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Research article

Interactive Effects of Visual and Auditory Intervention on Physical Performance and Perceived Effort

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Abstract
The purpose of this study was to investigate the effects of using different types of media on physical performance and perceived exertion. This study was divided into two parts. In Part 1, we examined the effects of different combination of audio and video interventions on physical performance and rating of perceived effort (RPE). We recruited 20 collegiate students who performed a 12-minute cycling task (where they were asked to bike as hard as possible) under 4 conditions (music, video, music and video, and control) in a randomized order. Results indicated participants in the 2 media groups (music & audio) reported a significantly lower score for RPE. In addition, there was also an effect of media type where participants in music condition perceived less effort on the cycling task compared to the video condition. Part 2 examined how music preference influenced physical performance, but used a running task (where they were asked to run as hard as possible), and by recruiting a much larger sample. Seventy-five students were assigned into 5 groups (high preference and high motivation, high preference and low motivation, low preference and low motivation, low preference and high motivation, and control) based on responses on the Brunel Music Rating Inventory (BMRI. Results showed that music preference, but not its motivational quality, had a significant effect on physical performance. Overall, these results show that listening to music, and in particular preferred music increases physical performance and reduces perceived effort.

Key words: music preference, media type, exercise performance, BMRI.

Introduction

It is common to see people in a gym listen to music or watch TV when performing exercise. However, does exercising feel easier under these conditions? Research on the effects of external sensory stimulation on physical training and performance has typically involved testing the effects of music and video (Barwood et al., 2009; Edworthy and Waring, 2006; Eliakim et al., 2007). External stimulation is thought to facilitate the reduction or suppression of an individual's perceived exertion and physical pain (Edworthy and Waring, 2006; McKinney et al., 1997; Nethery, 2002). Also, it is suggested that external stimulation can enhance body's work efficiency and motor coordination, which improves physical performance (Locsin, 1981; Phumdoung and Good, 2003; Szmedra and Bacharach, 1998; Szabo et al., 1999). Additionally, external stimulus is believed to mitigate unpleasant emotions, and promote exercise motivation (Karageorghis et al., 1999; Karageorghis and Terry., 2001).

Music intervention during exercise is relatively simple and convenient (although see Karageorghis and Terry, 1997 for methodological challenges) and has therefore been studied and developed more extensively than other stimuli (Mohammadzadeh et al., 2008; Young et al., 2009). An early study by Anshel and Marisi (1978) found that the groups that listened to music exercised longer than those that exercised without music. In addition to Anshel and Marisi's (1978) efforts, researchers have adopted different experimental design by manipulating the intensity (Pearce, 1981), continuity (Beckeet, 1990), rhythm (Brownley, 1995; Copeland and Frank, 1991; Costa et al., 2011), motivational qualities (Elliott et al.,, 2004; Kargaeorghis et al., 1996; Lane et al., 2011), and repertoire (Potteiger et al., 2000) of the music and found that music has a positive influence on strength, endurance, technique, heart rate (HR), and rating of perceived exertion (RPE) (Copeland and Frank, 1991; Matestic, 2002; Potteiger, et al., 2000).

Researchers have suggested that video intervention may also be applied in empirical research (Annesi, 2001; Nethery, 2002). Cognition research has demonstrated that visual information accounts for 80% of human functioning, whereas auditory information accounts for only 13% (Ding, 2011). For example, Annesi (2001) examined the effects of music, television, and a combination entertainment system on distraction, exercise adherence, and physical output. Annesi (2001) found that the combined entertainment group had a higher level of distraction than the other three groups (i.e., video group, auditory group, and control group) but had a higher level of exercise adherence and cardiorespiratory function than the video group and control group. Furthermore, Nethery (2002) investigated the influence of different types of stimuli(music group, video group, non-music group and control group) on exercise and revealed that the degree of wakefulness was lower in the music group than in the non-music group and that music positively influenced physiological and psychological reactions during cycling exercise.

However, an additional factor that requires investigation is whether all types of video and audio positively influence physical performance to the same degree (Schwartz, et al., 1990; Tenenbaum, 2004). One particular factor that has been investigated is the motivational quality of the music, which has mainly been investigated using the Brunel Music Research Inventory (BMRI) (Karageorghis and Terry, 1997). Results on the effect of motivational music have been ambiguous - on one hand,

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researchers have found that motivational video and music on high-intensity has an ergogenic effect (Barwood et al., 2009). In contrast, Elliott and Carr (2004) found there was no significant difference in physical performance between the motivational music group and the oudeterous music (i.e. neutral) group. One important factor that may interact with the effect of motivational quality of the music is the preference for such music. Music therapy practitioners have demonstrated that listening to preferred music can reduce pain (Good and Chin, 1998) and therefore we hypothesized that music preference may play an important role in physical performance.

In light of these, issues concerning the effect of media on physical performance, the present study had two aims. Our first aim was to examine the influence of the media type – i.e., compare music and video stimulation on physical performance, perceived exertion, and heart rate. Our second aim was to examine the effect of music preference and motivational quality of music on physical performance.

Experiment 1

Methods

Participants

Twenty students in the Department of Physical Education were in enrolled in this study. All participants were free of high-blood pressure, asthma, and congenital heart diseases. Before the study, all participants were informed of the objectives, procedures, and possible risks of the study. The participants were given instructions and completed a basic information form and a health status survey form. Informed consent was obtained from all participants.

Procedures

The task of the participants was to perform a bicycle exercise task on a stationary bike with the goal of "biking as hard as possible" in 12 minutes. Participants engaged in bicycle exercise under four different conditions: the control condition (subjects wore eye patches and ear plugs to block external stimulation and interference), the music intervention condition (subjects used an mp3 player to listen to music but wore eye patches to block visual stimulation), the video intervention condition (subjects watched videos but wore ear plugs to block auditory stimulation), and the music-video intervention condition (subjects listened to music and watched videos). The music samples were selected from the top 30 Chinese songs on the KKBOX music ranking lists. The videos used were the music videos for the selected songs.

Each participant participated in one session per day, and the interval between each session was more than 24 hours. After the participants had put on a Polar heart rate (HR) monitor watch and the other necessary equipment had been set up, the participant began bicycling. The experimenter timed the participant for 12 minutes using a stopwatch. The duration of exercise, distance covered, HR, and RPE were recorded. The RPE is a scale that goes from 1-10 and was used to evaluate perceived exercise fatigue: a higher RPE value represents that participants perceived higher exertion.

Statistical analysis

SPSS software for Windows 13.0 was used to analyze the data and examine the group's differences on heart rate, perceived effort, and physical performance under different media interventions. A repeated measures analysis of variance (ANOVA) was conducted to test the differences in HR, distance covered and RPE. The level of significance was set at α=0.05 and effect sizes were measured using partial η^2.

Results

Table 1 shows the descriptive statistics of the HR, physical performance, and RPE of the participants while engaging in bicycling exercise under different conditions. HR did not reach the level of significance, F (2.205, 19) = 2.805, $p > 0.05$, suggesting that there was no significant difference in the HR of participants exercising under different conditions.

Physical performance reached statistical significance, $F(1.217,19) = 4.399$, $p < 0.05$, suggesting that a significant difference in physical performance under different intervention conditions (Partial $\eta^2 = 0.19$). A post hoc analysis indicated that group with music-video intervention cycled further than group without media intervention ($p < 0.05$).

The RPE analysis found media intervention groups perceived less effort than control group $F(2.208,19) = 4.937$, $p < 0.05$ (Partial $\eta^2 = 0.21$). Post hoc analysis showed that the significant difference between the control group and the three other groups - the music-video group, the music group and the video group (see Table 1). Furthermore, the degree of perceived exertion in the music group was significantly lower than in the video group.

Discussion

The primary objective of this study was to examine the effects of different media combination intervention on heart rate, physical performance and perceived exertion. Previous research revealed that accompanying exercise with different types of sensory stimulation affects HR (Thornby et al., 1995; Szabo et al., 1999). Unlike previous studies, we found that accompanying a 12-minute bicycle ride with sensory stimulation did not produce any difference in HR. However, previous studies suggesting that

Table 1. Heart rate, physical performance and RPE of the four groups in Experiment 1. Mean (± SD).

	Control	Music	Video	Video & Music
HR (bpm)	177 (12)	174 (11)	174 (14)	178 (11)
Performance (km)	2.98 (.11)	3.03 (.07)	3.02 (.05)	3.04 (.07)
RPE	8.39 (.88)	7.31 (1.51)	7.88 (1.33)	7.17 (1.66)

different interventions could influence cardio-respiratory function usually involved 6-12 weeks of training. Moreover, other research has shown that improving cardio-respiratory function requires at least 3-5 low-intensity aerobic workouts each week (Wang, 2000). Therefore, because our study involved only two weeks of exercise training without professional guidance, our results may be attributed to a lack of sufficient training time. In future studies, an experimental design requiring 16 weeks of training with sensory stimulation might enable us to further understand the influence of sensory stimulation on cardio-respiratory function.

In the analysis of the physical performance, the results of this study show that, compared to the control group without any stimulation, the music group and the video-music group exhibited improved physical performance. Previous studies have shown that the involvement of music intervention effectively extends exercise duration for endurance exercise such as stationary cycling and jogging (Anshel and Marisi, 1978; Copeland and Frank, 1991). Auditory stimulation has also been shown to increase exercise distance (Beckett, 1990) and speed (Simpson and Karageorghis, 2006) for such activities. Music is also known to stimulate the brain to release endorphins, dopamine, serotonin, and other beneficial compounds (Sutoo and Akiyama, 2004; Wolkowitz et al., 1993), which improve attention span, induce positive emotions, and improve endurance. As a result, music can decrease pain and produce a pleasant feeling. Music's ability to positively impact emotions and to inhibit pain is well supported by the literature, and these functions are also beneficial to physical performance. . In keeping with previous findings, the combination of music and video improved physical performance in our study. Furthermore, in this study, we found that there was a tendency for music to improve physical performance more than video.

Finally, with respect to RPE, we found that there was a lower degree of perceived exertion in the music and music-video groups than in the control group. We also found that music stimulus reduced perceived exertion more than video stimulus. Previous studies investigating the influence of sensory stimulation on physical performance have shown that music can significantly reduce the degree of RPE (Matestic and Cromartie, 2002; Potteiger et al., 2000), which is consistent with our finding that, compared with the group without stimulation, those who listen to music while exercising have a lower RPE.

In summary, Experiment 1 demonstrated that the effectiveness of media intervention on perceived effort and physical performance. However, past research has not yet clearly demonstrated the effectiveness of the different types of music on physical performance. Based on music therapy research (Lai, and Good, 2002), we examined the effect of both motivational quality and music preference on individuals' performances. In addition, we attempted to examine the generality of the effect to different aerobic tasks by examining a running task.

Experiment 2

Methods

In Experiment 2, we aimed to answer the question if the motivational qualities and music preference influenced physical performance and ratings of perceived exertion.

Participants

75 university students (age range = 19.4 ± 1.2 years) who were free of high-blood pressure, asthma, and congenital heart diseases were enrolled in the study. Before the study, all participants were informed of the objectives, procedures, and possible risks of the study. The participants were given instructions and completed a basic information form and a health status survey form. Informed consent was obtained from all participants.

Classification of songs on motivational qualities and preference

The preliminary selection of music samples was based on the most popular songs in the KKBOX (a popular music service in Asia, http://www.tw.kkbox.com) music ranking lists. The types of music selected included popular Chinese contemporary songs, popular Western pop songs, classical music, rock and roll, spiritual music, and six other musical styles. Ten songs of each type were selected. To prevent the participants from being burdened by too many songs and too lengthy of an experiment time in the preliminary study, we edited each song using mp3 Direct Cut software. After editing, only the essential part of the song remained (2-2.5 minutes). We selected 60 university students as study subjects and divided them into six groups of ten to listen to a designated type of music. The six songs that met the criteria established by the RPE form completed by the subjects were selected. Among the selected songs, three had a high motivational quality, and three had a low motivational quality as measured by the BMRI. Because music preference represents a habitual attraction to certain types of music, the tool for measuring preference was designed by the researchers. The purpose of the preference questionnaire was to determine a participant's level of preference for the song based on his or her level of emotional enjoyment after listening to the songs chosen. Participants rated their responses on a five-point Likert scale. Based on both the BMRI and the preference scale, the songs were subsequently grouped as follows: highly motivational music with a high preference, highly motivational music with a low preference, low-motivational music with a low preference, and low-motivational music with a high preference (as shown in Figure 1).

Procedures

The procedures of this experiment were as follows: first, we played the preferred songs in order. Then, the participants were asked to record their feelings using pen and paper in an open questionnaire. We then used the BMRI to classify the music samples into two categories - high and low motivational levels. Based on the BMRI scale, the songs with the highest and lowest scores were used to identify music preference. During the first week, a running test was conducted, and the participants ran without

listening to music. Each participant ran on a 400-meter running track for 12 minutes, and the distance covered was recorded. After the first two weeks, the participants were divided into 5 subgroups: 4 subgroups were assigned to listen to a music belonging to a different quadrant shown in Figure 1 and one group acted as the control group. Each participant then ran on the running track for 12 minutes as hard as possible while listening to music, and the distance covered was recorded.

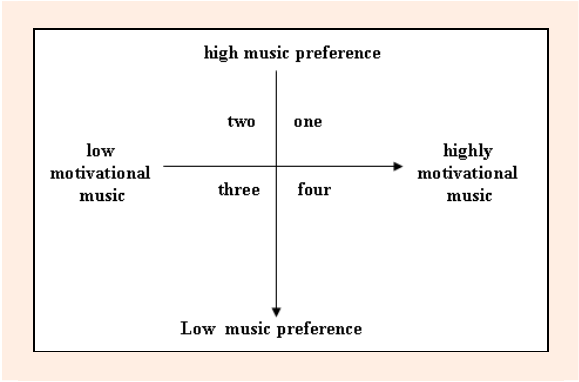

Figure 1. A four-quadrant diagram of the BMRI and music preference score.

Statistical analysis

SPSS for Windows 13.0 was used to analyze the data and examine the effects of music preference and motivational level on running performance. A dependent-sample *t* test was applied to analyze whether differences existed between before and experimental running performance in the experimental groups and the control group. A 2 x 2 ANCOVA with the pre-test distance (i.e. the distance covered without music) as the covariate was conducted to test the effect of the music's quality (motivation and preference) on running distance covered. The level of statistical significance was set at $\alpha = 0.05$.

Results

We performed an ANCOVA to determine whether physical performance was influenced by different degrees of musical motivation and preference. Table 2 shows that after adjusting for the influence of covariates (exercise without music) on dependent variables (exercise with music), there was a significant difference in physical performance between exercise accompanied by highly preferred or low-preference music ($F = 4.440$, $p < 0.05$) (Partial $\eta^2 = 0.104$). However, there was no significant difference in physical performance between exercise accompanied by highly motivational or low-motivational music ($F = 2.822$, $p > 0.05$) (Partial $\eta^2 = 0.015$).

Discussion

In experiment 2, we used different types of musical quality with different combination of the level of motivation and preference. Since 1950, scholars have investigated the effect of music on exercise and proposed varying hypotheses. However, there is no consensus about the role of individuals' selection of music. Most studies have demonstrated that listening to music during endurance exercise, such as sport walking, jogging, and bicycling, can extend exercise duration (Anshel and Marisi, 1978; Copeland and Frank, 1991), increase exercise distance (Beckett, 1990) and speed (Simpson and Karageorghis, 2006), and reduced RPE (Copeland and Frank, 1991; Matestic and Cromartie, 2002; Potteiger et al., 2000). However, other reports (Elliott et al., 2004; Simpson and Karageorghis, 2006) have shown that motivational music does not necessarily influence physical performance.

Therefore, based on music therapy research, we attempted to explore whether other factors influence physical performance. This study showed that listening to preferred music does have a significant influence on physical performance. Music therapy research has shown that the melody and beat of music affect the brain's peripheral system and hypothalamus, modulating the neuroendocrine system and nervous system (Guyton and Hall, 1996). In addition, related research shows that listening to music can reduce the effects of stress, including reducing anxiety, blood pressure, and HR and changing plasma osmotic pressure and hormone levels (Watkins, 1997). Recently, integrated clinical research by Pelletier (2004) clearly revealed that one's level of fondness for and familiarity with and the special characteristics of a type of music can influence one's reaction to that music. The level of fondness plays an especially important role in the inhibition of pain. Therefore, from the perspective of music therapy, listeners' interpretation of music varies, and music therapy can therefore achieve a satisfactory result only through individual evaluation (Gaston, 1968). Similarly, Good and Chin (1998) demonstrated that a type of music may have a therapeutic effect on one person but not on another. Therefore, based on the results of our study and other studies of music's therapeutic effect, the motivational level of the music is not the only important factor for exercise participants to consider when selecting music. Music preference is also indispensable to improving physical performance.

Conclusion

The design of this study was intended to resolve two main issues concerning the effect of external stimuli on physical performance. The first part was to examine the effect of music and videos intervention which are the most widely used (Barwood et al., 2009; Edworthy and Waring, 2006; Eliakim et al., 2007). However, because of

Table 2. Covariance analysis results for the effect of different levels of motivational quality and preference on running performance (n=75).

Variable origin	SS	df	MS	F	p
Without music	3685248.343	1	3685248.343	108.606	.000
Preference	150655.324	1	150655.324	4.440*	.040
Motivational quality	95752.626	1	95752.626	2.822	.099

* $p < 0.05$.

differences in study designs in these earlier studies, the effect of music and audio interventions on HR, sports performance and RPE were not conclusive. In the study 1 we found that although the music-video combination and music interventions had better effect than control, these two conditions were not statistically different. Therefore, using music intervention is a probably more efficient way. Second. Several studies have found support for the effect of music (Beckeet, 1990; Brownley, 1995; Copeland and Frank, 1991; Costa et al., 2011; Pearce, 1981). And through BMRI Scale distinction, the effect of motivation in music has also been studied (Elliott et al., 2004; Kargaeorghis et al., 1996). However, these findings have also not yet been conclusive. Therefore, in the second part of the research, we aimed to understand the impact of the music preferences on athletic performance. Our results are consistent with the results of medical research and support the hypothesis that music with high preference will indeed lead to better athletic performance. In summary, this study found that in addition to the presence of music, the preference for the music also affects athletic performance.

This study shows that in selecting a form of external stimulation to enhance physical performance during exercise, music is a better choice than video. In addition, music preference is an effective way to distract one's attention, and the motivational quality of the music can influence physical performance. Therefore, for exercise participants, motivational and preferred music can be used to extend exercise duration and improve physical performance. For future research, the training time with stimulation should be extended to understand more thoroughly the effects on physical training of a given stimulation.

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Key points

- Among different sensory stimulations, music can enhance physical performance more strongly than video.
- In addition to the motivational level of the music, music preference can also influence the physical performance of aerobic exercise participants.

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