The Psychophysical Effects of Music in Sport and Exercise: A Review

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Music has been widely recommended as a technique to enhance the psychophysical state of participants in sport and exercise. However, there is scant scientific evidence to clarify its proposed benefits The purpose of this paper was to present the conceptual framework underlying the psychophysical effects of music, to discuss published findings since the review of Lucaccini and Kreit (1972), and to consider limitations in previous research. Certain generalizations about the effects of music emerge. First, it appears that synchronization of submaximal exercise with musical accompaniment results in increased work output. Second, music apparently reduces the rate of perceived exertion during submaximal exercise. Third, music tends to enhance affective states at both medium and high levels of work intensity. However, the effect of asynchronous music in contributing to optimal arousal is unclear. Based on a review of related literature, it was concluded that appropriately selected music can enhance enjoyment levels and adherence to physical activity.

La musique a été generalement recommandée comme méthode pour améliorer l'état psychophysique de ceux qui participent au sport et á l'exercice physique. Cependant, il n'existe peu de recherches scientifiques précisant les avantages proposées. Le but de cet article était de présenter le cadre conceptuel qui soutient les effets psychophysiques de la musique, d'examiner les conclusions publiées depuis le rapport de Lucaccini et Kreit (1972) et de considérer les limites de la recherche antérieure. Certaines généralisations sur les effets psychophysiques de la musique se dégagent. Premièrement, il paraît que le résultat de la synchronisation de l'exercice physique sous-maximal avec un accompagnement musical soit une augmentation sensible de performance. Deuxièmement, la musique semble réduire le taux d'effort perçu pendant l'exercise physique sous maximal. Troisièmement, la musique a tendance á améliore l'état affectif aux intensites de travail moyennes et élevées. Toutefois, l'effet de la musique asynchronique comme élément contribuant à une stimulation optimale reste incertain. Après avoir considéré de la documentation à ce sujet, la conclusion était que la musique, lorsqu'elle est sélectionnée pertinemment, peut augmenter le niveau de plaisir et d'adhésion à l'activité physique.

The psychophysical effects of music has become an area of increased interest amongst sports researchers during the last decade. Selected research has demonstrated that music has significant psychophysical benefits during physical activity (e.g., Boutcher & Trenske, 1990; Copeland & Franks, 1991; Lee, 1989). These studies have shown that listening to music can produce ergogenic effects in terms of improved motor performance and increased aerobic endurance, and can also enhance the exercise experience. The proposed mechanisms through which music produces psychophysical benefits include lowered perceived effort, arousal control, improved affective states, and a synchronization effect. By contrast, however, other studies have shown that music has no psychophysical benefits (Patton, 1991; Schwartz, Fernhall, & Plowman, 1990).

Studies which have examined the synchronization of movement with music have consistently shown an ergogenic effect (Anshel & Marisi, 1978; Michel & Wanner, 1973; Uppal & Datta, 1990). However, a greater number of studies which have examined the effects of asynchronous (background) music have produced equivocal findings in that some studies identified psychophysical effects (e.g., Boutcher & Trenske, 1990; Copeland & Franks, 1991), whereas other studies (e.g., Patton, 1991; Schwartz, Fernhall, & Plowman, 1990) showed no effects.

To date, there has been no comprehensive review of the psychophysical effects of music since the work of Lucaccini and Kreit (1972). They concluded that scientific research has failed to reveal a strong link between music and improved motor performance. Lucaccini and Kreit highlighted a number of methodological problems. One recurrent problem is the lack of control on dependent variables, such as the simultaneous introduction of other stimuli along with music. Furthermore, findings since 1972 also appear to arise from a questionable theoretical base and numerous methodological limitations.

An increased understanding of how different types of music influence psychophysical processes will improve musical selections for different types of physical activity. Likewise, examining limitations of past research in the study of music will improve future experimental designs. The purpose of this review is to present the conceptual framework underlying the psychophysical effects of music in sport and exercise, to review published findings since 1972, and to consider the limitations of previous research.

Conceptual Framework

The conceptual framework underlying the study of music in sport and exercise has resulted in three main hypotheses. First, music narrows the performer's attention and, as a consequence, diverts attention away from sensations of fatigue during exercise. This process is comparable to the cognitive strategy of dissociation (Rejeski, 1985) and tends to promote a more positive mood state. Second, music can alter psychomotor arousal and, therefore, can be used either as a stimulant or a sedative prior to and during physical activity. Third, during continual submaximal activity, the organism has a predisposition to respond to the rhythmical element of music. The result is a synchronization between the music's tempo and the performer's movement.

With regard to the first hypothesis, some researchers have explained the psychophysical effects of music with reference to theories of narrowed attention (Anshel & Marisi, 1978; Wales, 1986). Such theories advocate that the amount of information which can be processed in any single moment is limited. Hence, focusing on an attentionally demanding task might alter the performer's perception of effort. Ostensibly, music may increase work output or improve emotions that accompany exercise by inhibiting the psychological feedback associated with physical exertion and fatigue (Hernandez-Peon, 1961).

The intensity of exercise appears to moderate the relationship between attentional processes and psychophysical effects. High intensity exercise results in attentional switching from external stimuli, such as music, to sensations of fatigue. Rejeski (1985) explained how psychological factors and physiological factors combine to influence ratings of perceived exertion (RPE) through his parallel information processing model (see Figure 1):

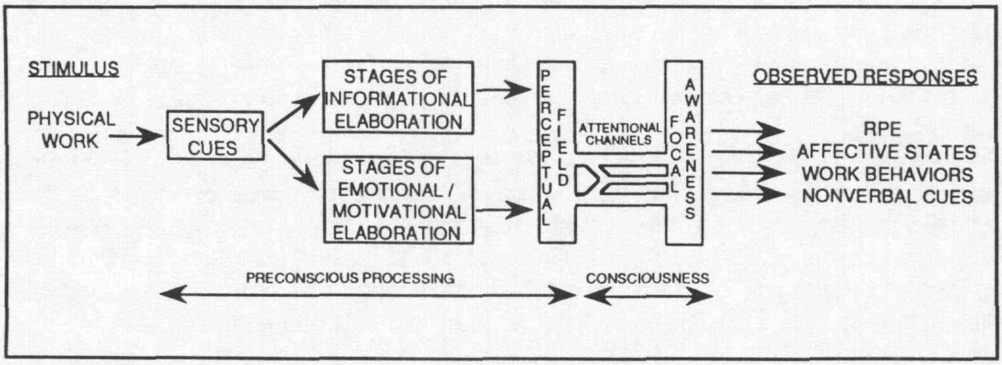

Figure 1. Rejeski's (1985) Parallel-processing model (adapted from Leventhal & Evenhart, 1979).

Note. From "Perceived exertion:an active or passive process?" by W. J. Rejeski, 1985, *Journal of Sport Psychology, 7,* p. 374. Copyright 1985 by Human Kinetics. Reprinted by permission.

Rejeski (1985) proposed that sensory and affective information is processed preconsciously in parallel. Preconscious processing is seen as an active process that filters information through to focal awareness. Thus, sensory information such as a sense of effort, or affective information, such as apprehension resulting from a heavy work load, can form the object of attention and determine affective responses and RPE during exercise. Rejeski has suggested that during high intensity exercise, physiological cues predominate as the most salient influence on psychophysical responses. At lower intensities, external cues such as music may become more influential.

In relation to the second hypothesis that music alters arousal, sport psychologists often recommend music as part of a psych-up strategy in preparation for competition, or to calm overanxious athletes. This hypothesis has been advocated by many reviewers (Brown, 1980; Hohler, 1989; Vogel, 1986) but has received scant attention from researchers. It has been proposed that familiarity with a musical selection will play a crucial role in moderating the influence of music upon arousal level (Lucaccini & Kreit, 1972). Further, Gfeller (1988) suggests that music will influence arousal if it evokes an extra-musical association, i.e., the sound promotes thoughts that inspire physical activity or promotes relaxation. The association made between a specific musical selection and particular activities, such as the theme from the "Rocky" movie series and intense exercise, or Vangelis' "Chariots of Fire" and Olympic glory, can act as a potent stimulus. The resultant association can be attributed not only to the inherent musical characteristics, but to the influence of elements of popular culture, such as cinema, television, and radio. If the media promote an association between a specific musical selection and physical activity this may function as a conditioned stimulus eliciting a conditioned psychophysical response from athletes (Lucaccini & Kreit, 1972).

Within the same hypothesis, the therapeutic properties of music are proposed as a means of anxiety control (Alvin, 1975). However, research into the differential effects of sedative and stimulative music on arousal has yielded equivocal results in non-sport related studies (Ellis & Brighouse, 1952; Smith & Morris 1976; 1977; Zimney & Weidenfeller, 1963). This raises the possibility that the individual's *interpretation* of music, rather than the musical characteristics *per se*, determines the psychophysiological response.

The third hypothesis, that the organism has an underlying predisposition to synchronize movement with the rhythmical component of music, has been frequently cited by philosophers and musicologists, but seldom tested by scientists. As early as 1902 MacDougal (as cited in Anshel & Marisi, 1978) explained the positive influences of rhythm on the human organism in terms of motor behavior. He claimed that rhythm was pleasurable to the individual because it replicates "natural forms" of physical activity. He proposed that the body has a natural predisposition to rhythmical movement. Indeed, it can be observed how athletes apply the force of rhythm for their specialized purposes. In support of this view, Smoll and Schultz (1978, 1982) concluded that rhythm is one of the most important components underlying motor skill acquisition and performance.

In summary, the conceptual framework underlying the study of music identifies four mechanisms through which music may have a psychophysical effect in sport and exercise: (a) it reduces sensations of fatigue; (b) it improves mood state; (c) it influences psychomotor arousal; and (d) it encourages synchronization. The following review of research will address the psychophysical effects of music as observed responses which are divided into three categories; psychophysiological functioning, affective responses and motor performance.

Effects of Music on Psychophysiological Functioning

The primary objective of research in this area has been to measure the interaction of music and exercise on psychophysiological functioning. The most common dependent measures used have been either physiological, predominantly heart rate (HR), or psychophysical, usually employing Borg's (1970, 1982) RPE scale.

Physiological Measures

It has been shown that music influences HR during submaximal exercise. For example, Copeland and Franks (1991) examined the effects of "soft/slow" and "loud/upbeat" asynchronous music on treadmill endurance. HR was measured every 30 s until voluntary exhaustion was reached. HR was significantly ($p<.10$) higher than the control with "soft/slow" music. These results, the authors argued, provided support for the hypothesis that soft/slow music reduces physiological arousal during submaximal exercise, thereby increasing endurance performance.

Another investigation revealing that music may influence HR involved two studies by Dorney et al. (1992). Study 1 measured dart throwing performance after listening to slow classical music, after listening to fast modern music, and without music. Listening to either type of music significantly ($p<.05$) lowered HR. In Study 2, an imagery-plus-music group showed an increase ($p<.05$) in HR during preparation for a sit-up task when compared to an imagery only group. This suggests that music can enhance the impact of imagery, and hence, may contribute to preperformance strategies. In another study, Michel and Wanner, (1973) investigated the effect of music on HR during a submaximal multi-activity circuit task. Examining the moderating influence of age and gender, they found that only 18 yr-old female subjects showed significant ($p<.05$) decreases in HR during music tests.

In contrast to such findings, other studies have revealed that music does not influence HR. For instance, Lee (1989) reported no significant differences in HR during submaximal treadmill running between Baroque music (60 bpm), an upbeat rock selection (152 bpm), and a non-auditory control condition. Similarly, Johnson and Siegel (1987) investigated the effect on HR of active attentional manipulation (arithmetic problems), passive attentional manipulation (loud asynchronous music), and a control condition during treadmill performance for 5 min at either 60 or 90% of maximal exertion ($V0_2$ max). HR measures taken 10 s after each exercise period, revealed no significant differences in HR between the music and control conditions suggesting that music has no effect.

Also, Schwartz et al. (1990) reported that during cycle ergometry at 75% $V0_2$ max, untrained subjects showed no significant ($p<.01$) differences in HR, or in oxygen uptake, minute ventilation, respiratory quotient and blood lactate between stimulative music and a control condition. Similarly, Boutcher, and Trenske (1990) found that music had no significant effect on HR during cycle ergometer bouts at light, moderate, and heavy workloads. Notably, the participants brought their own musical selections with 21 selecting "lively" music and three selecting "relaxing" music. A further study which examined musical preference on HR was conducted by Patton (1991). She found that HR did not significantly differ between preferred/non-preferred and familiar/unfamiliar music conditions. Finally, Uppal and Datta (1990) examined cardiorespiratory responses of school girls to exercises performed with and without music. Only measurements of blood pressure exhibited significantly ($p<.05$) higher values for the music group than the non-music group at the end of a six-week program. This finding was attributed to their greater overall work output. However, there were no significant differences in HR between groups exercising with and without music.

In summary, there is conflicting evidence as to the effect of music on HR. This may be due to the diverse nature of the designs employed to test such effects. Despite limited evidence to suggest that sedative music lowers HR and therefore, may prolong submaximal activity (Copeland & Franks, 1991), the impact of stimulative music on HR is unclear.

Psychophysical Measures

Studies reporting positive findings for perceived exertion all used asynchronous music. For example, Johnson and Siegel (1987) investigated the effects of active attentional manipulation (mental arithmetic) and passive attentional manipulation (asynchronous music) on perceived exertion, as measured by the Physical Activity Questionnaire (PAQ). Analyses revealed that the Fatigue factor of the PAQ was the only component significantly ($p<.01$) reduced by music. Boutcher and Trenske (1990) reported similar findings through monitoring RPE after subjects participated in control, deprivation and music conditions. Results showed significantly ($p<.01$) lowered perceived exertion during the music condition when compared to the control condition, at moderate workload. It was concluded that the influence of music on RPE was load dependent, hence, supporting Rejeski's (1985) parallel information processing model (see Figure 1). The study by Copeland and Franks (1991) included retrospective measures of RPE for five equally spaced points during the test. The five points consisted of light work (walking), low/high moderate work, voluntary exhaustion, and concluded midway through cool-down. Results revealed that RPE was significantly ($p<.10$) lower with the soft/slow music condition during moderate work. Taken together, these results give some credence to the argument that asynchronous music reduces perceptions of fatigue during submaximal exercise, although not as effectively as active attentional manipulation, such as performing mental arithmetic.

In contrast to these findings, Patton (1991) assessed the effects upon RPE of musical preference and familiarity during aerobic dance classes. Participants, who had greatly varying levels of fitness, synchronized their movements to the music. No significant main effects were found for either variable. Participants reported that instructor enthusiasm and support had a greater effect on their enjoyment of the class than musical preferences. Wales (1986) reported similar findings for RPE after investigating the effects of tempo and disposition (emotional impact) in music during submaximal treadmill running. No significant differences in RPE were found between fast/positive music, slow/negative music, and a no music condition. Finally, Schwartz et al. (1990) found that at 75% $V0_2$ max, RPE values did not significantly differ for untrained participants between stimulative music and a control condition.

In summary, studies investigating RPE have provided conflicting evidence as to whether music has any effect. The only consistent finding has been that music appears to be more effective in reducing perceived exertion during submaximal exercise than beyond anaerobic threshold (Boutcher & Trenske, 1990; Copeland & Franks, 1991; Johnson & Siegel, 1987; Schwartz et al., 1990). An examination of the methodologies employed revealed that all studies yielding positive findings for RPE during submaximal exercise reported utilizing "untrained" participants. This may suggest that "untrained" participants, however they are defined, are likely to derive greater psychophysical benefits from music.

Effects of Music on Affective Responses

A further body of research has measured the effects of music on affective responses during exercise tasks. Comparison between studies is difficult because each has used a different means of measuring affect and has employed a different experimental design.

It has been proposed that music can influence mood, and mood, in turn, can influence performance (Hohler, 1989; Lucaccini & Kreit, 1972). To investigate this process, Boutcher and Trenske (1990) used the 10-point bipolar Feeling Scale (Rejeski, 1985) to record affective responses during cycle ergometry at low, moderate and high workloads. They found that, at the moderate and heavy workloads, affect was significantly ($p<.05$) more positive than during a condition of sensory deprivation. It is hypothesized (Rejeski, 1985) that external auditory stimuli are not influential at high workloads. However, although music has no effect on RPE at high workloads, it appears that it continues to influence affective responses. Wales (1986) also investigated the relationship between music and affect. He found that music with a positive disposition (upbeat/stimulative) lowered anger, fatigue, and depression significantly ($p<.05$) more than music with a negative disposition (slow/sedative). It was concluded that the upbeat positive music condition was more efficacious than music of a negative disposition in lowering levels of depression and fatigue.

Further, Lee (1989) investigated the influence of musical tempos [*sic*] on affect during submaximal treadmill running. Affect was measured using a music rating inventory (MRI) which consisted of 10 positive and 10 negative mood adjectives. The MRI data revealed that the upbeat condition (rock music) yielded significantly ($p<.05$) higher positive mood states and lower negative mood states than either a slow condition (Baroque music) or a control condition. Similarly, in a longitudinal study examining the effects of a music program for Russian weightlifters, Kodzhaspirov, Zaitsev, and Kosarev (1986) claimed that musical tempo should be matched to the activity it is accompanying for maximum impact. In a questionnaire addressing the effectiveness of the music, 100% of the weightlifters claimed that the use of music improved their mood. Additionally, 95.4% stated that they eagerly looked forward to the training sessions with music.

Further, Patton (1991) assessed the moderating influence of musical preference and familiarity using the Multiple Affect Adjective Checklist-Revised after aerobic dance activity. Participants exercised to musical selections which they *collectively* rated for preference and familiarity, and which were idiomatically similar. This may have contributed to an erroneous conclusion that affective responses to music were not dependent upon preference and familiarity.

In summary, it appears that there is strong evidence to suggest that the use of music enhances affective states during exercise and that such improvements are not necessarily dependent on workload (Boutcher & Trenske, 1990). This finding has important implications with regard to prescribing music as a means of increasing exercise adherence.

Effect of Music on Motor Performance

Research in this area can be divided into studies investigating the ergogenic effects of synchronous music, and studies investigating the impact of asynchronous music on motor performance via its arousal control qualities.

All studies looking at the effects of synchronous music report that music enhances work output. For example, Michel and Wanner (1973) administered a circuit task to youngsters from three age groups. They found that 12 and 15 yr old male participants reached significant ($p<.05$) improvements in performance with music. A further study which in part examined the differential effects of synchronous music between sexes was conducted by Anshel and Marisi (1978). Their study included tests of synchronized and asynchronized movement to music on a cycle ergometer until participants could no longer maintain a predetermined rate of movement as regulated by a metronome. The results showed that the synchronous condition elicited significantly ($p<.05$) better scores for endurance than the control condition. Additionally, male participants endured significantly ($p<.01$) longer than females with the music. Uppal and Datta (1990) also reported an increase in work rate through synchronization during PE classes using calisthenic-type exercises, when compared to a no music condition.

Studies investigating the effects of asynchronous music on motor performance have employed a wide range of dependent measures. For example, a longitudinal study on the use of music in the training of weightlifters using a questionnaire approach (Kodzhaspirov et al., 1986), reported that 89.2% of weightlifters felt that the quality of their training improved with music. Moreover, 96.9% stated that the volume of training increased, whilst 98.5% noted that the intensity of training increased. Similarly, Ferguson, Carbonneau, and Champliss (1995) studied the effects of music on performance of a karate drill. They concluded that both positive and negative music yielded significantly ($p<.01$) better performance when compared with white noise. In addition, Copeland and Franks (1991) reported that soft/slow music increased treadmill endurance relative to a control condition.

There is also a body of evidence which suggests that asynchronous music does not enhance motor performance. For example, an investigation into anaerobic performance (Pearce, 1981) measured grip strength using stimulative and sedative music played for 2 min before initiation of the task. The sedative music significantly ($p<.01$) decreased grip strength compared to silence, while stimulative music had no effect compared to silence. Lee (1989) also used stimulative and sedative music in testing stride rate per minute during submaximal treadmill running. He reported no significant differences between treatment conditions. Schwartz et al. (1990) also reported no significant differences in endurance time during a cycle ergometer task at 75% VO_2 max between stimulative music and a control condition. Finally, Dorney et al. (1992) investigated the effects of stimulative and sedative music on dart throwing performance. They concluded that music had no effect on performance. A second part of this investigation found that music combined with imagery had no effect on sit-up performance when compared with imagery alone.

The findings from studies which have investigated motor performance indicate that the mechanisms through which music has an ergogenic psychophysical effect can be dichotomized into synchronization and arousal control. Synchronization appears to benefit submaximal physical activity, whereas the effect of asynchronous music in contributing to optimal arousal is unclear.

Limitations in Previous Research

The view that music has a potentially powerful effect on the human psyche is not supported strongly by the evidence presented in this paper. Two hypotheses can be advanced as explanation. First, music has an inconsequential impact on the human organism. Second, methodological limitations in exposing the effects of music preclude consistent positive findings. The latter hypothesis will be examined in reference to the studies detailed earlier. If such limitations are addressed this will allow researchers to test the former hypothesis with greater precision.

One of the major limitations in previous research has been a general failure to control for the types of musical selections used and to report procedures in sufficient detail. Researchers often fail to specify musical selections and how they were used, making it difficult for the reader to evaluate the results fully and apply them to practical use. Failure to specify music intensity (volume) further complicates the interpretation of findings because intensity may influence reactivity to music. Similarly, the delivery of music through headphones or speakers is important because it influences the ecological validity of the findings.

Temporal factors such as the duration of music, and the point at which it is played relative to the task, also receive little consideration by researchers. For example, some studies have used music prior to the initiation of the task, at which point it was switched off (e.g., Dorney et al., 1992; Pearce, 1989). This procedure assumes that reactions to music continue correspondingly after its cessation. Researchers should develop clear hypotheses about the temporal relationship between the music and the type of task when constructing a research design.

Another research limitation involves confusion with music terminology. For example, the title of the study by Copeland and Franks (1991), "Effects of types and intensities of background music on treadmill endurance" implies an investigation into the effects of both type (tempo) and intensity (volume) of music. The researchers compared loud/upbeat music with soft/slow music, whereas to isolate the effect of intensity and tempo required two additional music conditions consisting of soft/upbeat and loud/slow music. Similarly, Lee (1989) claimed to have investigated the effects of tempo but used two highly contrasting musical idioms (Baroque and Rock). To isolate the psychophysical effects of tempo, only one musical idiom should have been used. It is essential that researchers in this area show greater sensitivity to important aspects of musicality.

An additional limitation in this research area is that sociocultural influences are overlooked. Several authors have emphasized the role that sociocultural rearing plays in determining psychophysical responses to music (Hohler, 1989; Lucaccini & Kreit, 1972; Vogel, 1986). Hence, social class, area of residence, ethnic background, and peer group influence are crucial factors in the selection of research participants. Age and musical preferences of participants also warrant consideration in the selection of a music program. Pearce (1981) for example, used music by heavy metal band, Led Zeppelin, as one of her experimental conditions. This non-mainstream choice may have been either unfamiliar to, or disliked by, many of the college undergraduate participants thereby nullifying any potential benefits of stimulative music on grip strength. Although problematic to control, some consideration by researchers to the sociocultural background of their research participants appears essential.

Another limitation involves the selection of inappropriate dependent measures. For example, Lee (1989) used stride rate (SR) to determine the ergogenic properties of asynchronous music. However, it is apparent that SR is determined primarily by leg length and treadmill speed rather than reflecting work output. Some studies have used HR as an index of arousal level (e.g., Copeland & Franks, 1991; Domey et al., 1992) while other researchers have pointed out that HR is a limited measure in this capacity (e.g., Gould, Weinberg, & Jackson, 1980; Sturgis & Arena, 1984). Similarly, Schwartz et al. (1990) employed a battery of physiological tests, including respiratory analysis and lactate measurement, as dependent measures. Collectively, the intrusive nature of these tests may have distracted participants' attention away from the music. It is apparent that researchers should consider carefully the appropriateness of dependent measures when assessing the effects of music.

Task selection also appears to be a limitation in previous research. For example, Patton (1991) used aerobic dance, the intensity of which is impossible to standardize due to varying fitness levels and differences in motivation and motor ability. Uppal and

Datta (1990) used callisthenic-type exercises synchronized to music, which are equally difficult to standardize. Thus, to increase experimental control, simple movements which can be standardized should be employed, such as, treadmill running, cycle/rowing ergometry, motorized stair climbing, or standing squats.

These limitations demonstrate the difficulties faced by researchers in this field. An awareness and subsequent control of these factors may not only facilitate a more accurate interpretation of findings, but may produce better research.

Conclusions and Implications

The proposed mechanisms through which music produces psychophysical benefits are generally supported by research. However, there is equivocal evidence concerning whether asynchronous music influences arousal and how this subsequently affects motor performance. This equivocality can be accounted for by the proposal that reactions to music are in part dependent upon sociocultural rearing, age, and preference (Hohler, 1989; Lucaccini & Kreit, 1972; Vogel, 1986). Hence, it is very difficult to standardize personal meaning and reactivity to any musical selection across a group of participants. Synchronous music appears to benefit submaximal exercise and this is reflected in the huge popularity of dance aerobics and exercise to music classes.

The implications of Rejeski's (1985) parallel-processing model (see Fig.1) are supported by the literature with the exception that music can enhance affective states beyond anaerobic threshold (Boutcher & Trenske, 1990). Generally, there is strong evidence to support the hypothesis that well chosen music can improve affective states during exercise. The major considerations of a practitioner should not only include sociocultural rearing but also the nature of the task. Hence, music should be synchronized and coordinated with physical activity (Kodzhaspirov et al., 1986).

A number of limitations have been identified in studies examining the psychophysical effects of music. Such limitations are inevitable in any growing field of research, and it is imperative that future researchers learn from previous designs. Future research should address the influence of music on affective states during high intensity exercise, differential reactions to music between the genders, and the influence of selected musical characteristics such as tempo, volume, and lyrics. Also, controlled longitudinal studies are necessary similar to those conducted in industrial settings (see Lucaccini & Kreit, 1972), so that the effects of music can be examined after, rather than before the plateau of work output level.

As a general guide for future researchers we present an outline of an appropriate research design in this field. Our example involves testing the influence of tempo and intensity in asynchronous music on affect during a 20 min treadmill run at 75% of maximal exertion: Survey a large pool (n>150) of aerobically trained female participants who are homogeneous in age to assess their sociocultural rearing and musical preferences. Using these data select a homogeneous sample (n>30) for laboratory investigation. Subject each participant to five experimental conditions using the musical idiom to which the experimental group expressed a preference (e.g., contemporary popular music in the Top 30 of the national charts) at 75% of estimated $V0_2$ max for 20 min in random order; (a) loud/fast, (b) loud/slow, (c) soft/fast, (d) soft/slow, and (e) no music. Conditions *a* and *c* involve the same musical selections as do *b* and *d*. Music is played through speakers and the volume monitored using a decibel meter to ensure consistency; loud at 75 decibels Sound Pressure Level (db SPL) and soft at 60 db SPL (cf. Alessio & Hutchinson, 1991). Tempo is standardized at 140-160 bpm for the fast condition and at 60-80 bpm for the slow condition. Affect is measured using Rejeski's (1985) bipolar feeling scale taking measurements in 5 min intervals beginning at the 5th minute.

It appears likely that appropriately selected musical accompaniment to exercise and sport-related activities is likely to enhance the enjoyment and adherence levels of participants. However, the multitude of factors which influence reactions to music make valid and reliable scientific investigation an onerous task. Nevertheless, additional research into the potential benefits of music on human performance is warranted.

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