrovert subjects. A decrease in the reaction time in introvert subjects is a kind of defense in which participants decide to pass stressful conditions as soon as possible. The findings of the current study are consistent with those of Kazempour et al. (2011) who reported the same results [27]. The present study confirms previous findings and contributes additional evidence that suggests higher levels of selective attention in extrovert subjects than introvert subjects.

5. Conclusion

The aim of the current study was to investigate the effects of noise on selective attention of the university students. The results of the current study demonstrate that stress (noise) improves selective attention in extrovert subjects. More studies with larger sample sizes are needed to better support this issue.

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Conflicts of interest

The authors declare that there is no conflict of interest.

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