Proceedings of the 7th Triennial Conference of European Society for the Cognitive Sciences of Music (ESCOM 2009) Jyväskylä, Finland
Jukka Louhivuori, Tuomas Eerola, Suvi Saarikallio, Tommi Himberg, Päivi-Sisko Eerola (Editors)

Do Physiological Responses and Personality Traits Relate to Auditory Perceptual Learning in Musicians and Non-Musicians?

Miia Seppänen,[*1] Pentti Henttonen, [*#2] Mari Tervaniemi[*3]

[*]*Cognitive Brain Research Unit and Department of Psychology, University of Helsinki, Finnish Centre of Excellence in Interdisciplinary Music Research, Department of Music, University of Jyväskylä, Finland*

[#]*Cognitive Science, Department of Psychology, University of Helsinki, Finland*

[1]miia.seppanen@helsinki.fi, [2]pentti.henttonen@helsinki.fi, [3]mari.tervaniemi@helsinki.fi

ABSTRACT

Peripheral nervous system can influence learning and memory functions by increasing the activity level ('arousal') of the system with increasing task difficulty. Several studies show that musicians discriminate auditory stimuli more effectively both neurally and behaviourally. Yet, the effects of individual peripheral nervous responses or personality during auditory learning have not studied in musicians. In this paper, we show preliminary evidence on physiological differences between musicians and non-musicians during auditory perceptual learning. Results suggest that musicians have a higher change in skin temperature and heart rate between resting state and active auditory discrimination than non-musicians. Musicians had also higher levels of approach (vs withdrawal) related personality trait that correlated with their skin conductance level changes. Approach tendency correlated with respiration in non-musicians. Both groups showed a significant relationship between physiological responses and learning scores in active auditory discrimination task. Taken together, the present results indicate that there are differences in basic physiological processes as well as in personality profiles between musicians and non-musicians.

I. INTRODUCTION

Physiological response level ('arousal') seems to relate in a non-linear manner to optimal task performance and learning. This 'inverted-U' hypothesis assumes that optimal memory, learning and task performance occur during intermediate level of arousal. The level of arousal increases when sympathetic nervous system prepares the body to act. Accordingly, the relationship between arousal and learning is depending on the task difficulty (Eysenk 1976) Studies show that arousal elevates glucocorticoid levels that seem to have an inverted-U-shaped relationship with memory functions: intermediate (not too high or low) levels of glucocorticoid would be optimal for memory retention (Baldi & Bucherelli 2005).

Individual personality traits such as behavioural inhibition/activation system (or BIS/BAS) traits seem to modulate task-related physiological arousal (Heponiemi, Keltikangas-Järvinen, Kettunen, Puttonen, & Ravaja 2004). To our knowledge, there are only few studies examining the effects of individual traits and physiological responses during auditory discrimination learning.

In this paper, musicians are compared with non-musicians. Musical expertise is known to enhance both the behavioural performance and neural processing in various auditory discrimination tasks but so far the modulating effects of individual peripheral responses or personality traits are not understood. In this study, the roles of individual peripheral nervous reactivity and personality characteristics (i.e., approach tendency) during auditory perceptual learning are examined between musicians and non-musicians. Specific questions were the following:

1) *Physiological:* Do skin conductance, respiration, temperature and heart rate differ between musicians and non-musicians during auditory perceptual learning?

2) *Personality:* Do approach-related personality factors modulate physiological responses during auditory learning differently in musicians and non-musicians?

3) *Learning:* Are physiological responses and approach related personality traits connected with auditory learning efficacy?

II. METHODS

A. Subjects

10 musicians from Sibelius Academy (a Finnish university for professionally studying classical musicians) and 10 non-musicians (students from University of Helsinki) were recruited. Musicians had 16 (± 4.2) years of training on average, the average onset age of playing was 7.6 (± 2.3), and the average practice hours per week was 7.6 (± 4.4). None of the non-musicians played more than ½ hours per week. Subjects gave a written informed consent before participation. All experiments were conducted according to Helsinki Declaration.

B. Physiological recording

Electrodermal activation was measured with two passive electrodes (BioSemi ActiveTwo) placed on the medial phalanx of the middle and ring finger of the left hand. Respiration was recorded with individually adjusted strain gauge belt (Nihon Kohden TR-753T) around the abdomen. Skin temperature was recorded with a temperature sensor (HP Agilent 21078A) which was affixed to the middle of the palm of the left hand. Blood volume pulse (heart rate) was recorded with a finger clip plethysmograph (ADI instruments, MLT1020). All physiological signals were recorded together with EEG data using Biosemi ActiveTwo measurement system with samplerate of 2048 Hz (BioSemi, The Netherlands). The EEG data will be reported elsewhere.

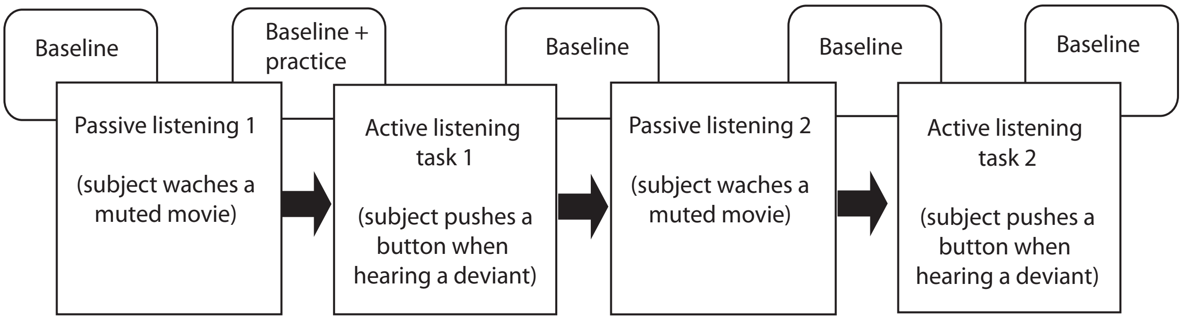

Figure 1. Order of the conditions during physiological recordings

C. Stimuli in physiological recordings

Auditory stimuli consisted of sinusoidal sounds. They were presented in sequences of 15+15 minutes in passive conditions and 5 minutes in active conditions (total duration of the experiment: 70 min). There were four different types of sounds: Rare deviant sounds including Pitch, Duration and Sound Location deviations were presented infrequently among frequent Standard sounds. Furthermore, all deviants were presented in three difficulty levels; Easy, Medium and Difficult. Stimulation proceeded into more difficult level if subject was responding correctly to the easy stimuli. All subjects had a visual feedback after correct responses during Active tasks (see Procedure).

D. Procedure

In the first experimental day, an Edinburgh handedness and musical background questionnaires were filled. A hearing threshold was assessed and based on individual SPL, stimuli were presented adding 50 dB to this level. During recording session, participants were sitting in a comfortable chair while watching a silent movie (in baseline and passive listening conditions) or doing an active listening discrimination task. Baseline recordings were three minutes long and no auditory stimuli were presented during those conditions. In a task they were instructed to push the button for deviant sounds. Subjects were instructed to minimize other movements during recordings. The order of the conditions is shown in Figure 1.

In a separate testing day, a follow-up testing of active listening task 3 was performed. It was followed by self-evaluation personality questionnaires such as: Tridimensional Personality Questionnaire (Cloninger 1987), BIS/BAS Scale (Carver & White 1994), and Sensitivity to Punishment and Sensitivity to Reward Questionnaire (Torrubia, Àvila, Moltó & Caseras 2001). Other tests including attention and memory tests were also administered (not reported here).

Personality questionnaires were selected based on their suitability to measure reward (or approach) related behavioral tendency. Furthermore, used questionnaires are constructed with a biological model of personality as their theoretical basis.

E. Data analysis

Physiological data were downsampled into 25 Hz (respiration and SCL), 400 Hz (heart rate) and 4 Hz (skin temperature). Movement or recording failure related artifacts were manually removed and segments containing more than 30% of artefactual data were interpolated. Derivative data were downsampled to 4 Hz. Physiological data were analysed using Anslab v2.4 (Frank Wilhelm & Peter Peyk, University of Basel, Switzerland).

One average value from all physiological measures was computed for each condition over the time period of first 160 seconds for the pre- and post-task baselines and first 200 seconds for the active tasks. First and last ten seconds were omitted from analysis. In addition, a difference score was calculated by subtracting the pre-baseline condition from the active task condition (Δtask-pre) and from the post-baseline condition (Δpost-pre). In overall there were four difference values: 1) Active task 1 minus pre-task baseline (ΔTask1-pre1), 2) Post-task 1 baseline - minus post-task 1 baseline (ΔPost1-pre1), 3) Active task 2 minus pre baseline (ΔTask2-pre2) and 4) Post-task 2 baseline minus pre-task 2 baseline (ΔPost2-pre2). Difference scores gave a single index for the individual differences in resting state when compared to active task performing and the state after the task. After this, differences scores were normalized with logarithm transformation.

Internal consistency for personality questionnaires were evaluated with Cronbach's alpha. Based on Cronbach's reliability analysis, BIS and TPQ Reward dependency scales were omitted from further analyses ($\alpha<.6$). Principal component analysis was done to compute individual scores from the selected personality measures.

A MANCOVA with factors Condition (ΔTask1-pre1, ΔPost1-pre1, ΔTask2-pre2 and ΔPost2-pre2) and Group (Musicians, Non-musicians) with Gender as covariate were computed for each physiological measure. One-way ANOVAs were computed to analyse group differences in personality and learning scores. Where sphericity, variance homogeneity or normality violations occurred, those were reported with corrected values. One subject was left out from the further analysis because of the outlier data, final N being 10 in both groups.

Learning in active auditory discrimination tasks was indexed with a change in hit rates (% of correct answers) for Pitch, Duration and Sound location deviants between active task 1 and 2. N of subjects was smaller for some of the learning score variables due to technical problems.

Pearson correlations were computed separately for musicians and non-musicians for examining the relationships between learning scores, physiological differences scores and personality score. For these multiple comparisons, the alpha level was adjusted to be $\leq.01$.

III. RESULTS

Results are summarized by introducing first the group differences in physiological and personality measures separately and finishing with the overall analysis of the effects of each measure to the learning.

A. Personality measures

Principal component analysis gave one main component explaining 60% of total variance. Component loadings and communalities were satisfactory for all other except Sensitivity to Reward scale. Component was interpreted as 'Approach tendency' since Novelty seeking and Behavioral activation system scores were high and withdrawal related scores such as Harm avoidance and Sensitivity to punishment were low (see Table 1).

Table 1. Component loadings for personality measures

'Approach tendency' component	
Personality scale	**Loading**
TPQ Novelty Seeking	0.851
TPQ Harm Avoidance	-0.902
Sensitivity to Punishment	-0.871
Sensitivity to Reward	0.261
Behavioral Activation System (BAS Total)	0.785

According to one-way ANOVA, musicians had significantly higher Approach tendency than non-musicians [F(1,18)=6.31, p=.02].

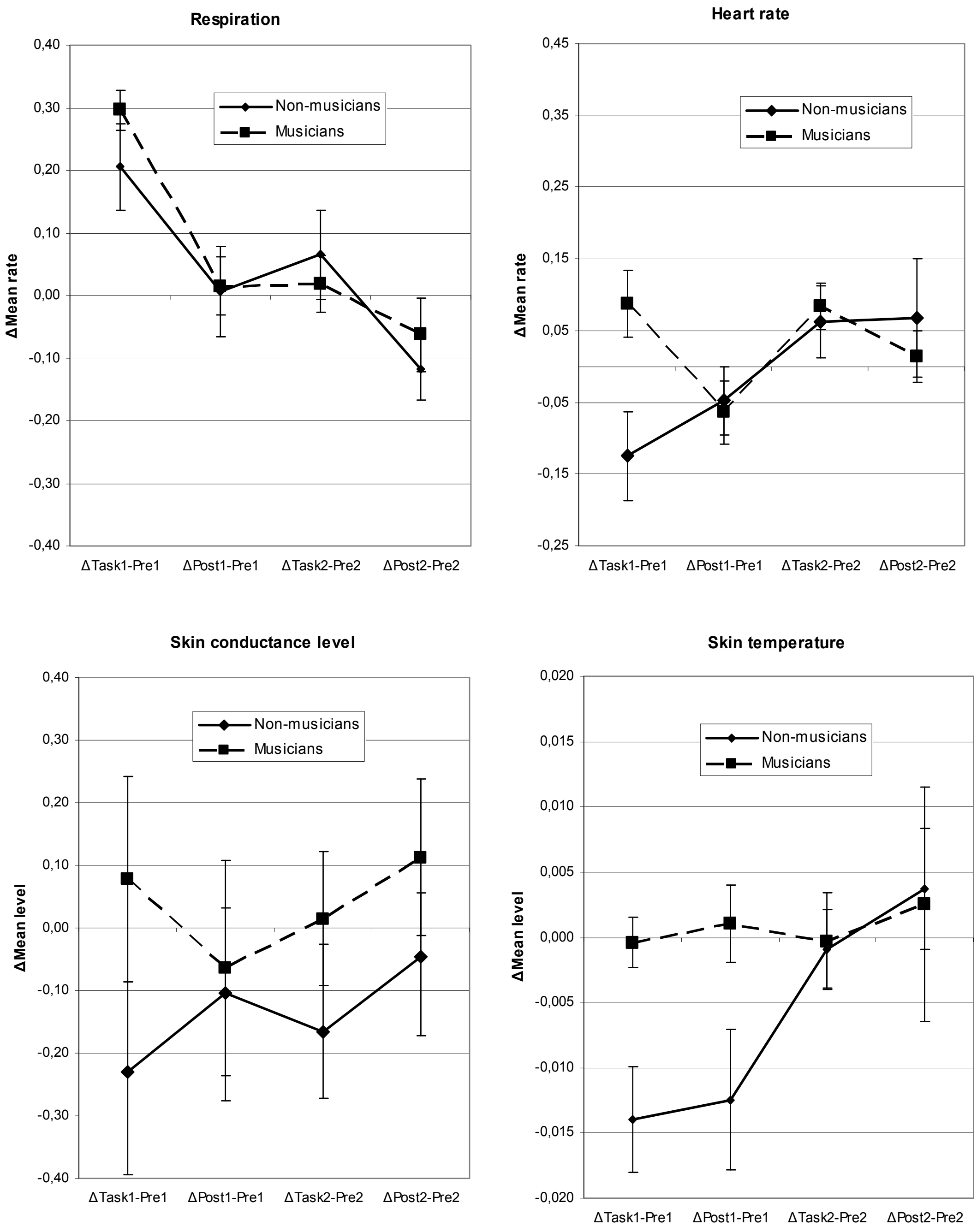

Figure 2. Change rates (with SEM error bars) for physiological measures

B. Physiological measures

Physiological responses are illustrated in Figure 2. Responses are represented as differences between active tasks and the pre-task baseline, and differences between post-task and pre-task baseline. In other words, the responses obtained during the baseline (rest) conditions *before* active tasks were subtracted from the responses *during* the task (Δtask-pre) or from the baseline responses *after* the task (Δpost-pre).

In MANCOVA analysis, a significant group difference was found between Active task 1 and pre-task baseline (Δtask1-pre1) for skin temperature [F(1,18)=5.09, p=.038] and for heart rate [F(1,18)=5.06, p=.039]. In both cases musicians had higher levels (see Figure 2). Gender covaried significantly with respiration changes between post- and pre-baseline for Active task 2 (Δpost2-pre2) (p<.05). Age covaried with heart rate (Δpost1-pre1) and skin conductance (Δpost1-pre1) (p<.05).

Approach tendency correlated in non-musicians to respiration changes between post and pre-task baselines for Active task 1 (r=-.779, p=.008) and in musicians to skin conductance level changes between pre-task baseline and Active task 1 (r=.685, p=.029). In other words, the higher Approach tendency musicians had, the more skin conductance level changes there were.

C. Relationship between physiological responses and personality traits on auditory learning

In terms of hit rates, learning scores did not differ significantly between the subject groups. However, physiological measures related differently to learning scores in musicians and non-musicians. Following correlations were found:

For musicians:

- Respiration (ΔTask1-Pre1) & Medium Pitch (r=-.80, p=.005)
- Heart rate (ΔPost1-pre1) & Medium Duration (r=.919, p<.001)
- Heart rate (ΔTask2-Pre2) & Difficult Pitch (r=-.795, p=.006)
- Skin conductance (ΔPost1-Pre1) & Medium Duration (r=.81, p=.004)
- Skin temperature (ΔTask2-pre2) & Medium Duration (r=.78, p=.008), and

For non-musicians:

- Respiration (ΔTask1-Pre1) & Easy Pitch (r=.821, p=.007)
- Heart rate (ΔPost2-Pre2) & Difficult Pitch (r=.907, p=.002)
- Heart rate (ΔTask2-Pre2) & Difficult Sound location (r=-.893, p=.003)

Approach tendency did not correlate significantly to learning in either of the groups.

IV. CONCLUSIONS

In this study, the effects of peripheral nervous responses and approach-related personality trait on auditory learning were compared between musicians and non-musicians. By approach-related personality traits we mean here traits such as novelty seeking, behavioural activation system, and sensitivity to rewards.

First, we found that physiological responses were differently modulated during auditory learning in musicians and non-musicians. Musicians had higher skin temperature and heart rate changes between first active auditory discrimination task and the pre-task baseline than non-musicians. This indicates that the peripheral nervous systems were tuned differently in musicians and non-musicians during auditory learning task.

Secondly, approach-personality trait related differently to physiological responses in musicians and non-musicians. Approach was related to skin conductance in musicians while it related to respiration with non-musicians. Unexpectedly, musicians had higher levels of approach tendency.

Finally, we asked whether individual physiological responses and personality would predict auditory learning. Findings suggested that in both groups respiration and heart rate changes relate to auditory learning. Furthermore, skin temperature and skin conductance related to auditory learning only in musicians.

Taken together, the present results indicate that there are differences in basic physiological processes as well as in personality profiles between musicians and non-musicians.

ACKNOWLEDGMENT

The study was supported by National Graduate School of Psychology, Finland. We thank Mr. Miika Järvenpää, M.Sci., for his technical support and Ms. Eeva Pihlaja, B.A., for her assistance in behavioural testing.

REFERENCES

Baldi, E. & Bucherelli, C. (2005). The inverted “U-Shaped” dose-effect relationships in learning and memory: Modulation of arousal and consolidation. *Nonlinearity in Biology, Toxicology, and Medicine, 3,* 9-21.

Carver, C. & White, T. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: the BIS/BAS scales. *Journal of Personality and Social Psychology, 67*, 319-333.

Cloninger, C. (1987). A systematic method for clinical description and classification of personality variants - A proposal. *Archives of General Psychiatry, 44*, 573–588.

Eysenck, M. (1976). Arousal, learning, and memory. *Psychological Bulletin, 83*, 389-404.

Heponiemi, T., Keltikangas-Järvinen, L., Kettunen, J., Puttonen, S., & Ravaja, N. (2004). BIS-BAS sensitivity and cardiac autonomic stress profiles. *Psychophysiology, 41*, 37-45.

Torrubia, R., Àvila, C., Moltó, J., & Caseras, X. (2001). The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ) as a measure of Gray’s Anxiety and Impulsivity Dimensions. Personality and Individual Difference, 31, 837–862.