

THE EFFECT OF LISTENING TO TECHNO MUSIC ON REACTION TIMES TO VISUAL STIMULI

Maja Meško¹, Vojko Strojnik², Mateja Videmšek², Damir Karpljuk²

¹ *Independent researcher, Celje, Slovenia*

² *Faculty of Sport, University of Ljubljana, Ljubljana, Slovenia*

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The aim of the research was to establish the influence of techno music on the reaction times of participants in the research. Our hypothesis was that stimulating music, such as techno, would shorten the participants' reaction time to visual stimuli while, without music, the reaction time would be longer. To define the reaction time to expected light stimuli we used a special apparatus for measuring the angle of elbow extension, an electric goniometer and a red colour LED diode attached to it. We also used a computer programme as well. The athletes, 10 students at the Faculty of Sports, aged between 20 and 45, participated in the research, representing the control group as well as the experimental group. In our research we established that listening to techno music does affect the shortening of participants' reaction time. Their reaction time shortens significantly according to a measurement taken after 30 minute of listening to techno music, nevertheless it is not shortened during the listening. The control group established that 35 minutes of waiting between the measurements does not significantly affect the reaction time. Moreover, it was established that 30 minutes of listening to techno music affected the shortening of the reaction time 45 seconds after the music was turned off. For further research, it would be necessary to engage more participants. However, the research results are useful data and may serve as a starting point for further research.

Keywords: Simple reaction time, techno music, expected light (visual) stimulus, apparatus for measuring the angle of elbow extension, goniometer.

INTRODUCTION

Reaction speed is the ability to give a quick motor response to a definite stimulus, while the time that elapses between the sensory stimulation and the motor reaction is called reaction time (Štrulc, 1989). This is the time that elapses between a stimulus and the response to it. This process consists of sensory and perceptual processing. After a stimulus is perceived by our receptors (in our eyes and ears, for example), identification in the central nervous system begins. If we recognize a certain stimulus to be significant for us, we response, in the opposite case we do not. The speed of identifying the stimulus is an essential factor in this process. The last stage of the response to the stimulus is muscle tensing which is followed by a motor reaction (Sanders, 1980). Reaction times can be subdivided according to the stimulus, which can be expected or unexpected. An unexpected stimulus cannot be anticipated in advance, which means that it appears when the subject is not ready to react. This is common for all types of sports, but most likely for those where participants face a high number of unpredictable situations. An expected stimulus can be anticipated in advance, but we cannot tell when it will

appear. With the expected stimuli, reaction times can be subdivided according to the number of diverse stimuli that the subject already expects and responds with a specific automatic motor reaction. In the case where the number of stimuli is higher than one, this reaction time is defined as choice reaction time; if not higher than one, it is defined as simple reaction time. According to Colavita (1974) and Cooper, Edwards, Gibton and Strokes (1998), simple reaction time is shorter than choice reaction time. Simple reaction time is defined as the interval between the onset of the signal (stimulus) and the beginning of the movement. During this time, the physical signal is transformed into nerve information which is then transmitted to our nervous system to the centres for detecting, processing and interpreting, even though conscious recognition is not indispensable (Alvero, Erik, Joaquim, Leonardo, & Mark, 1992). The accepted figures for mean simple reaction times for college age individuals are about 190 ms (0.19 sec) for light stimuli and about 160 ms for auditory stimuli (Galton, 1899; Fieandt, von Huhtala, Kullberg, & Saarl, 1956; Welford, 1980; Brebner & Welford, 1980). The reason for faster reactions to auditory stimuli is most likely due to the fact that auditory stimuli reach the brain in 8 to

10 ms (Kemp, 1973), while visual stimuli in 20 to 40 ms (Marshall, Talbot, & Ades, 1943). There are several methods to measure the reaction time. We can perform the measurements with a goniometer by which we can observe the angle changes within a chosen time period (Nagasawa et al., 1991). There are several other factors that influence the reaction time, besides those previously mentioned (type of reaction time experiment, type of stimulus and stimulus intensity). These are arousal, age, gender, left vs. right hand, direct vs. peripheral vision, practice and errors, fatigue, fasting, distraction, warnings about impairment by alcohol, order of presentation, finger tremors, personality type, exercise, punishment, stimulant drugs, brain injury, illness and others factors (Brebner, 1980; Brebner & Welford, 1980; Welford, 1980).

Attempting to explain sound perception and how it affects human beings is complicated. Sound has a physical and a psychological component. The physics of sound has its origin in changing the blood pressure and pulse rate. There are studies showing increased pulse rates as a result of stimulating music and decreased pulse rates associated with sedative music (Besson, Faita, Peretz, Bonnel, & Requin, 1998; Platel, 2002). Techno music seems to produce a significantly increased pulse rate, systolic blood pressure and stress related hormones. Classical music produces no significant changes in these parameters (Gerra et al., 1998). Research on students of music and people without special musical education has shown that music exerts complex influences on the central nervous system (CNS), manifested in changes to a number of neurophysiological reactions attesting changes in the flow of excitations in the cortico-thalamic and cortico-limbic circles. Listening to music is accompanied by a partial replacement of the dominating alpha rhythm by activity in the frequency range of beta, theta and delta waves and with a change to some vegetative reactions (Zakharova & Avdeev, 1982). The psychology of sound is based on the perception of its characteristics. Sounds and music affect the emotions and mood of a human being and provoke various feelings (Besson et al., 1998; Platel, 2002).

When listening to music, most people do not realize the noise equivalence of the volume of their music. Everyday conversation is approximately 55 decibels while the threshold of pain is about 120 decibels. A jet airplane is 150 decibels, and a rocket engine is 180 decibels. Experts have recommended that people should not be exposed to noises louder than 85 decibels for extended periods of time (Friedhoffer, 1992; Gardner, 1991).

A study on the effect of music on motor reaction time and interhemispheric relations showed that music shortened reaction time, and its stimulating effect was stronger in the case of longer initial reaction times with-

out music. The influence of various other types of music was more effective than of classical music (Zakharova & Ivashchenko, 1984). Listening to stimulating (techno) music can influence certain factors (e.g. arousal) affecting reaction time. Reaction time is faster at an intermediate level of arousal and slower if the subject is either too relaxed or too tense (Welford, 1980).

The principle aim of the research was to establish if listening to techno music affects the reaction times of the participants. Considering data from previous research (Zakharova & Ivashchenko, 1984), we expected that techno music would shorten the reaction times of the participants of the research.

METHODS

Participants

Ten athletes (6 women and 4 men) aged between 20 and 45 years participated in the research. They represented the control group and the experimental group. All participants included in the research participated in the research voluntarily and were informed about the research either by the announcement on the notice board or during their lectures. All the participants signed a special form, confirming their voluntary participation in the research and were briefly informed about the purpose and the procedure.

Instruments and procedure

Measurements were performed in the Laboratory for Biomechanical Measurements at the Faculty of Sports, University of Ljubljana. We used a special apparatus for measuring the angle of elbow extension which was designed exclusively for this research and a computer programme to calculate the reaction time to light stimuli. The apparatus was designed to prevent body turns as well as upper arm and wrist movement of the fastened arm. However, a controlled elbow extension in a horizontal plane was possible. The elbow was leaned against the axis of the rotating part which was made of a light material in order to reduce the inertia moment.

The angle between the moving and the fixed part of the apparatus was measured in relationship to time with an electric goniometer that was attached to the apparatus fixed on the table. Next to the table, there was a sitting participant with his hand fastened to the apparatus in parallel position with the table surface. In the starting position, the arm was raised up to the shoulder height with an elbow angle of 90 degrees and the palm turned downwards. At the starting position, the angle of the participant's arm attached to the moving part was set by a fixed obstacle. There was a red LED diode placed at eye level, one meter in front of the participant. It was

used as a light stimulus. The diode was triggered manually and each time it was turned on, a control signal was sent to the computer and indicated that the light was on.

Three trials were performed before the testing began. Each measurement was repeated three times. After the arm signal, the participant had to focus on the diode and wait for the light to come on. It was turned on unexpectedly between the third and the fourth second after another arm signal by the researcher. The participant's task was to react to the light signal as soon as possible with the extension of the upper arm which was fastened to the apparatus. Signals were saved if they were credible, if they were not, the measurement was repeated again. All the participants used headphones while listening to the same music (techno winter megamix 2005, various artists) with the sound level of 85 decibels. The sound level was measured with a Minilyzer ML1 (NTI, Schaan, Liechtenstein).

All the participants took part in the control group as well as in the experimental group. The task of the control group was to measure the participants' reaction time to the visual stimulus in the experimental group. Each measurement was repeated twice after a 40 minute interval. The task of the participants in the experimental group was listening to the music with the sound level of 85 decibels. The reaction time was measured before the music started, as soon as it started, before the end and after the end.

The time schedule of measurements for each participant of the research is shown in the following scheme (Fig. 1).

Methods of processing statistical data

The obtained data were saved to the computer at the same frequency – 2000 HZ. For further processing, the data record was transformed from a graphic into a numerical format using a programme for processing analogical signals. The beginning of the movement was determined by the moment of a one degree change indicated by the goniometer. The device also detects the appearance of light stimuli. The simple reaction time measurements (measured in ms) to a light stimulus were gathered separately for each measurement and for each individual.

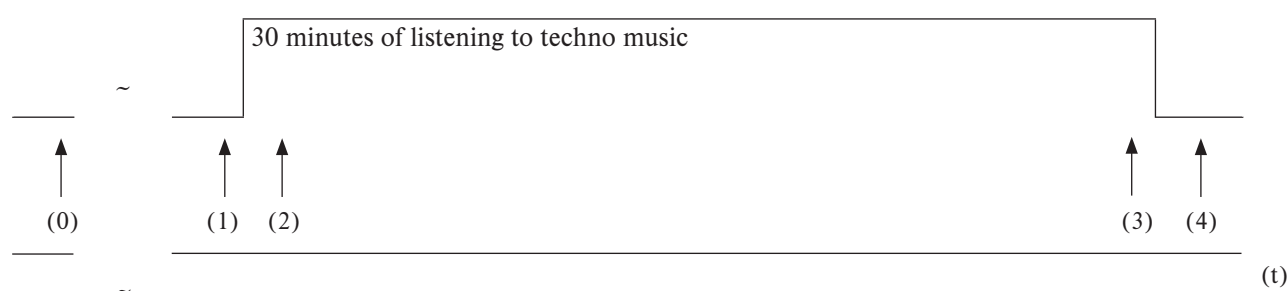
For the evaluation of the obtained data we used statistical package SPSS. Basic descriptive parameters, mean value (M) and standard deviation (SD) are displayed in the table. To determine statistically significant differences in measurements we used a t-test for two dependent samples at ($P < .05$ risk interval). We used a Kolmogorov-Smirnov test to perform the normal distribution test. A normal distribution test is assumed for using the t-test.

RESULTS

Due to the small sample size, the findings of the research cannot be generalized to apply to the whole population of athletes; they refer only to the participants in the research (students of the Faculty of Sports in Ljubljana).

Fig. 1

Diagram of the measurement time schedule for one of the participants



Legend:

- (0) = measurement 35 minutes before the testing
- (1) = measurement without music at the beginning of the testing
- (2) = measurement with music at the beginning of the testing
- (3) = measurement after 30 minute listening to the music
- (4) = measurement without music after the testing

TABLE 1

Participants' age, height, weight and the sport practiced

Participants	Age	Height	Weight	Sport
Pa1	21	160 cm	51 kg	Gymnastics
Pa2	20	190 cm	100 kg	Athletics (shot put)
Pa3	35	172 cm	70 kg	Unprofessional
Pa4	25	177 cm	64 kg	Athletics
Pa5	31	169 cm	63 kg	Skiing
Pa6	45	186 cm	89 kg	Middle distance running
Pa7	21	162 cm	52 kg	Athletics, climbing
Pa8	20	160 cm	53 kg	Basketball
Pa9	23	179 cm	65 kg	Sport climbing
Pa10	21	167 cm	61 kg	Gymnastics

TABLE 1 displays age, height, weight and the sport practiced for each participant in the research.

TABLE 2

Mean value, standard deviation and Kolmogorov-Smirnov test of the reaction time of the measurements

Measurements	M	SD	K-S	p
measurement 0 (ms)	256.9	47.96	.472	.979
measurement 1 (ms)	272.1	77.89	.465	.982
measurement 2 (ms)	266.3	48.87	.453	.986
measurement 3 (ms)	256.5	40.01	.560	.913
measurement 4 (ms)	233.0	43.95	.704	.704

Legend:

measurement 0 = measurement 35 minutes before beginning of the testing

measurement 1 = measurement without music at the beginning of the testing

measurement 2 = measurement with music at the beginning of the testing

measurement 3 = measurement with music after 30 minutes of listening to the music

measurement 4 = measurement without music after the testing

M = mean value

SD = standard deviation

K-S = Kolmogorov-Smirnov

p = statistical significance for Kolmogorov-Smirnov test

TABLE 2 displays the basic descriptive statistics of the data for the whole group: mean reaction time, standard deviation and Kolmogorov-Smirnov test. We can see the variability of the measurement results by standard deviation. We used the Kolmogorov-Smirnov test for testing normality of distribution. The advice from SPSS is to use the latter test when sample sizes are small ($n < 50$). The null hypothesis, that there is no difference between your variable distribution and a normal distribution, is evaluated.

A finding of statistical significance means we cannot reject the null hypothesis. What is the null hypothesis? It means that our distribution is not significantly different from a normal distribution. The conclusion is that measurements are assumed to come from a normal distribution with the given mean and standard deviation.

TABLE 3

T-test for two dependent samples for control group

	M (ms)	SD (ms)	df	t	p
measurement 0	257	48	9	-.632	.543
measurement 1	272	78			

Legend:

(0) = measurement 35 minutes before the testing

(1) = measurement without music at the beginning of the testing

M = mean value

SD = standard deviation

ms = milliseconds

df = degrees of freedom

p = statistical significance

TABLE 4

T-test for two dependent samples for experimental group

	M (ms)	SD (ms)	df	t	p
measurement 1-2	272 266	78 49	9	.325	.752
measurement 1-3	272 256	78 40	9	.967	.359
measurement 1-4	272 233	78 44	9	2.519	.033*
measurement 2-3	266 256	49 40	9	.712	.494
measurement 2-4	266 233	49 44	9	2.073	.068
measurement 3-4	256 233	40 44	9	4.545	.001**

Legend:

* = $p < 0.05$

** $p < 0.01$

(1) = measurement without music at the beginning of the testing

(2) = measurement with music at the beginning of the testing

(3) = measurement after 30 minute listening to the music

(4) = measurement without music after the testing

ms = milliseconds

df = degrees of freedom

p = statistical significance

TABLES 3 and 4 display the statistically significant differences in mean values between measurements in pairs. The dependent t-test is a test of the significance of

differences between means of two sets of scores that are related, such as when the same participants are measured on two occasions (Thomas & Nelson, 2001). The results of the t-test for two dependent samples with the control group (TABLE 3) do not display statistically significant differences between the results of the measurements 35 minutes before the beginning of the testing and the results of the measurements without music before the beginning of the experimental part of the research. The results of t-test for two dependent samples with the experimental group (TABLE 4) display statistically significant differences among the results of the measurements without music at the beginning of the testing, the results of the measurements without music after the testing, the results of the measurements with music after 30 minutes of listening and the results of the measurements without music after the testing.

DISCUSSION

The aim of this research was to determine the influence of techno music on the reaction times of the participants in the research. Considering the data from the previous research by Zakharova and Ivashchenko (1984), we presumed that techno music, being a stimulating type of music, shortens reaction times, which in turn means that reaction times are longer if a person is not subjected to the influence of music. Supposing that listening to stimulating techno music affects the state of arousal, which in turn influences reaction times, we could expect a higher level of engagement during the exercise and consequently its stronger effect. Reaction times get shorter at a higher level of arousal (Welford, 1980; Broadbent, 1971). In the present study, the participants listened to music at the volume of 85 decibels – the volume which does not result in hearing impairment not even with longer exposures to music (Friedhoffer, 1992; Gardner, 1991). The music was played at an above average volume, which is one of the factors that contributes to a stimulating effect of music.

The data presented in the descriptive statistics by the participants showed that the standard deviation of reaction times in separate measurements, calculated on the basis of three consequent measurements, was rather high and that the reaction times vary substantially in 9 participants. The mean standard deviation in all reaction time measurements in this research was 63.5 ms. This was almost twice as high as with measurements of reaction time to visual stimuli (which were highly controlled), where the mean standard deviation was 32 ms (www.utm.edu/staff/gbrown/running_head.pdf). However, it is not much higher than the mean standard deviation of reaction time measurements where the visual stimulus was not carefully controlled and amounted

to 57 ms (Gomez, Vaquero, Vazquez, Gonzalez-Rosa, & Cardoso, 2005). We can see the reason why there are so many varying results in our research in a small number of measurement trials and repetitions of reaction time measurements, as according to Sanders (1998) and Luce (1986), there should be a higher number of reaction time measurements for the purpose of adequate results. Another reason for such high result variability may be found in the diminished attention paid, due to nervousness at the beginning of testing and also due to boredom while waiting for the repetition of the measurement or while listening to music.

There are no significant statistical differences between the results of measurements taken 35 minutes before the testing and those taken before the experimental part of the research conducted without music, e.g. in the part of the research performed by the control group. Therefore, 35 minutes of waiting for the next reaction time measurements do not significantly lengthen or shorten reaction times. However, the reaction times before the testing are 35 minutes longer than those at the beginning of the experimental part without music, which can be explained by a slight decline in the amount of attention paid or the occurrence of boredom while waiting for the next reaction time measurement.

There are no significant statistical differences between the reaction times measured without music and reaction times measured after 30 seconds of listening to techno music. Therefore, it may be concluded that listening to techno music for a short period does not affect the length of reaction times in the participants. Nevertheless, there are significant statistical differences between the measurements without music at the beginning of the testing and those at the end of the testing. Our hypothesis about shorter reaction times of the participants while listening to techno music was partly proven as they are shorter when measured without music after 30 minutes of listening to techno music. However, they do not shorten 30 seconds before turning the music off. Likewise, no significant statistical differences were found between the measurement results 30 seconds after turning the music on and those 30 seconds before turning the music off. The measurement results with music at the beginning of the testing differ substantially ($p < 0.068$), however, this difference is not statistically significant. The reaction times measured without music at the end of testing are shorter than those measured with music at the beginning of the testing. Statistically significant differences also appear between the measurement results with music after 30 minutes of listening and the measurement results without music at the end of testing. The results may also reveal that people while listening to music at a higher volume (85 decibels) pay more attention to lyrics or musical rhythm and less attention to

their surroundings and what is happening around then (www.drdriving.org/music_strick_report.html).

CONCLUSIONS

To sum up, we can conclude that listening to techno music has the effect of shortening the reaction times of the participants. However, they are shortened significantly at the measurement without music after 30 minutes of listening to the music, but not during the listening. These findings differ from previous ones, which established that stimulating music shortens the reaction time to visual stimuli and that the reaction time is longer without music (Zakharova & Ivashchenko, 1984). The difference can be explained by the research findings which showed that the reaction times were not shortened during listening to music but 45 seconds after 30 minutes of listening to techno music. The control group established that 35 minutes of waiting between the measurements does not significantly affect the reaction time. Moreover, it was established that 30 minutes of listening to techno music affected the shortening of the reaction time 45 seconds after the music was turned off. For the purpose of result evaluation, we should consider the small sample size. Moreover, the research results were probably affected by the participants' specific characteristics. They are all actively involved in sports and most of them are students at the Faculty of Sports in Ljubljana.

For further research more participants should be involved. The results of this study have raised new questions to be answered in the future: e.g. the effects of different types of music, volume level or a person's favourite music (as the results could be influenced by a person's emotions) on reaction time. Further research could also include monitoring the EMG signal of an active muscle and measuring physiological parameters, such as the heart rate frequency and blood pressure. Above all, more participants should be involved in order to obtain results which could be generalized to apply to a broader population.

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ÚČINKY POSLECHU TECHNO HUDBY NA DOBU REAKCE NA VIZUÁLNÍ PODNĚTY (Souhrn anglického textu)

Cílem výzkumu bylo stanovit míru vlivu techno hudby na reakční časy účastníků výzkumu. Naše hypotéza byla ta, že stimulující hudba, například techno, zkracuje dobu reakce účastníků na vizuální podněty, zatímco bez hudby je reakční čas delší. K určení doby reakce na očekávané světelné podněty jsme použili speciální zařízení na měření úhlu extenze lokte, elektrický goniometr a k němu připevněnou červenou LED diodu. Také jsme používali počítačový program. Výzkumu se zúčastnili sportovci, 10 studentů Fakulty sportu, ve věku 20 až 45 let, kteří představovali kontrolní i experimentální skupinu. V našem výzkumu jsme zjistili, že poslech techno hudby zkracuje reakční doby účastníků. Dle měření provedených po 30 minutách poslechu techno hudby se jejich doba reakce významně zkracuje, nicméně nezkracuje se během poslechu. Kontrolní skupina stanovila, že

35 minut čekání mezi měřeními reakční dobu významně neovlivňuje. Navíc bylo zjištěno, že 30 minut poslechu techno hudby mělo vliv na zkrácení reakční doby 45 sekund poté, co byla hudba vypnuta. Pro další výzkum by bylo nezbytné zapojit více účastníků. Výsledky výzkumu ovšem poskytují užitečné údaje a mohou sloužit jako východisko pro další výzkum.

Klíčová slova: prostá doba reakce, techno hudba, očekávaný světelný (vizuální) podnět, zařízení na měření úhlu extenze lokte, goniometr.

Maja Meško, Ph.D.



Slovenia Control Ltd.
Kotnikova 19a
1000 Ljubljana
Slovenia

Education and previous work experience

Ph.D. in kinesiology at the Faculty of Sports, University of Ljubljana (2008).

Degree in psychology from the Faculty of Arts, University of Ljubljana (2003).

Scientific orientation

She is active in the field of civil and military aviation. Her main areas of research interest are human resources management, organizational culture, organizational social climate, aviation psychology and sports psychology. Her work has been published in professional and academic journals. She actively participates in local and international conferences.

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