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Original Article

Influence of different background music volumes and mobile phone communication on the reaction time of sports active students

ŠTEFAN BALKÓ[1], JACEK WĄSIK[2], VLASTIMIL CHYTRÝ[3], KAMILA DUNAJOVÁ[4], MARTIN ŠKOPEK[5]
[1,3,4,5] Faculty of Education, J. E. Purkyně University in Ústí nad Labem, CZECH REPUBLIC
[2]Institute of Physical Education, Tourism and Physiotherapy, Jan Dlugosz University of Czestochowa, POLAND

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Abstract:
The main goal of the present study was to determine the differences in the reaction time after visual stimulation while listening to different volumes of background music. Another goal of the study was to compare the reaction times (simple reaction time - SRT and choice reaction time - CRT) measured when using a smartphone and hands-free. The research sample consisted of 75 sports active students (35 men of 24±2.1 years and 40 women of 23±3.3 years). The values of the reaction time were identified using the Fitro Agility Check and Fitro Reaction systems. Tested subjects had to react via arm or leg movements in a seated position to the visual stimuli. The results show that the reaction time during the entrance test and tests during which the tested subjects were exposed to interfering sounds of 60 and 90 dB showed no significant differences in SRT. Tested subjects reacted significantly faster to four stimuli while listening to music at 90 dB. When the smartphone was used, the SRT and the CRT both worsened. The results of the study can be used in practice when people are exposed to audial stimuli during physical activity. The results and outcomes of the study can be useful for preparing athletes before their performances in sport disciplines in which a fast reaction is an important variable of their performance. The results, which showed a decrease in reaction time during the use of a hands-held phone and a hands-free, can be useful in everyday activities of people (e.g., driving a car).
Key words: visual stimulation; reaction time; sport performance; audio-load intensity.

Introduction

To optimally prepare athletes, trainers and sport researchers are attempting to find ways to influence individual factors that create an overall sports performance. The performance level is (in some sport areas) fixed on the predispositions of one particular dominant factor that represents the overall quality of the performance. In weight-lifting, the factor is strength, and in gymnastics, the factors are the level of muscle coordination, perception of time and space of the movement under relatively constant ambient conditions. There are, however, some sports that require the ability to adequately react to constantly changing conditions. In some sports, the performance is created by an interaction with different factors that must be regarded as a complex aspect. In some sport disciplines, the overall performance consists of different condition predispositions, somatic predispositions, technique levels, tactics and psychologies. One of the variables that seems to be part of all of the above-mentioned aspects and a factors in sports performance is reaction time, which is to this date being investigated by researchers, psychologists, physiologists, pharmacologists and many others who have reported on the efficiency of intervention methods that could possibly influence reaction time. This particular variable is a significant indicator that influences the movement speed, which can be used in many sport areas (start reaction during a 100-m run, reaction to an opponent's attack in karate, fencing, boxing, etc.). The significance of reaction time can be, however, found in everyday life situations (catching a falling object, stepping on the breaks in a car, or pressing breaks while riding a bicycle, etc.). During championships, we may observe athletes preparing and exercising while using headphones. Such preparation has its substantiation, and it is definitely not just for pleasure but is part of the warm-up (Eliakim, Meckel, Nemet, & Eliakim, 2007). Athletes are better concentrated on their following performance in the sport.

The influence of music on mental and physical performance has been previously analyzed by Habibzadeh (2016). It is quite common to see people in gyms using loud music as a tool to motivate themselves to maximal performance. It is also possible to find other examples of audial interferences regarded as undesirable, and physical or psychological performance can then be negatively influenced. This influence can be seen during big sport events, where athletes are exposed to loud music and sound interferences due to fans cheering (football, volleyball, ice hockey, streetball, etc.). Additionally, audial stimulus has an effect, for example, on cyclists during big events in which cyclists obtain information from their team colleagues that could disrupt their concentration. Another example of how audio load can influence overall performance is, of course, driving while listening to loud music, which could also influence reactions. The breaking distance of a car

Corresponding Author: ŠTEFAN BALKÓ, E-mail: stefan.balko@ujep.cz

speeding up to 100 km/h is 11 m, whereas the driver response is 400 ms. However, when the reaction is 300 ms slower, the breaking distance increases to 20 meters. This distance can be critical in heavy traffic. The relationship of reaction time during driving has been studied by Consiglio, Driscoll, Witte, and Berg (2003), who tested reaction time using a driving simulator. They found that hands-free communication during driving negatively affected the reaction time. Similar findings were verified after cellular phone usage or during conversation with a passenger. Al-Darrab, Khan, and Ishrat (2009) and Haque and Washington (2014) state similar results in relation to the reaction time. The authors mention similar negative effects of both hands-held phone and hands-free device on reaction time. Applied to sport areas, these findings are important for motor racing in which a driver obtains track information from a navigator. The influence of music on reaction time was not determined to be significant in that study. An increased (four times higher) risk of car accidents occurred when using a phone while driving (Redelmeier & Tibshirani, 1997). That study found that hands-free handling is much safer than using a cellular phone held in one hand. That study, however, included only a small number of participants, which could have negatively distorted the results and outcomes, as mentioned by Maclure and Mittleman (1997).

Another study by van der Zwaag et al. (2012) found that listening to music can positively influence mood during driving, which can then influence driving behavior. The study found no musical influence on the driver's performance. Other studies include applying music to physical performance. Anshel and Marisi (1978) observed the effects of synchronized and asynchronized movement during music perception. Their conclusions stated that, thanks to synchronization of music and movement, the physical performance of tested persons can be positively affected. According to many authors, music has a positive influence on exercise of varying intensity. Elliott Carr, and Orme (2005) found that due to motivational and non-motivational music, a positive influence on the physical performance occurs during cycling. Similarly, Simpson and Karageorghis (2006) stated that listening to motivational music before a 400-m run can have positive effect on the sports performance. However, Yamamoto et al. (2003) argued that no effect was found regarding fast or slow music in relation to the performance during a supramaximal test using a bicycle ergometer. A theoretical overview of the musical influence on either mental or physical performance was presented in the work of Habibzadeh (2015). The goal of our study is to determine if there are any differences in reaction time when listening to two different thresholds of audio-load intensity: 60 and 90 dB. Furthermore, we observed differences in the reaction time during communication using either a hand-held phone or a hands-free. In the case of the 60-dB threshold, it was set to have no interfering character, but the next level (90 dB) can cause functional disorders when the person is exposed to such loudness for a long time (neurotic state, nausea, vomiting, decreased attention), and this can have a harmful effect on overall health.

Material & Methods

Participants

The research sample consisted of 75 test subjects (35 men, ages 25±2.1 and 40 women, ages 23±3) who had no hearing difficulties. All participants were students in the Department of Physical Education and Sport at the Faculty of Education of J. E. Purkyně University in Ústí nad Labem. Before the analysis, the test subjects were introduced to the design and goals of the research. Every test subject had to sign an informed consent in which they declared that their participation was voluntary. The research project was also approved by the Ethics Committee on 9 September 2016 under the reference number 3/2016/03. Throughout, the testing procedures adhered to standard national and international regulations regarding the use of human subjects in research.

Procedure

For the reaction time measurement, the Fitro Agility Check and Fitro Reaction (Fitronic, s. r. o., Slovak Republic) devices and software were used. Visual stimuli for the simple reaction time (SRT) and choice reaction time (CRT) were generated on the 16" monitor of a laptop. The test subjects had to observe the screen from a 100-cm distance in a sitting position. To avoid test subjects anticipating the stimuli occurrence, a randomly generated stimuli protocol was initiated that generated 15 stimuli (for both SRT and CRT) at the interval of 500-2000 ms. During the SRT testing, the test subjects had to react to one stimuli occurrence (6 x 6 cm red square in the upper right corner of the computer screen) by pressing the sensitive hand platform (HP) with the dominant hand. For the CRT test, one of four stimuli occurred on the screen, to which test subjects had to react via four possible movement responses and press only one of two HPs placed on the table or step on one of two leg platforms (LP) placed below the feet of the test subject. According to the pre-set protocol, the red 6 x 6 cm square occurred in the upper right or left corner of the screen. If the square occurred in the upper right or left corner, the test subjects had to react by pressing the HP under the right or left hand. If the square occurred in the lower right of left corner, the test subjects had to step on the left or right 30 x 30 cm LP. The middle distance of the HP on the table or LP on the ground was set to 40 cm for the CRT testing.

For the drum and bass music (130-140 BPM) listening, the GTK-X1BT audio system (SONY, Japan) was used. For the phone call, a hand-held (SONY Xperia™) mobile phone (in SRT testing) and hands-free (in CRT testing) were used. The level of loudness in dB when listening to the music was measured using a digital Sound Level Meter AZ8922 (AZ Instrument, Taiwan) placed in the ears of the test subjects. The first series of tests included four types of SRT testing: 1) without audial stimuli interference at first (entrance test, ET), 2) then during musical interference set at 60 dB (M60), 3) then at 90 dB (M90), and 4) during communication with the researcher via a hands-held mobile phone (HH). Between the individual tests (ET vs. M60 vs. M90 vs. HH), test subjects underwent a 5-minute rest interval. After the 15-minute rest from the first test series, the CRT series followed, which used a similar procedure as in the previous experiment. Given the need to use both hands during CRT testing, it was hands-free (HF) instead of hand-held (HH) phone. The communication via HH and HF included daily life questions to which test subjects had to reply during a reaction time measurement. Test subjects were not influenced by any external interferences. The room temperature was set to 22°C.

Statistical analysis

The results of the Fitro Agility and Fitro Reaction were processed in Statistica software (StatSoft Inc., 2016). The Shapiro-Wilks test confirmed that the data were not normally distributed. For this reason, nonparametric statistical methods were used. To eliminate the negative influence of anticipation (under 100 ms) and error attempts (over 1000 ms), the first 10 "correct" attempts out of 15 overall attempts were processed for the SRT test. In the case of CRT anticipation (under 160 ms) and error (over 2000 ms), attempts were eliminated. The data were at first processed via Friedman´s ANOVA. A comparison of the individual variables was performed via a post hoc analysis using a Wilcoxon pair test. The statistical significance was set to $p < 0.01$. The effect size was also counted.

Results

The results of SRT test are presented in the following table. This series of measurements involved the reactions of the test subjects who pressed the HP with the dominant hand; then, the relations between the CRT tests will be presented.

Table 1. Differences between individual tests of SRT

	M60	M90	HH
ET	*p* = 0.12/r = 0.13	*p* = 0.14/r = 0.12	*p* = 0.00/r = 0.58**
M60		*p* = 0.93/r = 0.01	*p* = 0.00/r = 0.61**
M90			*p* = 0.00/r = 0.61**

ET = entrance test; M60 = music audio load of 60 dB; M90 = music audio load of 90 dB; HH = hands-held phone use; p = error probability after H_0 rejection; r = effect size; ** = p < 0.01, 0.5 > r < 0.8

Table 1 shows a comparison of the values between the entrance test and music load set for the thresholds of 60 and 90 dB. No significant difference in the observed relations were found. Based on these results, we conclude that audio load measured in dB has no significant effect on simple reaction time. When the HH is compared with other tests (ET, M60, M90), significant differences were detected. The reactions significantly worsened when the HH used compared with the other tests.

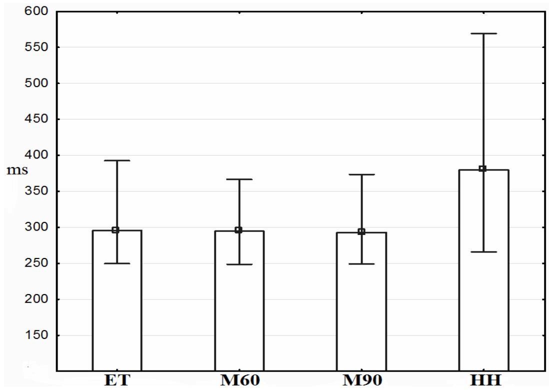

Figure 1. All SRT test series

ET = entrance test; M60 = music audio load of 60 dB; M90 = music audio load of 90 dB; HH = hands-held phone

Even though the test subjects during SRT testing were exposed to only one stimulus to which they had to always react by the same movement of the dominant hand, significant differences were found during the SRT testing, as shown in Figure 1 (the negative influence of the HH on SRT was obvious).

Table 2. Differences between individual tests during the CRT measurement

	M60	M90	HF
ET	*p* = 0.24/r = 0.10	*p* = 0.00/r = 0.36*	*p* = 0.00/r = 0.42*
M60		*p* = 0.00/r = 0.35*	*p* = 0.00/r = 0.46*
M90			*p* = 0.00/r = 0.48*

ET = entrance test; M60 = music audio load of 60 dB; M90 = music audio load of 90 dB; HF = hands-free phone; p = error probability after H_0 rejection; r = effect size; * = p < 0.01, 0.3 > r < 0.5; ** = p < 0.01, 0.5 > r < 0.8

The relations between individual tests for CRT are shown in Table 2. Interestingly, there was a significant difference between the M90 test and entrance test (p = 0.00, r = 0.36), and even when we compared M90 with the M60 test (p = 0.00, r = 0.35), the difference was still significant. The test subjects improved their reaction time levels during the M90 test compared with the ET or M60 test. The positive effect was not expected due to the load intensity. Instead, a negative effect was expected. As well as in the case of the SRT measurement, the CRT analysis showed that a significant increase in the reaction time level occurred when communication via a hands-free was used (when comparing ET, M60 and even M90).

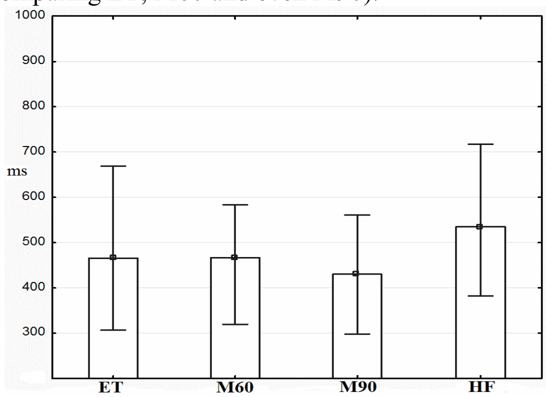

Figure 2. All CRT test series

ET = entrance test; M60 = music audio load of 60 dB; M90 = music audio load of 90 dB; HF = hands-free phone

Figure 2 shows that listening to music caused an improvement in the CRT values after the audio load reached 90 dB. It is, therefore, possible to conclude that for visual stimulus processing, using a hands-free is worse than listening to music.

Discussion

The possibilities for influencing reaction time that are due to genetic factors are rather small, but there are some possibilities that can be taken into account, e.g., in preparation for a sports performance or recovery from exercise-induced fatigue (Jing & Xudong, 2008). It is possible to deduce that reaction time plays an important role in everyday life situations for human beings. Related to this fact, we can ask, if there are any situations in which people are not exposed to any reaction time requirements.

It is our confident argument that it more suitable to find “clear” ways (without using supportive pharmacological substances) to influence reaction time or at least find connections in which the reaction time levels will not drop dramatically while using negative intervention (e.g., loud music). The reaction delay can be visible even while listening to an MP3 player during cycling, which can endanger the athlete. We also observed the negative effect of phone conversations (hands-held or hands-free phones) during activities requiring fast reactions (Alm & Nilsson, 1995; Brookhuis & Waard, 1994; Irwin, Fitzgerald, & Berg, 2000). In this context, Consiglio et al. (2003) stated that an audio load, such as music, does not necessitate demands for attention like conversation during driving a car. Many times, we are exposed to an audio load that is beyond the hygienic level that was established by the World Health Organization. The scale of fast damage to the auditory system is set at 95-130 dB. The negative effects of loud noise are observable even beyond the threshold of 70 dB. In our study, we used audio load (90 dB) similar to the loudness that can be measured, for example, during a hockey match. Ironically, at this time, the fans should create “cheerful and pleasant” ambience that is suitable for their representatives on the ice. Based on our results, we conclude that an audio load measured in dB has no significant effect on the simple reaction time with regard to the reaction time obtained in our entrance test (M60 p = 0.12, r = 0.13; M90 p = 0.14, r = 0.12). Similar findings were presented also by Meško, Strojnik, Videmšek, and Karpljuk (2009), who stated that the reaction time does not change during music perception. This is in the contrast to our findings. They, however, added that in their study an improvement in the reaction time in the experimental group appeared 45 seconds after 30 seconds of listening to music. There were no significant differences in the reaction time detected among the control group. Such results, however, can be used for future preparation of athletes right before a sports performance during the warm-up.

Significant differences were detected between the reaction time measurement during hands-held phone communication and the other tests (ET p = 0.00, r = 0.58; M60 p = 0.00, r = 0.61; M90 p = 0.00, r = 0.61) when the simple reaction time was measured. The reactions significantly worsened in the case of hands-held phone use compared with the other tests. In the case of choice reaction time, interestingly, there was a significant difference between the M90 test and entrance test (p = 0.00, r = 0.36), and even when the M90 test was compared with the M60 test (p = 0.00, r = 0.35), a significant difference was also detected. The test subjects improved their reaction time levels during the M90 test in relationship to the ET or M60 tests. This positive effect was not expected due to the load intensity. We supposed that loud music would be distracting. Additionally, in the case of the SRT measurement, the CRT analysis showed that a significant increase in the reaction time level occurred when there was a conversation through a hands-free phone (when comparing ET, M60 and even M90). The results clearly show that hands-free use can negatively influence the reaction of a particular person in a variety of situations.

Turner Fernandez and Nelson (1996) concluded that no difference was found in the reaction to a visual stimulus while the listening to music in a comparison of men to women. The best reaction times achieved by the test subjects were during listening to 70 dB of music. This threshold was approximately their preferred loudness threshold (72 dB for men and 66 dB for women). The authors also stated that in the case of listening to music at a loudness level of 60 or 80 dB, the reactions were worse. Cassidy and Macdonald (2009) added that if a test subject selects music that they find suitable according to their current mood, such decision making could decrease their feelings of anxiety and tension. Cassidy and Macdonald (2009) also state that if the test subjects are exposed to music of a high volume intensity, the accuracy levels dropped and anxiety and tension grew. The selection of preferred music is thus the best tool for optimal performance in everyday life, regardless of the activity taking place.

Conclusions

The differences in choice reaction time were found when listening to different music volume. The negative effect of hand-held phone and hands-free use on the reaction to visual stimuli was also found. These findings can be used in practice for injury prevention. Changing the driver´s behavior by listening to loud music can affect his/her safety and the safety of others. In other similarly focused studies researchers can monitor how this changed the drivers´ or cyclists´ behavior. It would be interesting to observe the changes in anaerobic or aerobic performance and reaction time as a function of listening to different kinds of music.

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