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INDIVIDUAL DIFFERENCES IN MENTAL PROCESSING UNDER QUIET AND NOISY LABORATORY CONDITIONS

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Abstract. *A mental arithmetic task was applied on 17 medical students (134 males and 4 females) under quiet (42 dB/A/Leq) and noisy laboratory conditions (recorded traffic noise, 60 dB/A/Leq). Subjective noise sensitivity (SNS) was assessed with the Weinstein's Noise Sensitivity Scale. Personality traits of extro-intraversion and neuroticism were estimated with the Eysenck Personality Questionnaire. Concentration problems and tiredness during the experiments were measured with ten-graded, self-rating scales. There was no significant effect of noise on the accuracy and speed of mental processing compared to quiet condition. Correlation analysis revealed a significant negative influence of the level of neuroticism on shallow mental processing in quiet ($P < 0.05$). Neuroticism also significantly influenced the concentration problems ($P < 0.01$) and fatigue ($P < 0.05$) during performance in quiet, and fatigue only under noisy conditions ($P < 0.05$). No significant correlation was found between the personality traits of extraversion and SNS, and the performance on mental arithmetic task.*

Key words: *subjective noise sensitivity, mental processing, correlation analysis*

1. INTRODUCTION

Mental performance in a moderately noisy ambient is an increasingly frequent problem both in occupational and living environment [1]. Among performance tests, mental arithmetic is used to estimate parallel mental processing. The results of the studies concerning the effects of noise during mental arithmetic tasks have not been consistent. Performance has been reported to be unaffected [2] or poorer under loud noise of about 100 dB [3]. Therefore, studies concerning individual factors that influence mental processing in noise are of scientific interest. Among these factors, personality traits of extraversion, neuroticism and SNS have been denoted as relevant [4].

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This experimental study was designed to estimate in a single performance test the influence of personality traits of neuroticism, extraversion and SNS on different levels of mental processing under quiet and moderately noisy conditions.

2. MATERIAL AND METHODS

Seventeen medical students from the Belgrade University (13 females and 4 males), aged 24-26 years, with normal hearing, and in good general health, volunteered as subjects in this experimental study. Hearing levels at 0.5, 1, 2, 4 and 6 kHz were measured in all the subjects with the "Peters AP6" audiometer. Normal hearing was diagnosed if an arithmetic mean of these values was less than 20 dB [5].

The experiments were performed with two subjects in a classroom. Urban street traffic noise was emitted from a FM tape recorder through two loudspeakers, and equivalent noise levels (Leq) were measured at the subjects places with the "Brüel & Kjaer" Noise Level Analyzer 4426. Quiet condition referred to an Leq of 42 dB (A), while an Leq in noisy condition was 60 dB (A).

The Mental Arithmetic task (MA), a test of parallel mental processing, was designed by the author, Goran Belojevic, in accordance with advice from John Langdon (Building Research Station, Garston, UK). A set of 15 tasks involved mental division of two-digit numbers by 6,7,8 or 9, with a two-decimal result. The efficiency and the depth of mental processing were estimated by the number of correct whole numbers in the results (shallow), one-decimal results (intermediate), total results (deep), and by the time spent to complete the results. The applicability of this test under moderate levels of noise was proved in a previous laboratory study [6].

The test was applied in two versions of similar difficulty, under randomly ordered quiet and noisy acoustic conditions, thereby neutralizing the learning effect. All the trials started at the same time of a day (2 p.m.), as it seems that performance ability varies during the daytime [7]. The subjects were advised to eat only a light meal no later than 2 h before the experiment, as performance might have been impaired immediately after the consumption of a meal [8]. Personality traits of extroversion and neuroticism were measured with the Eysenck Personality Questionnaire [9], comprising 65 questions with offered binary answers. Twenty four questions referred to extrovert/introvert tendencies in behavior (liveliness, sociability, talkativeness etc.). Other 24 questions were connected with neurotic tendencies in behavior (worrying, irritativeness, anxiousness, nervousness etc.). Seventeen questions were used for the estimation of a subject's sincerity in answering. Each answer was given 0 or 1 point on the scales of extraversion, neuroticism and lying. The answers were considered reliable if the sum of points on the lying scale was under 8.

SNS was measured with the Weinstein's Noise Sensitivity Scale [10], consisting of 21 statements with proposed degree of agreement, graded from 0-5. A higher score on this scale refers to a higher sensitivity to noise. The questionnaire emphasizes the subject's affective reactions.

Concentration problems and tiredness during the experiment were measured with ten-graded, self-rating scales, with two poles having verbal labels. Grade 1 was given to the labels "extreme difficulties in concentration" and "very tired and feeble", while grade 10

referred to the opposite statements.

Performance under quiet and noisy conditions was statistically compared using Wilcoxon's matched pairs sign rank test (number of correct results) and Student's t-test for small dependent samples (times in seconds). The Spearman's rank correlation order was used to estimate the relation between the personality traits and performance. A probability level of less than 0,05 was accepted as significant.

3. RESULTS

There were no significant differences in accuracy of shallow (whole digits), intermediate (first decimals) and deep (total results) mental processing under quiet, and noisy conditions (Table 1). The speed of performance on the mental arithmetic task under quiet and noisy conditions was similar (470 ± 161 s and 480 ± 171 a respectively, $p > 0,05$, Student's t-test).

Table 1. Performance on the mental arithmetic task under quiet [42 dB (A) Leq], and noisy laboratory conditions [60 dB (A) Leq].

Performance	Quiet	Noise	P-level*
Number of correct whole digits	14.8 + 0.4	14.8 + 0.4	–
Number of correct results on the first decimal	13.8 + 1.2	13.7 + 2.0	> 0.05
Number of correct total results	10.2 + 3.2	10.5 + 3.6	> 0.05

* Wilcoxon's matched pairs sign rand test

Correlation analysis (Table 2) revealed a significant negative influence of the level of neuroticism on shallow mental processing (number of correct whole digits) under quiet conditions, and the shift of this influence toward deep processing (number of correct total results) under noisy conditions. No significant correlation was found between the personality traits of extraversion and, and performance on the mental arithmetic task.

Table 2. Correlation coefficients (Spearman) between the accuracy on the mental arithmetic task and the personality traits of neuroticism, extraversion, and subjective noise sensitivity (SNS), under conditions of quiet [42 dB (A) Leq] and noise [60 dB (A) Leq], (n = 17)

Personality trait	Depth of mental processing					
	Shallow		Intermediate		Deep	
	Quiet	Noise	Quiet	Noise	Quiet	Noise
Extraversion	0,043	0,221	0,084	0,129	0,317	0,248
Neuroticism	–0,513*	–0,016	–0,458	–0,461	–0,263	–0,557*
SNS	–0,014	0,284	–0,204	0,331	0,194	–0,038

*P < 0,05 (Spearman's rand correlation order)

Further correlation analysis (Table 3) showed that the speed of performance on the MA task was under no significant influence of personality traits of extraversion, neuroticism and SNS.

Table 3. Correlation coefficients (Spearman) between the times (in seconds) required to complete the mental arithmetic task and the personality traits of neuroticism, extraversion and subjective noise sensitivity (SNS), under conditions of quiet [42 dB (A) Leq] and noise [60 dB (A) Leq], (n = 17)

Personality trait	Quiet	Noise
Extraversion	-0,338	-0,371
Neuroticism	0,036	0,214
SNS	0,034	0,202

P > 0,05 (Spearman's rank correlation order)

Comparison of the mean scores on a teh-graded scale of subjectively reported fatigue and concentration problems during mental arithmetic task revealed no significant differences under conditions of quiet and noise (Table 4).

Table 4. Subjectively reported fatigue and concentration problems on the mental arithmetic task under conditions of quiet [42 dB (A) Leq] and noise [60 dB (A) Leq], (mean, N = 17)

Variable	Quiet	Noise	P-level*
Fatigue	5,29	5,88	>0,05
Concentration	7,06	6,23	>0,05

* Wilcoxon's matched pairs sign rand test

Correlation analysis between personality traits and subjectively reported fatigue and concentration problems during mental arithmetic task. (Table 5), showed that only the level of neuroticism significantly influenced the concentration problems in both conditions and fatigue in quiet.

Table 5. Correlation coefficients (Spearman) between subjectively reported fatigue and concentration problems on the mental arithmetic task, and the personality traits of neuroticism, extraversion and subjective noise ensitivity (SNS), under conditions of quiet [42 dB (A) Leq] and noise [60 dB (A) Leq], (n = 17)

Personality trait	Fatigue		Concentration	
	Quiet	Noise	Quiet	Noise
Extraversion	0,302	0,272	-0,217	0,434
Neuroticism	-0,537*	-0,342	-0,614**	-0,490*
SNS	-0,275	-0,017	-0,329	-0,259

* P < 0,05 (Spearman's rank correlation order), ** P < 0,01

4. DISCUSSION

Moderate levels of noise (50–70 dB (A) Leq) are mostly present in an industrial milieu of offices where mental performance could be dominant part of a job. Recorded traffic noise, familiar to the studentst-subjects, was used in our study in order to enable

applicability of the obtained results in occupational environments. Employees might be exposed to a great variety of different sounds at their work places, but an overwhelming majority of these is familiar to them. The irregular nature of traffic noise was expected to raise the possibility of adverse effects of noise on mental performance, as it transmits more information and produces overarousal in comparison with regular continuous noise.

In contrast to previously applied mental performance tasks [2,3] which involved one or two mathematical operations under loud noise of about 100 dB, in the present study the task involved four operations and short-term memory under moderately loud noise. The mental performance task in this study was designed according to the finding of Woodhead [11] that the accuracy of mental computation was likely to be impaired in noise only if it had been necessary to memorize a number to solve the problem. Nevertheless, moderate level of noise in the present study did not significantly affect the accuracy and the speed of mental processing. This result is in accordance with the previous study in which this test was applied in three groups of subjects with different SNS, in quiet, moderate and loud noise (30 dB, 55 dB and 75 dB (A) Leq, respectively) [6]. It might be assumed that the subjects' high intellectual level (students), favorable time of day (afternoon) and familiarity of the applied traffic noise could have enhanced their ability to maintain the level of performance in unfavorable noisy experimental conditions.

Our findings have showed that the main personality factor which significantly influenced mental processing both under quiet and moderately noisy conditions was the level of neuroticism. Negative correlation between neuroticism and shallow mental processing in quiet might be explained with the distracting effect of self oriented thoughts, worry, and anxiety, often present in these subjects [12]. This assumption is supported by our finding of a negative correlation between the level of neuroticism and subjectively reported fatigue and concentration problems in quiet. The shift of a negative influence of neuroticism toward deep mental processing under noise could be explained with the "arousability" of neurotic persons in stressful conditions. The significant influence of extra-introversion and SNS on mental performance in noise, that was found in previous studies [4] was not confirmed in our study. Thus, the assumption that in complex mental tasks at lower noise levels the main personality variable of importance appears to be neuroticism rather than extraversion [13] is supported with the results of this study.

5. CONCLUSIONS

This experimental study with a mental arithmetic task showed that neuroticism was the most relevant personality variable for mental performance both under quiet and moderately noisy conditions. A significant negative correlation was found between the level of neuroticism and shallow mental processing in quiet. Under noisy conditions, a shift of this negative influence toward deep processing was observed. No significant influence of extra-introversion and SNS on mental performance was noticed. It may be assumed that less inconsistency would appear between the results of the studies concerning mental performance and noise, if the level of subjects' neuroticism was controlled.

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INDIVIDUALNE RAZLIKE U MENTALNOM PROCESIRANJU U TIHIM I BUČNIM LABORATORIJSKIM USLOVIMA

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Zadatak mentalne aritmetike primenjen je na 17 studenata medicine (13 muških i 4 ženske), pod tihim (42 dB/A/Leq), i bučnim laboratorijskim uslovima (snimljena saobraćajna buka, 60 dB/A/ Leg). Subjektivna osetljivost na buku procenjena je Vajnstajnovom skalom osetljivosti na buku. Osobine ličnosti ekstra-intravertivnost i neuroticizam procenjene su Ajsenkovim upitnikom ličnosti. Problemi sa koncentracijom i umorom tokom eksperimenta mereni su desetostepenom skalom samoprocene. Nije uočen značajan efekat buke na tačnost i brzinu mentalnog procesiranja, u odnosu na tihe uslove. Korelaciona analiza pokazala je da postoji značajan negativan uticaj neurotičnosti na plitko mentalno procesiranje u tihim uslovima ($P < 0.05$). Stepent neurotičnosti negativno je uticao i na probleme sa koncentracijom ($P < 0.01$) i umorom ($P < 0.05$) tokom rada u tihim uslovima, i samo na umor tokom rada u buci ($P < 0.05$). Nije uočena značajna korelacija između osobina ličnosti ekstravertivnosti i subjektivne osetljivosti na buku i uspeha u zadatku mentalne aritmetike.