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The effect of music type on running perseverance and coping with effort sensations

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Abstract

Objectives. To examine: (a) the effect of music type on running time and on sensations and thoughts experienced by the runners under high physical exertion, and (b) the role that music plays in the use of two distinct self-regulation techniques during high exertion, namely dissociative and motivational.

Design and procedure. Three studies were conducted. In Study 1 and Study 2, performed in the laboratory, participants ran at 90% of their maximal oxygen uptake on a motorized treadmill four times, once each with rock, dance, and inspirational music, and once without attending to music. Ratings of perceived exertion (RPE) and heart rate (HR) were monitored during the run, and discomfort symptoms and music-specific questions were examined. In Study 3, performed in the field, participants ran a hilly course eight times, four under a competitive-pair condition, and four under a single-mode condition. Running time was the dependent variable.

Results. Music failed to influence HR, RPE, and sensations of exertion in the three studies. However, about 30% of the participants indicated that the music helped them at the beginning of the run. The participants stated that music both directed their attention to the music and motivated them to continue. Despite the heavy workload reported by the runners, running with music was perceived as beneficial by many.

Conclusions: People engaged in high intensity running may benefit from listening to music, but may not increase their ability to sustain that effort longer than they could without music. Further research that incorporates personal music type and rhythm preferences should be carried out in order to advance this line of inquiry.

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Introduction

Music motivates exercisers to sustain effort and at the same time is used to dissociate from the exertive sensations stemming from their bodies (see Karageorghis & Terry, 1997 for a review). It affects perceived exertion and exertion tolerance through several mechanisms. One is that music synchronizes the exercise pacing, tempo, and rhythm (Abernethy & Batman, 1994; Anshel & Marisi, 1978; Mertesdorf, 1994; Szabo, Small, & Leigh, 1999). Another mechanism is that music enhances arousal (Becker, Brett, Chambliss et al., 1994; Brownley, Murray, & Hackney, 1995; Karageorghis, Drew, & Terry, 1996), particularly when it has personal meaning for the individual (Blumenstein, 1992; Gfeller, 1988; Karageorghis & Terry, 1997). Thus, music enables one to cope more efficiently with specific exercise modalities (e.g., those that evoke feelings of monotony and boredom) and with specific exercises that evoke feelings of pain (Karageorghis & Terry, 1997). Music was also found to affect the mood (Karageorghis & Terry, 1997), self-esteem, and confidence of exercisers (Becker et al., 1994; Lampl, 1996; Taylor, 1992), and also to enhance the production of imagery (Lampl, 1996). Finally, Gfeller (1988) based on a qualitative data analysis, asserted that music enhances exertion tolerance through the diversion of attention from the exertive and uncomfortable physical sensations to the various features of the music (i.e., rhythm, melody, and lyrics). These mechanisms may also operate interactively during endurance running.

Findings have been equivocal in studies examining the effect music has on performing various tasks. Several studies have shown that up-tempo music has enhancing effects on performance, while slow tempo music had detrimental or relaxing effects (Beaver, 1976; Ferguson, Carbonneau, & Chambliss, 1994; Karageorghis, Drew & Terry, 1996). Others have shown both up-tempo and slow tempo music have improved performance when compared to a white noise condition (Becker et al., 1994). In contrast, Copeland and Franks (1991) failed to support the claim that loud and fast music enhances physiological and psychological responses in sub-maximal exercise (i.e., endurance task on a treadmill). In a literature review by Karageorghis and Terry (1997), the use of many music types was noted. However, no definitive conclusions as to the match between the task and its demands to the music type were made. In line with Lampl (1996) and Meyer (1994), if music serves to increase arousal in exercise, then it may be an effective preparation strategy when power or muscular endurance exercises are performed, but this same music may be counter productive for activities that require high levels of concentration and coordination. Thus, in the current study the three selected music types were chosen as they shared the rhythm and melodies that young adults indicated as being motivating, especially when experiencing high effort levels.

Tenenbaum (2001) introduced a conceptual framework linking associative and dissociative strategies to the physical demands of the task. According to the model, the main factors that evoke feelings of exertion are the physical intensity of a task and the endurance required completing it. Kinsman and Weiser (1976), Weiser and Stamper (1977), and Pandolf (1978) proposed four levels of subjective reporting of sensory experiences during an ongoing physical exercise, each associated with physiological processes, which induce fatigue. These levels of sensory experiences were derived from extensive research on exertion feelings reported during engagement in various tasks at various intensities. The first level, Discrete Symptoms, includes responses such as sweating, perspiring, panting, heart pounding, leg aches and cramps, muscle tremors, leg twitching, heavy and shaky legs, tiredness, vigorous mood, and determination. The second level, Subordinate, is associated with cardiopulmonary, leg, and general fatigue. The third level, Ordinate, is linked to task aversion and the motivation to adhere to the task. The fourth level, Superordinate, is associated with extreme fatigue. At this stage the individual cannot identify specific sensations (i.e., muscle aches, breathing, etc.), and experiences an extreme general fatigue and exhaustion (see Noble & Robertson, 1996).

Subjective (emotional) and objective (physical) components of exertion are associated with perceptions of exertion and tolerance. The subjective-objective link with respect to exertion is strongly related to the attention mode of the exerciser. Increase in physical load results in intensification of perceived exertion. Consequently, attention shifts from an external-dissociative mode to an internal-associative mode, when the exerciser is coping with extreme exertion. Under low to moderate physical load, perceived exertion can be manipulated by attending to external cues, such as music (passive) or solving mental problems (active). However, diverting attention is substantially limited when the exerciser is in the Superordinate level and coping with extreme levels of fatigue and physical effort. At this stage, one needs a high level of motivation and exertion tolerance in order to persist in the task.

The subjective-objective symptomatologic link with respect to attention mode and perceived exertion manipulation is illustrated in Tenenbaum's (2001) recent model. The model asserts that strategies for coping with physical exertion are classified as either internal or external to the performer. External strategies are those in which the performer shifts his/her attention to external events, in an effort to reduce his/her perception of neural exertion signals coming from the muscles, joints, and the cardiopulmonary systems. Internal strategies are aimed at coping directly with feelings of overuse and exertion through 'fighting' against them or other negative events imaged at this time. These two strategies have also been termed 'dissociative' and 'associative' techniques respectively (Morgan & Pollock, 1977). Rejeski's (1985) Parallel Processing Model (PPM), in line with Tenenbaum's (2001) model, suggests that both associative and dissociative coping strategies can be successful under low to moderate loads of exertion. However, under high loads, their effectiveness is limited (see Noble & Robertson, 1996 for review; Szabo, Small & Leigh, 1999). In the three studies presented herein, the purpose is to challenge the view that under extremely high physical effort, exercisers will be unable to experience the potential benefits of music (i.e., motivation, rhythm, distraction of attention, fun, enjoyment, and others). Despite its theoretical premise, this view has not been evident in a standardized controlled environment. The objective and subjective consequences of introducing music while engaging in extended high efforts are the main goals of the three studies.

In Studies 1 and 2, participants ran individually on a motorized treadmill at 90% $VO_{2\ max}$ Three music types commonly heard by young university students were compiled after being classified in a pilot study (i.e., rock, inspirational, and dance). In Study 3, the same music types were attended to in the field, but non-competitive and competitive conditions not used in Studies 1 and 2 were added. Individual and two-person competitive running conditions were contrasted because evidence suggests that competitive conditions elevate arousal state and motivation through social facilitation (Zajonc, 1965). According to social facilitation theory, the presence of others raises concerns of peer evaluation. This, in turn, may have a debilitating effect on the performer by creating evaluation apprehension. In the present context, competitors' motivation will increase, and as a consequence, runners may be faster and exert more effort when competing against an opponent than they do under individual running conditions. Thus, music may play a different role under each condition. Under the single running condition, it was expected that music would result in increased effort by the runners, thus resulting in faster times than under the running condition without music. In contrast, under the competitive-pair condition, which evoked high exertion, the effect of music diminished as a consequence of the extreme exertion felt during the run.

The heavy physical load in the first two laboratory studies was chosen because it has been indicated that, under heavy loads, attention cannot be diverted to external signals, and motivation to adhere to the task is reduced as intense pain, discomfort, and fatigue are experienced. In these two studies it was expected that the effects of music on running performance would be minimal despite music's potential motivational and physical benefit. Perceptions of exertion under high physical intensity would not allow attention to be divided between external and internal sources, thus resulting in similar performances to the no-music running condition.

Method

Three studies were carried out to examine (a) whether very heavy physical exertion limits attention to external stimuli, such as music, and (b) how individuals participating in a physically demanding run perceived the music that they were hearing. Studies 1 and 2 were conducted in the laboratory while Study 3 was a field study. The two laboratory studies were similar, though personal reflections were recorded only in the second experiment. Two similar studies were conducted in order to be consistent with Cohen's (1994) recommendation to rely on repeated trials of different samples rather than on significance levels for generalizability purposes. The field study was carried out to verify the laboratory findings and to examine their generalizability and ecological validity in a natural setting.

Study 1: A laboratory study

Participants

Fifteen male participants who regularly run fewer than three times per week were asked to participate in the study. Participants were recruited from a university student population using an advertisement placed on the university's bulletin boards. They had normal hearing and were healthy with no physical disabilities. The ages ranged from 18 to 35 years (M=23.34, SD=3.46), weight M=76.7 Kg, SD=4.68, and $VO_{2\ max}$ M=51.63 (ml.kg.min^{-1}), SD=7.19 (ml.kg.min^{-1}).

Instrumentation

In addition to informed consent, the following questionnaires and single items were administered:

Demographic details Name, age, and time spent running each week (hours).

The Physical Activity Readiness Questionnaire (PAR-Q; British Columbia Department of Health, 1975). The PAR-Q consists of seven questions, which are answered in a YES–NO format. It assesses an individual's general medical condition, and overall level of fitness. It contains questions such as "Has your doctor ever said you have heart trouble?"

The General Health and Life type Questionnaire (GHLQ) The GHLQ is part of the PAR-Q. It contains eight items, and is similarly answered in a YES–NO format. The GHLQ consists of more specific items on coronary and cardio-vascular conditions. Items such as "Do you have a history of high blood pressure and/or diabetes?" are included.

Rating of Perceived Exertion Scale (RPE; Borg, 1982) The RPE ratio scale allows participants to give a subjective exertion rating for the physical task at any time during the activity. The scale ranges from 0 to 10. The higher the RPE score, the higher the rating of perceived exertion. The RPE scale is a reliable indicator of physical discomfort, has sound psychometric properties, and is strongly correlated with several other physiological measures of exertion (Borg, 1982).

Running Discomfort Scale (RDS; Tenenbaum et al., 1999) This scale lists 32 symptoms grouped into eight dimensions which runners have reported in running conditions: Proprioceptive symptoms (ten items, score range 10–50), leg symptoms (six items, range 6–30), respiratory difficulties (four items, range 4–20), disorientation (two items, range 2–10), dryness and heat (two items, range 2–10), task completion thoughts (three items, range 3–15), mental toughness (two items, range 2–10), and head/stomach symptoms (three items, range 3–15). The participants were asked to rate how intensely they felt each of the symptoms immediately after completing the run on a 5-point Likert-type scale ranging from '1' (not at all) to '5' (extremely). The score of each of the eight discomfort symptoms is determined by the summation of all items within each dimension. The higher the score, the more the symptom is felt during performance of the task. The internal consistency reported for runners ranged from 0.63 (mental toughness—two items) to 0.91 (proprioceptive symptoms—ten items). The concurrent reliability correlation with the Borg's RPE scale ranged between 0.34 and 0.65 for eight different running races. The construct validity was examined by comparing the extent of discomfort runners felt in races differing in distance. It was found that the longer the race, the higher the reported symptoms by the runners.

Perception, motivation and attention Two questions were designed to measure the subjective feelings of the participants about "how demanding" the run was, and "how much exertion" they experienced. A 5-point Likert-type scale ranging from '1' (not at all) to '5' (very much) was used. An additional eight questions were related to the specific features of the music types used: how much the participants enjoyed the music, how much it helped them in tolerating the exertion during the different phases of the run (beginning, middle and end), and the components of the music (i.e., melody, rhythm, lyrics) they attended to most and least, if at all. For each question, specific wording was attached to the Likert-type scales, ranging from '1' (not at all) to '5' (very much). The items share high face validity.

Music manipulation

The three music types, which were chosen for this study, consisted of preferences that students indicated in a pilot study, and the way they categorized pieces of music they were asked to listen to. A Sanyo compact disc portable Audio System (model no. MCD-Z7F) was located in front of the treadmill from which headphones were attached for use of the participants. During the experiment, a tape player played music at constant volume (75% of maximum volume on the tape player's scale). This volume was chosen in the pilot phase of the study to overcome the treadmill noise and to establish a clear sound of the music while running. The music selections are presented in Appendix 1. The following three music types were played:

Rock style Rock music is a type of popular vocal music characterized by a hard, driving beat featuring electric guitar accompaniment and heavily amplified sound. Rock is based on a very powerful beat, and tends to have short melodic patterns that are repeated several times. The harmony is often quite simple, consisting of only a few chords (Kaimen, 1990). The rock tape consisted of seven songs operationalized as rock songs by people not connected to the study. Of the 14 listeners, 86% (n=12) identified the tape as rock music.

Inspirational style Inspirational music is regarded as music that creates invigorating feelings in the listener. The listener is stirred into a spirit of motivation and power. Inspirational input has an animating, enlivening, or exalting effect upon an individual (Webster's, 1971). Inspirational songs usually have some relevance to the listener, and are usually associated with commercials, films, or sporting events. Snyder (1993) collected qualitative data about various musical selections associated with sport. Two of these selections were two of the inspirational songs of this study: the themes from “Chariots of Fire” and “Rocky.” Participants wrote about the meanings and feelings associated with the selections they listened to. According to the listeners, the theme from the film “Rocky” (“Eye of the Tiger” by Survivor) elicited the motivation and desire to excel, overcome the odds, and become a winner. The theme from the film “Chariots of Fire” elicited feelings of striving to win, endure, meet the challenge, persistence, and determination. The inspirational tape consisted of eight songs. The musical pieces were operationalized as inspirational songs using the same procedure described above. Of the 13 listeners, 100% identified the tape as inspirational music.

Dance style Modern dance music has a beat suitable for dancing, typically characterized by predominant beats, usually bass notes of synthetic origins, ranging in speeds from 110 to 200 beats per minute. Dance music may or may not include vocals. The dance tape consisted of two pieces of music and then a professional mix of eight pieces of music. The music was operationalized as dance songs as described above. Of the 15 listeners, 100% identified the tape as dance music.

Design, procedure, and task manipulation

Participants were instructed to perform a single treadmill run in order to measure their maximal oxygen uptake. Participants would then perform four weekly runs at 90% of their $VO_{2\ max}$ for as long as they could sustain that exertion level. The participants were instructed to rest and drink water, but not eat, prior to testing. These instructions were given in all three studies. They were required to read the participant information sheet, sign the consent form, and show a signed certificate from their personal physician clearing them to participate in this study.

Before the $VO_{2\ max}$ test, runners completed a series of forms and questionnaires, as decribed, to measure their psychological and physical characteristics prior to their performance. The PAR-Q was utilised as a screening tool for all participants. This was done to rule out the possibility of any cardiac and/or respiratory complications that might occur during the physically demanding task. Each participant then performed a $VO_{2\ max}$ test. The heart rate monitors were attached to three locations: the top of the manubrium, 5 cm below the left nipple, and at the base of the neck as recommended (McArdle, Katch, & Katch, 1991). Participants then completed a $VO_{2\ max}$ test. This required participants to run on a treadmill until the point of voluntary exhaustion.

A standard protocol to reach $VO_{2\ max}$ was implemented and overseen by an attending exercise physiologist. The protocol was as follows: the initial 3 min were completed at 1.2 miles/hour with a 10% gradient. Every 3 min, the speed was increased to 2.5, 3.4, 4.2, 5, 5.5, and 6 miles/hour, with the gradient increasing by 2% each time. Participants use a mouthpiece and a nose plug to prevent any air escaping via the nose. Participants were instructed to indicate their level of exertion on the Borg RPE scale every 30 sec, by using their fingers (e.g., one finger extended represented one on the RPE Scale), and heart rate was monitored simultaneously. Both measures were recorded on a response sheet. At voluntary exhaustion, the participants were instructed to grasp the front railing of the treadmill while the treadmill slowed down. While the treadmill was slowing down, participants were instructed to continue walking until their heart rate had lowered to an acceptable level (i.e., 120–130 bpm). The supervising physiologist determined this level.

The order of the four running conditions (silence, rock, inspirational, and dance) was counterbalanced to mask any order effect. The sub-maximal test followed a protocol designed to bring the participants to 90% of their $VO_{2\ max}$ within 5 min. During the first minute, the participants' reached a heart rate level that corresponded to the heart rate found at 50% of their $VO_{2\ max}$. This heart rate level was increased by 10% per min until 90% $VO_{2\ max}$ was achieved. To monitor this, participants were again fitted with a heart rate monitor. The sub-maximal protocol was as follows: the attending exercise physiologist calculated an approximate heart rate for each participant using data from the heart rate monitor which was equivalent to 50, 60, 70, 80 and 90% of their $VO_{2\ max}$. These heart rates were achieved at each subsequent minute by increasing the speed of the treadmill every minute for 5 min. Further, a 5% gradient on the treadmill was used throughout. At the 5 min mark, participants were asked to breathe into the mouthpiece to make sure their level of oxygen uptake (VO_2) was at the correct level (90%). Similar to the first test, participants were instructed to indicate, using the Borg RPE scale, their level of exertion at each minute. Once the participants could not tolerate the adverse exertion of the task, they placed their hands on the front railing, and the treadmill was brought to a stop. Once the treadmill had completely stopped, the participants completed the RDS and the questions on motivation, perception, and attention focus/diversion they experienced during the run. A stopwatch was used to measure the total running time during the $VO_{2\ max}$ and 90% of VO_2 max trials. Time when participants reported RPE "strong" (i.e., RPE=5), and time in "exertion" were also measured. During their sub-maximal runs, no encouragement or any other type of communication was given to participants.

Statistical analyses
To examine the effect of music type on performance (i.e., exertion tolerance), means and standard deviations for "time to RPE strong" and "time in exertion" were calculated for each of the four 90% of $VO_{2\ max}$ running conditions. To account for the music and "no music" conditions, a repeated measures (RM) MANOVA, followed by RM-ANOVA and multiple post-hoc comparisons procedure, were performed once a significance level of $p<0.05$ was obtained. The four running conditions were treated as a within-subjects repeated factor. Furthermore, similar analysis was performed for the eight discomfort/exertion symptoms of the RDS scale to examine the extent that music affected the eight somatic and psychological symptoms associated with running. In addition, RM-MANOVA was applied to the single questions pertaining to the unique features of the music type. This was performed to obtain: (a) detailed information as to what phase (beginning, middle, end) of the run did music help in tolerating exertion; (b) to which stimuli (external and/or internal) did the runners attend during the run; and (c) to which music features did the runners attend (e.g., words, rhythm, and/or melody).

Results
The effect of music on running endurance Multivariate homogeneity and normality tests indicated that the data did not violate the main assumptions underlying the analyses. Skewness and kurtosis coefficients were smaller than 1.96 despite the small sample size. Mauchly's test of sphericity for "time," "time to RPE-strong," and "time in exertion" resulted in MW values of 0.64–1.00 for music type, time, and music by time interaction, respectively, all of which resulted in non-significant ($p>0.05$) Chi-Square statistics. Epsilon coefficients (Greenhouse-Geisser, GG; Huynh-Feldt, HF), which adjust for degrees of freedom in testing the null hypothesis that an error covariance matrix or the othonormalized transformed dependent variable is proportional to an identity matrix, indicated satisfactory (non-significant) coefficients (GG: 0.78–1.00: HF: 0.94–1.00). Homogeneity tests among the means' variances also resulted in non-significant ($p>0.05$) statistics.

Repeated measures (RM) MANOVA revealed non-significant ($p>0.05$) effects during all three running trials. Across all four running conditions, participants ran M=4.82 min, SD=2.83 until they felt they were in the exertion level "strong," remained "in exertion" for M=5.85 min, SD=2.83, resulting in a total time on task of M=10.67 min, SD=5.27.

Objective and subjective measures during the run Heart rate (HR; b.p.m.) and ratings of perceived exertion (RPE) were monitored every 30 sec during the run. Participants varied in time to voluntary exhaustion, hence Figs. 1 and 2 illustrate the runners' HR and RPE values until the 12th min. From the 12th min on, a substantial decrease in runners participating was evident. The two figures, however, show similar patterns of HR and RPE, as expected, throughout the run in the four running conditions. HR increased gradually until 4.5–5 min, and remained consistent (175–185 b.p.m.) until the 12th min. In contrast, RPE increased monotonically until the 10th min, during which time RPE was perceived as "very strong." This RPE pattern was almost identical under all four running conditions.

Similar analyses performed for the eight discomfort/ exertion symptoms of the RDS revealed a significant effect for "symptoms" (Wilks' Lambda=0.10. F (7, 18)=22.67, $p<0.001$), but not for running condition or its interaction with discomfort/ exertion symptoms. In all running con-

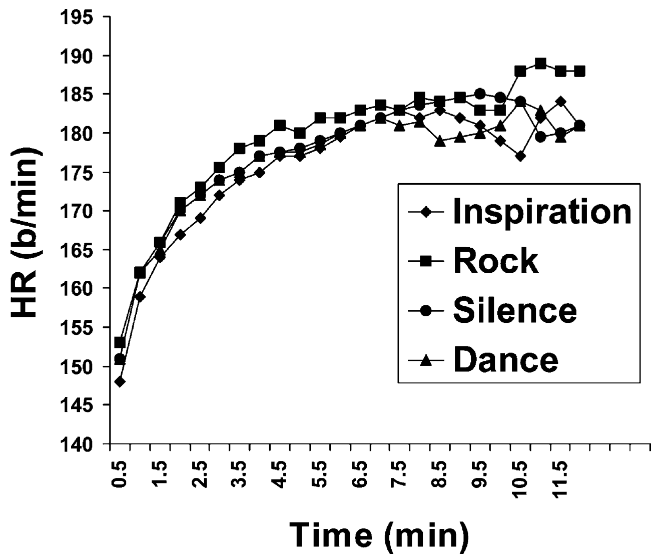

Fig. 1. Comparison of heart rates among the four running conditions at 30 sec intervals during the 12-minute run.

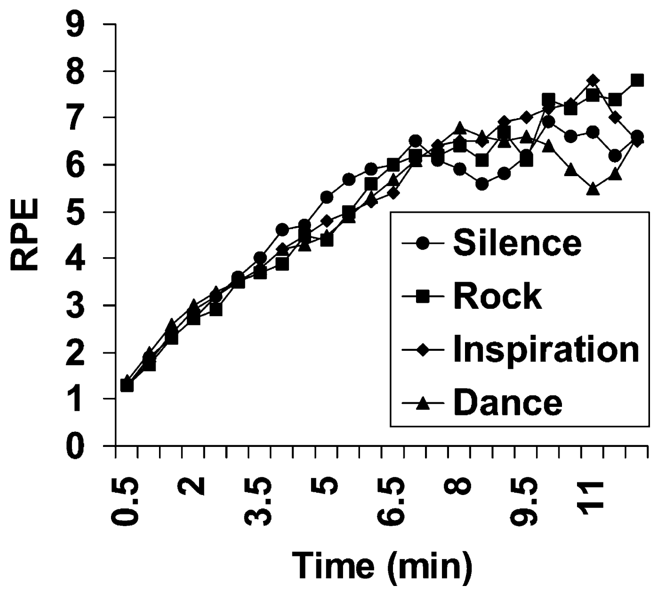

Fig. 2. Comparison of rates of perceived exertion among the four running conditions at 30 sec intervals during the 12-minute run.

ditions, “mental toughness” and “task completion thoughts” were felt strongly (mean range: 3.0–3.2), “dryness/heat,” and “legs” were felt moderately (mean range: 2.1–2.4), and “proprioceptive,” “respiratory,” “disorientation,” and “head/stomach” symptoms were felt slightly to moderately (mean range: 1.3–1.8).

Effort perception, motivation, and attention focus during the run Demands of the run and the exertion experienced during the run revealed a non-significant ($p > 0.05$) effect for running condition. Mean values ('5' was maximal) ranged between 3.80–4.04 for "demand," and 4.00–4.20 for "exertion experienced," indicating high physical demand and very high exertion in all four runs.

Eight questions were related to the unique features of the music and the effect of the music types on various perceptions of the run. These questions were administered to the participants after they completed each run that included music. The analysis revealed a significant effect for music type (Wilks' Lambda=0.73, F (2,23)=4.13, $p<0.03$), resulting from a higher overall mean rating given to inspirational (M=3.24, SD=0.72) compared to rock (M=2.82, SD=1.04), and dance (M=2.78, SD=0.91) music types. The runners rated the extent to which they liked the music, and the extent to which it helped them tolerate the exertion level, as "moderately" (M=2.83, SD=0.61, and M=2.91, SD=0.92, respectively). They also reported that music had a greater effect during the initial phase of the run than during the last phase (M=3.54, SD=1.12 vs M=2.52, SD=0.74, respectively). During the run, the participants attended more to the melody and rhythm of the music and much less to the lyrics (M=3.22, SD=0.61, and M=3.23, SD=0.54 vs M=1.52, SD=0.34, respectively). These differences resulted in a significant effect from the music-specific type (Wilks' Lambda=0.12, F (7,18)=18.52, $p<0.0001$).

Study 2: laboratory study

Participants

Fifteen males, aged 18–25 yrs (M=21.65, SD=2.1; weight: M=78.9 Kg, SD=5.81; $VO_{2\ max}$ M=50.61, SD=5.32 $ml.kg.min^{-1}$) participated. Participants were recruited from an advertisement on the university's bulletin boards. They did not take part in any organized strenuous activities. Before engaging in the study, participants underwent a medical examination by a physician who was present at all testing sessions. This examination ensured that each participant was healthy and able to participate in maximal and sub-maximal ergometry tests with minimal risk.

Instrumentation

Study 2 used the same questionnaires as Study 1. However, after each run, an additional open interview pertaining to the participants' feelings and thoughts about their exertion level and the music they listened to was administered. This allowed Study 2 to capture aspects beyond those elicited from solely using the closed introspective questions from Study 1.

Open interview Runners were asked to 'think aloud' by mentioning any feelings or thoughts they had. Immediately after completing the run, participants were asked to share their thoughts and feelings with a researcher and assistants individually. The questions asked were: (a) What pain / discomfort did they experience? (b) What type was the music, and how it was perceived? (c) At which stage of the run was the music more or less effective? (d) Was attention diverted, i.e., did the participant focus on the discomfort, or on the music? (e) What images, if any, did the music produce, and, if applicable, how vivid or clear were these images? (f) What strategies or thoughts did they use during the run, i.e., were their thoughts about bodily sensations, relaxation (associative), or did they focus on externals (dissociative)? (g) What was their perception of the time of the run?, and (h) What motivated them or invigorated them during the run?

Music manipulation

Music selections were identical to those in Study 1.

Design, procedure, and task manipulation

The procedures and task manipulation were identical to those in Study 1.

Statistical analysis

Statistical procedures were similar to those used in Study 1. A qualitative analysis of "thinking aloud" and open interviews were performed to analyze the effects of music and the coping mechanisms participants used during the run. These analyses were consistent with guidelines offered by Marshall and Rossman (1999). Responses to each question were grouped into similar and meaningful clusters (i.e., those sharing similar content), and then counted and weighted. This facilitated a comparison of thoughts, feelings, self-reflections, and coping strategies of the runners in the four running conditions.

Results

The effect of music on endurance running No major multivariate normality and homogeneity violations were detected in the data. Skewness and kurtosis coefficients ranged between 0.89–1.38. Mauchly's test of sphericity for "time," "time to RPE-strong," and "time in exertion" resulted in nonsignificant ($p>0.05$) MW values of 0.77–1.56 for music type, time, and music by time interaction, respectively. Epsilon coefficients (Greenhouse-Geisser, GG; Huynh-Feldt, HF), indicated satisfactory (nonsignificant) coefficients (GG: 0.58–0.87: HF: 0.94–0.99). Homogeneity tests among the means' variances also resulted in non-significant ($p>0.05$) statistics.

The RM MANOVAs resulted in a significant effect for running condition (Wilks' Lambda=0.52, F (3,12)=3.71, $p<0.04$), on total time on task, and a strong tendency for significance for running condition on "time in exertion" (Wilks' Lambda=0.56, F (3,12)=3.21, $p<0.06$). Fig. 3 displays the first significant effect. Paired t-tests revealed that running time was greater while attending to inspirational music than when attending to dance music (t (14)=2.26, $p<0.04$,

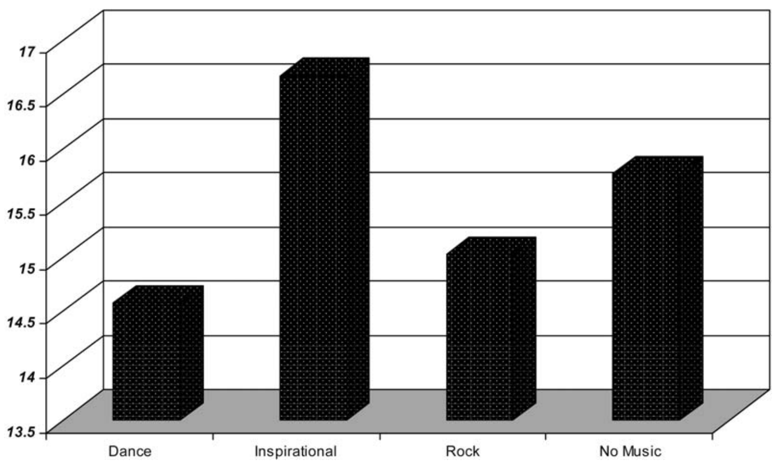

Fig. 3. Means of "time on task" for each of the four running conditions.

Effect Size (*ES*)=0.39) and rock music (t (14)=2.70, $p<0.02$, *ES*=0.10) (*M*=16.67 min, *SD*=5.35 vs *M*=14.58, *SD*=5.70, and *M*=15.03, *SD*=4.23, respectively). None of the runs with music resulted in longer times than the runs without attending to music. Moreover, running while attending to dance music resulted in a decrease of "time," compared to the run without music (*M*=6.55 min, *SD*=2.79 vs *M*=8.27, *SD*=5.06), $t(14)=2.15$, $p<0.05$, *ES*=0.43.

Objective and subjective measures during the run HR and RPE were monitored during the run in one-minute intervals. Similar to Study 1, a substantial decrease in participants occurred after the 12th min. Figs. 4 and 5 illustrate (a) similarity in mean HR and RPE measures during the four runs, and (b) a linear increase in RPE until 12 min, during which HR increased sharply until min 5–6, and then remained stable. The mean HR values indicated similar cardiac load during all four runs. The mean RPE values indicated similar exertion perceptions during all four runs.

The RM MANOVA performed for the RDS running revealed only one significant effect, that of discomfort symptoms (F (7, 98)=19.18, $p<0.001$). The differences among discomfort symptoms resulted from high ratings given to "task completion thoughts" (*M*=3.22, *SD*=0.91), the moderate ratings given to "dryness and heat" (*M*=2.51, *SD*=0.71) and "mental toughness" (*M*=2.71, *SD*=0.74), and relatively low ratings given to "proprioceptive," "legs," "respiration," "disorientation," and "head and stomach" symptoms (mean range: 1.23–1.72). These findings, however, were common to all running conditions regardless of the type of music listened to, including the "no-music" condition.

Effort perceptions, motivation, and attentional focus during the run The semi-structured interview after completion of the run and categorization of the responses revealed the following results: The majority of the runners' thoughts were related to the run (above 50% in each of the four

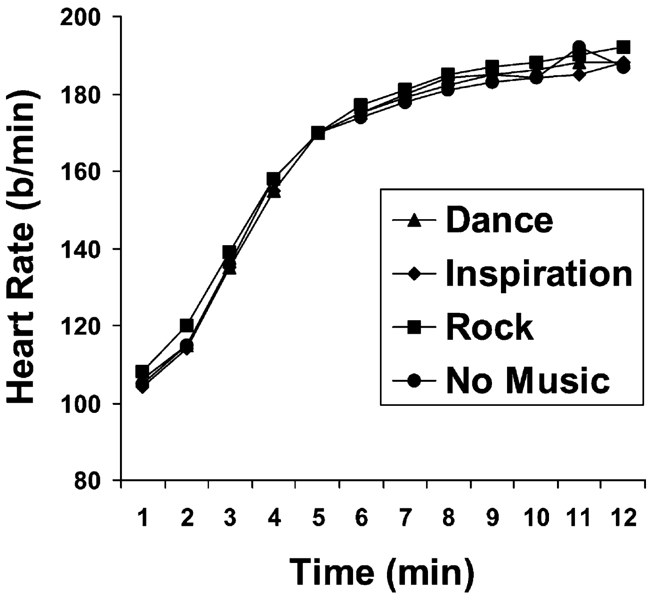

Fig. 4. HR means for the first 12 minutes of the 90% VO_2 max run.

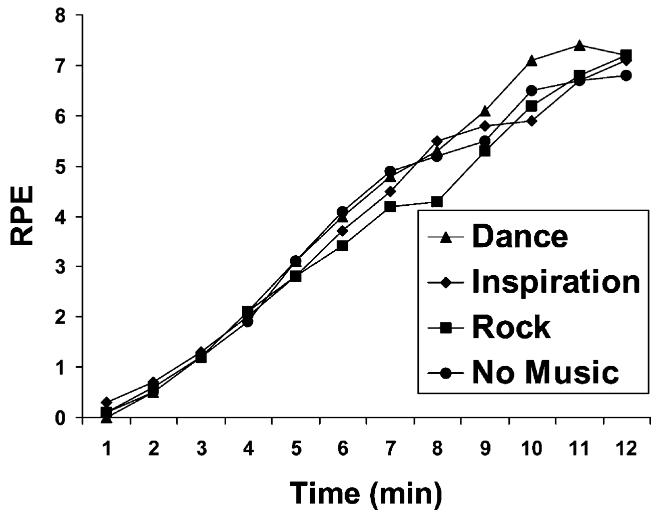

Fig. 5. RPE means for the first 12 minutes of the 90% VO_2 max run.

running conditions). Runners reported attending to music during the dance, inspirational, and rock music approximately 19, 22, and 5%, respectively. About 45% of the thoughts during the "no music" run were about the time taken to complete the run, and various positive thoughts. About 50% of them reported that they did not think about any specific matter. During the runs with music, thoughts about "things" were reported by 12–28% of the runners. However, when asked directly whether they concentrated on the music, 67% of them replied "yes" and 33% replied "sometimes" when inspirational music was played. During the runs where rock and dance types of music were played, only 37% said that they attended to the music. About 87% admitted that they diverted their attention from the music to other aspects associated with the run when dance music was played. Between 50–60% of the runners reported that this was the case when inspirational and rock music were played.

Approximately 100, 74, 33, and 87% of the runners felt pain or discomfort during the runs with dance, inspirational, rock, and no music, respectively. Running with rock music was associated with feelings of pain and discomfort at different stages during the run. However, 61 and 47% of the participants reported that their pain and discomfort were diverted externally while attending to inspirational and rock music, respectively. Only 18% of the runners felt this way when the dance music was played. Moreover, 57, 63, and 33% of the runners claimed that dance, inspirational, and rock music styles, respectively, encouraged and motivated them during various phases of the run. One participant made the comment that "Music is bad and had a reverse effect." During the run with rock music, the majority of the participants admitted that they had "other thoughts," rather than attending directly to the music.

Three runners responded that their personal music preference was dance, two indicated inspirational music, five selected rock music, and the remaining five specified a preference for no music. Thus, the majority of them ran the three runs while attending to a music type and songs they did not prefer.

The main issues raised by the participants in the interviews were as follows: All the runners in all four conditions felt pain and discomfort in various body parts at various times. Fewer than

17% reported that one or more music types were ineffective (i.e., neither motivating nor diverting attention) at any time during the run. While listening to dance, inspirational, and rock music, the runners perceived music to be more facilitative at the start of the run 21, 15, and 36% of the time, respectively. In addition, 36, 20, and 28% of them felt that dance, inspirational, and rock music, respectively, had a facilitating effect during the last phases of the run. Again, while listening to dance, inspirational, and rock music, 57, 47, and 43% of the runners, respectively, claimed that they concentrated on the music, and only 7, 6, and 29%, respectively, focused on the pain and discomfort they felt. The majority of the participants said that the images they had during the music were related to films that they had seen. Some participants associated the music with personal memories. Dissociative strategies were reported by 46, 32, 44, and 44% of the participants during the dance, inspirational, rock, and no-music conditions, respectively. Sixty seven percent of the participants perceived the run to be longer when music was not played, compared to 13, 27, and 7% for the dance, inspirational, and rock music conditions, respectively. About 19% (for dance and inspirational), and 28% (for rock) indicated music had motivated them during the run.

Study 3: A field study

Participants

Twenty-five male university students aged 20–26 years (M=22.35, SD=1.25; weight: M=76.69 Kg, SD=5.87) took part. Study 3 solicited students who participated in university required physical education classes. They were told that they could withdraw from the study at any time without any penalty. They produced a certificate from their physician indicating they could participate in moderate to vigorous physical activity. Participants signed a consent form.

Instrumentation

The same questionnaires and open interview administered in the two laboratory studies were used. However, the instructions for the questionnaires were adjusted to the context of a field run.

Design, procedure, and music manipulation

The running course was 2.2 km in distance, and had two hills, about 200 and 300 meters in height. The footing on the terrain was gravel; about half located in a forest and parts afforded bay views. The eight runs were performed during the summer in which the temperature and humidity remained stable at 27–30 °C and 85–95% respectively. Identical music types as before (rock, dance, and inspirational) were used.

The participants were informed that they would run the 2.2 km course three times to determine their maximal running capacity. When this stage was completed, they were given the information sheet describing the study. They expressed their interest in participating in the study, and run the 2.2 km course an additional eight times under different conditions. They were then asked to provide a health certificate from their physician and sign the consent form. One week later, they were administered: (1) The Demographic Details, (2) The Physical Activity Readiness Questionnaire (PARQ), and (3) The General Health and Life type Questionnaire (GHLQ).

Immediately after completing these questionnaires, they were told that in the next eight weeks they would be asked to run the same 2.2 km course under different conditions: four times against a matched partner and four times alone. The four competitive runs were performed first followed by the four single runs. Because competitive conditions are more demanding than a single-pace condition, it was decided to complete them first in order to avoid a possible ordering effect. Participants were instructed that during each run, a different type of music would be played in the headphones of a Walkman compact cassette player. They were also told that once in each condition (single and competitive) the cassette would be blank (no music), but they should, nevertheless, complete the run wearing the headphones. The instructions given to the participants were similar in all conditions. They were as follows: "You are asked to run the 2.2 km course as fast as you can while listening to three music types, or run with headphones attached to your ears without music being played in the walkman. Attach the headphones to your ears so that you can attend to the music throughout the whole run." Before the competitive pair condition, the instruction also stated that the goal is also to "run a bit faster than your competitor." The one blank tape and the three music tapes were counterbalanced in order among the participants. Shortly before each run, the participants adjusted their preferred sound volume and indicated that they were ready to go. Immediately after each run they were administered the RSD questionnaire and were interviewed individually by the researcher and assistants using open-ended and closed response format questionnaires which pertained to their personal feelings towards the music and effort experienced.

Statistical analysis

Means and Standard Deviations for the times recorded during baseline and eight runs were computed and subjected to a mixed RM MANOVA in which running condition (competitive vs. single), and music type (rock, dance, inspirational, and silence) were the within-subjects repeated factors. The interviews following each condition were subjected to qualitative analysis (classifying statements into categories that share common content and relate to specific topics), which was aimed at capturing the feelings and thoughts expressed by the runners during the runs.

Results

The effect of music on running endurance The majority of univariate normality coefficients of skewness and kurtosis were lower than 1.96 in the eight running sessions. Mauchly's test of sphericity for running times, running modes, music types, and their interactions resulted in MW values of 0.75–0.97. All were nonsignificant ($p>0.05$) according to approximation of Chi-Square statistics. Epsilon coefficients of GG and HF ranged between 0.82–0.87. Homogeneity tests among the means' variances were also nonsignificant ($p>0.05$). Thus, the F statistics in the RM MANOVA could be considered reliable estimates of their respective effects.

The RM MANOVA with respect to running conditions (three music types and no music) and running mode (competition and single) resulted in non-significant effects ($p>0.05$) for the three running time variables. The mean running times of the eight runs ranged between 642.06–664.85 seconds. HR and RPE were not measured during these field runs.

Effort perception, motivation, and attention focus during the run Exertion levels were equal in all eight runs and ranged between 3.5–4.6 of the five rating categories. The physical and mental demands were significantly higher under the competitive mode than under the single run mode (M=3.63, SD=0.72, vs M=3.17, SD=0.42, ES=0.76; Wilks' Lambda=0.87, F (1, 33)=4.97, $p<0.03$). The music types failed to affect the perceived task demand of the runners in any way.

Running condition, running mode, and their interaction were not significant ($p>0.05$). Under both competition and single modes, music was more effective at the beginning than at the middle and end phases of the runs (M=3.50, SD=0.61 vs M=3.02, SD=0.62, ES=0.57, and M=2.63, SD=0.44, ES=1.25, respectively). Runners attended to the melodies and rhythm more than to the words (M=2.94, SD=0.63, M=3.04, SD=0.53 vs M=2.04, SD=0.32, ES=1.23, and 1.97, respectively). The mean rating given to the helpfulness of the music was M=2.83, SD=0.39.

From the semi-structured interviews, the majority of the runners (between 51.15–72.7%) indicated that they concentrated on the run. When running without music, 70.3% of the runners in the competition-pair mode and 65.6% in the single mode indicated they were able to fully concentrate on their run. While attending to music, these rates shifted to 51–60%, with the exception of 72.7% under the single and inspirational music condition. In addition, under both condition modes (competition and single), the music resulted in more "no" answers than the "no music" condition. This indicates that the music shifted the thoughts of 9–21% of the participants from the run. No major differences were obtained among the running modes and conditions in the "a bit" responses. Between 18–28% of the runners concentrated "a bit" during the run.

About 26–27% of the runners indicated on the RDS that they felt discomfort and pain during the run whether attending to music or not. The majority indicated the body parts in which the pain was mostly felt. Between 30–50% indicated pains in legs, back, chest, dryness in mouth and throat, abdominal muscles, and breathing difficulties. Thus, 56–77% of the runners reported moderate to extreme degrees of pain and discomfort while running. About 20–40% reported some ("a bit") or moderate pains and/or discomfort feelings. Only a few runners reported that they did not experience any of the above. An exceptional result was obtained for the runners under the single condition run while attending to inspirational music; 24% of them reported "no pains and discomfort."

Under the inspirational music, 40% in the single mode and 53.3% in the competition mode did not divert attention from the music. An additional 20% of the participants diverted attention from the music at different phases while in the single mode, and 16.7% did it sometimes. In the competition-pair condition, the percentages were 6.0 and 10%, respectively; 34.4 and 38.7% diverted their attention from the music under single mode when rock and dance music were played, respectively. Under competition-pair the percentages were 37.9 and 34.4%, respectively. Thus, it seems that the inspirational music attracted more attention during the run, in particular under the single mode of running

The majority of the runners indicated that both rock and dance music failed to motivate them to run faster and invest more effort: 66.7 and 59.4% reflected it in the single mode and 51.6 and 55.5% in the competition–pair mode. Inspirational music failed to motivate 40.6% of the runners in the single mode and 41.9% in the competition–pair mode. However, only 31.2 and 32.2% said that the inspirational music motivated them strongly. Others felt it motivated them sometimes and at different phases during the run. This was lower under the rock and dance music conditions.

It is evident that the participants' music preferences were widely distributed; about 22% preferred rock, 16% preferred dance, 9% preferred pop and classic music, while others preferred other types. However, regarding the selection of songs in the present study, participants preferred the inspirational music as a strategy to motivate them and divert attention from the pain and discomfort associated with their exertion.

General discussion

Heart rates and perceived exertion did not differ while running with or without attending to music in the two laboratory studies. Although in the second laboratory study, inspirational music resulted in a longer running time than the dance and rock music types, it did not result in a longer time than the "no music" condition. These findings support the conceptual model of Tenenbaum (2001), and Rejeski's (1985) Parallel Processing Model, which view associative and dissociative coping strategies during high exertion load as very limited in their capability to extend the period of time one can cope with extreme effort sensations. The high level of physical exertion experienced by the participants during the run, indicated by their HR, RPE, and their free reflections and introspection, limited their ability to sustain and cope with the exertive feelings, although music was played at the same time. As these models suggest, external stimuli may attract the exerciser's attention and thereby distract from the perception of the painful and exertive physical sensations. A perceptual threshold exists, however, at which the physical symptoms of exertion intensify beyond the distraction capability of the external stimulus. At this perceptual threshold, attention shifts from the external stimulus to the internal sensations of pain, fatigue, and exertion, resulting in a narrow concentration on the acute stress, and most likely, cessation of effort (Pandolf, 1978). Thus, it is likely that the exertive symptoms experienced by the participants at the 90% $VO_{2\ max}$ level were beyond the distraction capabilities of the external stimulus (music), resulting in a failure to obtain any meaningful music effects. Inspirational music, however, was found to be somewhat more motivating than the other two music types, suggesting that the link between the type of music and performance under extreme demands, may be moderated by the motivation that this music evokes in the performers (Becker et al., 1994; Brownley et al., 1995; Karageorghis, Drew & Terry, 1996).

It still may be the case, however, that a runner's volitional exertion level may vary with the type of music they select and its intensity level. Though the music was played very loudly to overcome the treadmill noise in Studies 1 and 2, and it was individually calibrated in Study 3, the volume and preference of the music type could have a different influence on runners' ability to cope with stressful sensations such as those experienced in the current three studies. The theoretical models that were used as the foundation of the current studies (Kinsman & Weiser, 1976; Pandolf, 1978; Tenenbaum, 2001; Weiser & Stamper, 1977) must incorporate the dimension of external stimulus strength and type into their framework. Consequently, more studies that account for both the strength and type of the external stimuli are required to verify the entire spectrum of sensations, coping mechanisms, and performance outcomes of various external stimuli, as well as the mental techniques and interactions utilized when exercising at high intensity. The "mental threshold" that does not allow attention to shift outwards may change as a function of the sensations evoked by the external stimulus. The stronger the external stimulus, the farther this threshold may move. The limits of such a threshold are not yet clear, and are hard to determine when the personal safety of the exercisers is honored.

Although HR and RPE under hard conditions showed similar patterns during the runs with and without music, the subjective and reflective reports indicate additional aspects related to the music's effects on the runners that could not be revealed through the HR and RPE data. To uncover the thoughts and feelings of the participants during the runs, they reflected upon their experiences retrospectively immediately after the run. This procedure has been omitted from the majority of studies in the past. In contrast to the "objective" results, the runners in the first laboratory study reported that they liked the inspirational music more than the other types, and that it helped them to some extent in tolerating the exertion. The music was helpful mainly at the beginning stages of the run, and least in the latter stages where exertion level was intolerable. The melody and rhythm were attended to more than the lyrics. In the second laboratory study, the physical reflections indicated that about 50% of the runners concentrated on running-related sensations, but 5–22% claimed that the music, especially the inspirational type, was attended to during the run. Further reflections indicated that many runners shifted attention between the running sensation and the music. In particular, when inspirational and rock music were played, a "diverting effect" was evident during the run. Participants reported motivation to keep running during rock and inspirational music. Similar reports were obtained from the runners in the field study. Between 9–25% of them shifted their attention from the run to the music, and about 18–28% switched attention between the running symptoms and the music. However, the majority indicated that the music failed to motivate them, except the inspirational music. In summary, the reflections of the runners do indicate greater preference for inspirational music, over rock and dance, as a motivational tool and as a strategy for redirecting attention from the pain and discomfort to the music's melody and rhythm. The majority did report pain in various parts of the body, though more "other" thoughts were recorded when the run was performed without music. These findings suggest that music has some positive effect on the feelings and cognitions of runners during the run. However, some participants reported that the music helped them very much.

The self-reports and reflections of the runners immediately after the run provide some support to the previous findings, which attributed facilitative and inhibitory effects to various music rhythms and tempi, despite the fact that the exertion levels reported in theses studies were lower and not controlled as in the present studies (Beaver, 1976; Becker et al., 1976; Ferguson, Carbonneau & Chambliss, 1994; Karageorghis, Drew & Terry, 1996). Laboratory studies in which the level of exertion was precisely controlled (see Noble & Robertson, 1996 for a review and summary) indicate that external strategies failed to affect perceived exertion during high exertion tasks. However, these studies failed to include exertion tolerance as an outcome variable, and did not account appropriately for the reflections of the participants. Taking the limitations of the two groups of studies into account, the results of the current three studies show that perceived exertion, heart rate, and running exertion tolerance do not differ between the conditions of attending to music and not attending to music. However, a number of runners found the music enjoyable, motivating, and attention diverting, especially when listening to their preferred type of music. This is in line with Gfeller's (1988) and Blumenstein's (1992) claim that music can be enhancing when it has personal meaning and generates extra musical associations for the exerciser. The music selected for the inspirational condition included popular pieces such as the themes from "Chariots of Fire" and "Rocky" (Eye of the Tiger by Survivor), which are commonly associated with feelings of motivation and striving to achieve. It is likely that the participants found greater meaning and associations with these selections than with the pieces selected for the dance and rock conditions, and thus felt greater motivation and were distracted from painful exertion symptoms. Several studies have suggested that positive feelings towards, and enjoyment of, exercise greatly increase the likelihood of compliance and adherence to an exercise programme (Cervone, Kopp, Schaumann, & Scott, 1994). Thus, the subjective feelings of increased motivation and faster running support the use of music during exercise, despite the fact that objective evidence fails to support ergogenic effects of music. Further studies should be carried out to examine the effect of personally preferred music on perceived exertion and exertion tolerance. Based on the current results, we assume that such music has the potential to maximize the motivational and affective components associated with high levels of effort but not enhance performance quality.

Of the running symptoms, "mental toughness" and "task completion thoughts" dominate. Furthermore, changes of mood states and fatigue increase at similar rates with and without attending to music, which is in line with Tenenbaum et al.'s (1999) findings. When such sensations are felt, the ability to image (Lampl, 1996) is limited and probably ineffective. This, however, does not contradict the subjective reflections of some of the runners that music had a positive effect on their running sensations. Many of them even reported that the field run was perceived as shorter when they listened to inspirational or rock music.

In summary, although no direct effects were found for the music condition on HR, RPE, or "time in exertion," participants' subjective reports support the use of music during extended strenuous exercise. There is a practical application from this study's findings. First, when one is engaged in strenuous running and attends to his or her preferred music, it may result in better feelings at the beginning of the run, but not during later stages when the physical effort is very high. The melody and rhythm of the music are associated with enjoyment and divert attention from the discomfort, pain, and exertion level experienced during the run at its outset and middle phase, but much less at the end of the effort. The effects of music are more prominent when the physical load is moderate or low (see Noble & Robertson, 1996 and Karageorghis & Terry, 1997 for reviews).

Appendix A

Rock music

Song Title, Artist, Track duration

1. We Will Rock You: Warrant 2:43
2. Show No Mercy: Mark Williams 7:07
3. Dreams: Van Halen 11:50
4. Bound for Glory: Angry Anderson 15:18
5. Lay Down Your Guns: Jimmy Barnes 18:57
6. Kick Start Your Heart: Motley Crue 23:41
7. You Could Be Mine: Guns N' Roses 29:22

The tape then repeats to the end of the 45 minutes

Inspirational music

Song Title, Artist, Track duration

1. Aria: Yannis 3:44

2. Chariots of Fire: Vangelis 7:10
3. Conquest of Paradise: Vangelis 10:44
4. Circle of Life: Carmen Twillie 14:40
5. Top Gun Anthem: Harold Faltemeyer & Steve Stevens 18:42
6. The Olympic Spirit: John Williams 22:46
7. Theme from Rocky: Bill Conti 25:32
8. We are the Champions: Queen 28:30

The tape then repeats to the end of the 45 minutes.

Dance music

Song Title, Artist, Track duration

1. Alex F: Harold Faltemeyer 2:56
2. Again n' again: Magic Marmalade 8:18
3. Foreign: Dan Hartman 11:10
4. Love is the Answer: Tina Arena 12:34
5. Stay with me: Angelic 16:40
6. Movin' On Up: M People 20:03
7. Jacky Jack: Almond Marc 21:55
8. Saturday Night: Whigfield 25:05
9. Short… Man: Human Height Variation 29:06
10. Get Out of My Here: Hal Smith 31:20

The tape then repeats to the end of the 45 minutes.

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