June 2021

The Role of Antecedent Music in the Running Routines of Experienced Runners

Jennifer L. Cook
University of South Florida

Follow this and additional works at: https://digitalcommons.usf.edu/etd

Part of the Social and Behavioral Sciences Commons

Scholar Commons Citation
https://digitalcommons.usf.edu/etd/9091

This Dissertation is brought to you for free and open access by the USF Graduate Theses and Dissertations at Digital Commons @ University of South Florida. It has been accepted for inclusion in USF Tampa Graduate Theses and Dissertations by an authorized administrator of Digital Commons @ University of South Florida. For more information, please contact digitalcommons@usf.edu.
The Role of Antecedent Music in the Running Routines of Experienced Runners

by

Jennifer L. Cook

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy with a concentration in Applied Behavior Analysis
Department of Child & Family Studies College of Behavioral and Community Sciences University of South Florida

Major Professor: Raymond G. Miltenberger, Ph.D.
Kimberly Crosland, Ph.D.
Catia Cividini-Motta, Ph.D.
Diego Valbuena, Ph.D.

Date of Approval:
May 20, 2021

Keywords: running, music, podcast, auditory stimulation, survey

Copyright © 2021, Jennifer L. Cook
Dedication:

Four Men and a Dog

For Finley (2006-2021), who was genuinely affectionate and loving, and by my side until the day after I finished the first draft of this manuscript.

Finley, I love you and miss you (but not your jerky antics … those really tested my behavior analytic skills).

This is also dedicated to four men who have greatly influenced me on my road to academia. The common thread amongst them was an insistence on diligence and excellence.

For Bill Cook, who always encouraged my endless questions and curiosity about the world. Dad, observing your application of science as you built so many things inspired my foray into scientific philosophy. Except for those wooden pedals you made for my second-hand bike.

For Dr. Barry Yzereef, who introduced me to scholarly activity and the true beginnings of my study in human behavior. Also with your teaching, I learned to embrace suffering (as actors/artists must do); this is how I survived graduate school. And Finley’s shenanigans.

For Dr. John Rapp, who taught me so much in graduate school and beyond, and who has become a very dear friend. John, you have made me the researcher I am, and I could not imagine these past many years without your support and humour. Also in managing Finley!

Finally, for Dr. Raymond Miltenberger, my doctoral advisor. Ray, I am honoured (note the “u”) to learn from you. I am inspired with the academic freedom you give me (tolerate?), while keeping me in line with your guidance and kindness. Impressive instructional control.
Acknowledgements

Thank you to my mother, Lynn Cook, for inspiring my love of teaching. When I was very young, I wondered how to be a professor, and Dad explained I needed to write a book. At the time I thought that sounded really hard and would be too much work. Turns out I was right.

Thanks to my brother, who helped me get through my meltdown at the apex of my move to another country for my Ph.D., and literally helped me move. You’ve shown that sometimes a little brother can look after a big sister. Sometimes. Don’t let it get to your head.

Thank you to my sister, Kellie, for being the rock in our family (and your own). I have been able to pursue my studies far from home knowing you are there for our parents who, not unlike Finley, get up to their own shenanigans. It’s at least as much work as a Ph.D.

Thank you, Tracie Lindblad, for believing in my abilities and trusting your businesses in my hands for so many years, while opening up countless opportunities for me to develop various skills. I decided to pursue my Ph.D., in part, because of your encouragement. Or maybe it was because we had too much wine over dinner one night.

Thank you to my “academic brother,” Anthony Concepcion, for all your help in my dissertation research; I’d have been lost without your support (and our gossip sessions ... er, philosophizing). To several others who assisted in my dissertation; I am so thankful to Cynthia Livingston, Alex Capalbo, Shreeya Deshmukh, and Jeremy Buttice. Finally, I am forever thankful for a few dear friends I met at USF and for their support, inspiration, and valued friendship: Rasha Baruni, Vanessa Larson, Jennifer Weyman, and (again) Cynthia Livingston and Tony C.
# Table of Contents

List of Tables ....................................................................................................................... iv

List of Figures ....................................................................................................................... v

Abstract .................................................................................................................................. vii

Chapter One: Literature Reviews for Music’s Effects on Exercise .................................... 1  
  Conclusions .......................................................................................................................... 5

Chapter Two: Literature Review on Music’s Effects on Running ...................................... 9  
  Implications Across Measures ............................................................................................. 9  
  Physiological Changes ......................................................................................................... 10  
  Performance Changes .......................................................................................................... 11  
  Self-Selected Music ............................................................................................................ 11  
  Differences Across the Sexes ............................................................................................... 12  
  Trained Versus Untrained Runners ...................................................................................... 12  
  Correspondence Between Subjective Ratings and Objective Performance Measures ......................................................................................................................................................... 13  
  Other Considerations ........................................................................................................... 14  
  Conclusions .......................................................................................................................... 16

Chapter Three: The Importance of Promoting Running for Exercise ............................... 20

Chapter Four: Study 1: Survey on Running Habits and Preferences ................................ 22  
  Method .................................................................................................................................. 23  
  Participants ............................................................................................................................ 23  
  Design and Survey Tool ........................................................................................................ 24  
  Data Collection ..................................................................................................................... 24  
  Interrater Reliability ............................................................................................................. 25  
  Social Validity and Recruitment Interest ............................................................................. 25  
  Survey Procedures ................................................................................................................ 26

Chapter Five: Results .......................................................................................................... 28  
  Participant Demographics, Devices, and Running Locations ............................................. 28  
  Running with Auditory Stimulation ..................................................................................... 29
Chapter Six: Study 2: Within-Subject Experiments Evaluating Music’s Effects on Running ... 39
Method ......................................................................................................................... 40
Participants ................................................................................................................... 40
Setting and Materials .................................................................................................... 41
Data Collection ............................................................................................................. 45
Device Accuracy ........................................................................................................... 46
Observer Agreement ..................................................................................................... 47
Preference Assessments of Running with Auditory Stimulation .................................. 47
Experimental Design and Procedures .......................................................................... 49
Experiment 1: Presence of Music ................................................................................ 50
  No Music Sequence (Control) ..................................................................................... 50
  Music Sequence (Test) ............................................................................................... 50
Experiment 2: Using a Boost Song While Running to Music ......................................... 50
  Music Sequence (Control) ......................................................................................... 52
  Boost Song Sequence (Test) ....................................................................................... 52
Experiment 3: Presence of a Preferred Non-Musical Auditory Source ......................... 52
  No Podcast Sequence (Control) ................................................................................ 53
  Podcast Sequence (Test) ........................................................................................... 53

Chapter Seven: Results ................................................................................................. 54
Results for Experiment 1: Music Playlist Test Sequence Versus No Music Control
  Sequence ..................................................................................................................... 56
  Bertha ......................................................................................................................... 56
  Dolly ............................................................................................................................ 56
  Fay ............................................................................................................................... 60
  Hanna .......................................................................................................................... 60
  Josephine .................................................................................................................... 63
  Arthur ......................................................................................................................... 63
  Eduoarad ...................................................................................................................... 66
Results for Experiment 2: Boost Song Test Sequence Versus Music Playlist Control
  Sequence ..................................................................................................................... 66
  Bertha ......................................................................................................................... 66
  Dolly ............................................................................................................................ 70
  Fay ............................................................................................................................... 70
  Hanna .......................................................................................................................... 71
  Josephine .................................................................................................................... 74
  Arthur ......................................................................................................................... 75
Results for Experiment 3: Podcast Test Sequence Versus No Podcast Control
  Sequence ..................................................................................................................... 78
  Bertha ......................................................................................................................... 79
  Hanna .......................................................................................................................... 79
  Paulette ...................................................................................................................... 80
  Eduoarad ...................................................................................................................... 83
List of Tables

Table 1: Participant Information for Study 2 ................................................................. 42

Table 2: Accuracy Measures for Each Participant’s Device ........................................... 46

Table 3: Interobserver Agreement for Each Participant’s Pace Results Across Experiments .................................................................................................................. 48

Table 4: Summary of Results for Participants Across Experiments and Measures .......... 55

Table 5: Summary of Means for Experiment 1 .................................................................. 57

Table 6: Summary of Means for Experiment 2 .................................................................. 68

Table 7: Summary of Means for Experiment 3 .................................................................. 78
List of Figures

Figure 1: Social Validity Results for Survey of Study 1 ................................................................. 27
Figure 2: Sex and Age of Survey Respondents ................................................................. 31
Figure 3: Reason Survey Respondents Began Running ................................................... 32
Figure 4: If and How Survey Respondents Use a Device ................................................... 33
Figure 5: Where Survey Respondents Run (all options) and Top Option for Location .......... 34
Figure 6: Survey Respondents Use of Music While Running ........................................... 35
Figure 7: If and When Survey Respondents Use a Boost Song ......................................... 36
Figure 8: If and What Survey Respondents Use a for Nonmusical Audio when Running .... 37
Figure 9: If Survey Respondents Prefer No Audio Source During Runs ............................. 38
Figure 10: Running Site .............................................................................................................. 43
Figure 11: Running Site ........................................................................................................... 44
Figure 12: Experiment 1: Effects of Music Playlist Versus No Music for Bertha ............... 58
Figure 13: Experiment 1: Effects of Music Playlist Versus No Music for Dolly .................. 59
Figure 14: Experiment 1: Effects of Music Playlist Versus No Music for Fay ..................... 61
Figure 15: Experiment 1: Effects of Music Playlist Versus No Music for Hanna ................ 62
Figure 16: Experiment 1: Effects of Music Playlist Versus No Music for Josephine .......... 64
Figure 17: Experiment 1: Effects of Music Playlist Versus No Music for Arthur ............... 65
Figure 18: Experiment 1: Effects of Music Playlist Versus No Music for Eduoard ............. 67
Figure 19: Experiment 2: Effects of Boost Song Versus Music Playlist for Bertha .............. 69
Abstract

Promoting running as an accessible and cost-effective form of exercise is important because persistent runners have a 29 to 50% lower risk of cardiovascular mortality compared to those who never run (Lee et al., 2014). The results from the body of research on music and running have been inconclusive. This may be due to a reliance on self-report measures and the averaging of results employed with group designs. To address these issues, the current study measured performance (pace) as the primary dependent variable in a series of within-subject designs. First, an online cross-sectional survey (Study 1) was conducted to identify common behaviors and preferences of active runners to inform the subsequent study (Study 2). The results from 555 runners surveyed indicated that 77% of runners listened to music while they ran, and of those, 61% used a boost song to amplify music’s effects within their run. Moreover, 36% of runners listened to a podcast (or similar) while running. As such, the second study evaluated the effects of (a) music playlist, (b) boost song, and (c) podcast on running performance in a series of three-component multiple schedule arrangements. Despite participants reporting a preference for listening to audio when they ran, an increase in pace was found for only three of the 18 analyses conducted for this measure. These results suggest that music’s effects on running pace are likely idiosyncratic across individuals. A follow up survey focusing on the potential functional relationship between music and running adherence should be a consideration for future studies. Other future research should evaluate music in a consequent arrangement to further investigate if music can affect running pace.
Chapter One:

Literature Reviews for Music’s Effects on Exercise

There is an abundance of literature evaluating the effects of music on exercise, primarily in the area of sport sciences (i.e., sports medicine, sport psychology). Indeed, there have been at least eight literature reviews alone (Bishop, 2010; Brooks & Brooks, 2010; Karageorghis et al., 2012; Karageorghis & Priest, 2012a, 2012b; Karageorghis, & Terry, 1997; Koç & Curtseit, 2009; Van Dyck & Leman, 2016). The authors of the first published review (Karageorghis & Priest, 1997) presented a conceptual framework accounting for the effects of music on exercise. They discussed three main hypotheses: (a) dissociation, (b) stimulation, or (c) synchronization.

Dissociation can be considered in terms of dissociation or association, in which music controls the exerciser’s attention or focus. That is, music may cause dissociation, diverting the exerciser’s attention away from fatigue. Conversely, association may occur when a runner is focused on his or her physiological state to enhance performance, as is thought to occur with high intensity or elite-level performance. Stimulation occurs when music creates a state of psychomotor arousal, or motivation to engage in an effortful response. This may be due to the uplifting musical characteristics, inspirational lyrics, or cultural influences associated with a particular track (e.g., theme song for a popular action film). Synchronization refers to the rhythm of a song affecting the exerciser’s responding. By contrast, asynchronous music is a term that is synonymous with background music; that is, a situation using music where there is
no effort on the part of the exerciser to match their movements to the tempo, but where the song nonetheless may establish a condition of motivation to engage in effortful activity.

One of the conclusions from Karageorghis and Priest’s (1997) review was that positive effects were found for exercisers using synchronous music. These results were described in terms of increased work output, reduced perceptions of exertion, and enhanced affect for moderate to high exercise intensities. However, several studies showed similar effects with asynchronous music, and some studies showed partial or no effects with either synchronous or asynchronous music. The authors explained these inconsistent findings as issues relating to experimental control and methodological problems. They further concluded that music can improve exercise adherence by increasing enjoyment (i.e., ratings of affect); however, adherence to an exercise routine was never directly tested. Moreover, three of the five investigations reporting increased affect in their review were not peer-reviewed studies. Nonetheless, the authors summarized that, as a whole, music had positive influences on participants’ perception of exercise as measured by rating scales (i.e., affect and exertion), as well as increased work output.

Fifteen years later, Karageorghis and Priest (2012a, 2012b) conducted another two-part review on the effects of music on exercise. Within that 15-year time frame, several new studies were published on the topic, along with the development of a new tool for selecting music for participants. The Brunel Music Rating Inventory (BMRI; Karageorghis et al., 1999) was validated as a tool to standardize music stimuli in an attempt to address music selection in the music and exercise literature (Karageorghis, & Terry, 1997). Subsequently, the BMRI was revised to the BMRI-2 (Karageorghis et al., 2006) and was designed to select and rate music based on: (a)
rhythm (especially tempo or speed, measured using beats per minute; BPM), (b) musicality (pitch and tune; e.g., harmony and melody), (c) cultural impact (pervasiveness of a song within a culture or subculture), and (d) association (extra-musical cultural conditioning, such as songs from films, advertisements, etc.). The authors hypothesized that these four factors contribute to the “motivational qualities” of a song. They posited that the motivational qualities affect arousal control, reduced perceptions of exertion, and improved mood, and that the combination of these three effects contribute to exercise adherence (Karageorghis et al., 1999). Although there have been no direct tests for adherence, Karageorghis and Priest (2012b) suggested that an adherence effect is supported by interview-based evidence.

The BMRI-2 has been used by the participants themselves (e.g., Lane et al., 2011), although it has been more commonly used by others to rate the music for the exercisers, usually by homogenous participant groups. For example, Hutchingson and Karageorghis (2013) used the BMRI-2 to rate music for 34 runners, where songs were first selected by 40 different volunteer students, then rated for treadmill running by a panel of another nine students. The two highest rated songs were designated as “motivational” music, while two middle-ordered tracks were used for the “ouderterous” music condition (i.e., neutral, or lacking in motivational qualities). Though speculative, Karageorghis and Priest (2012a, 2012b) emphasized the importance of using “carefully-selected music” for obtaining the desired effects of music on running. The BRMI-2 rating scale has become a commonly used method for selecting music in studies since its development, although other options, such as experimenter-selected or participant-selected methods are also used.
Counter to the assertion that the utilization of the BMRI-2 is necessary to select music to produce effects on exercise, results from several studies from Karageorghis and Priest’s (2012a) review demonstrated that reductions in perceived exertion may occur regardless of how music is selected (i.e., self or experimenter). The authors additionally found that music predominantly decreases perceived exertion for low to moderate intensity exercise, but has inconsistent effects for high-intensity activity. They hypothesized that perceived effort is less likely to be low for high intensity workouts because increased association to physiological cues is required by the athlete. Although not consistent across the studies in their review, they additionally found a trend of enhanced affect for high-intensity exercise when using motivational music, suggesting music can still play a beneficial role for high-intensity work outs. Finally, they described that some studies showed music to be more beneficial for untrained athletes (compared to trained), and that music may have better effects for exercise which is self-paced. Karageorghis and Priest (2012b) identified a number of areas for further study, including: investigating the effects of individual variables such as age, sex, and personality type, the lyrical content of music, how music is selected, using to music accompanied by video, and how it effects anaerobic exercise. A review by Brooks and Brooks (2010) similarly concluded a need for further investigations of music’s effects on anaerobic exercise and resistance training across sporting activities, describing that the majority of studies have focused on aerobic exercise and endurance training.

Van Dyck and Leman’s (2016) brief narrative review was the only study that focused on the implications of music’s effects for running specifically; regardless, their conclusions for running were derived from studies evaluating music’s effects on exercise, broadly. The authors
narrowed their conclusions to running as an exercise to address the issue disqualifying competitive runners from races if they used music devices. They sought to determine if there was a legitimate basis for this policy in competitions. Van Dyck and Leman agreed with Karageorghis and Priest (2012a), who stated that “music can be thought of as a type of legal performance-enhancing drug” and ultimately concluded from the evidence reviewed that music has ergonomic effects on running. As such, they rationalized that banning access to music during professional running competitions is a reasonable policy for organizers to implement.

Conclusions

In sum, the above eight reviews on music’s effects on exercise have drawn at least seven broad conclusions. First, synchronous music promotes exercise by timing activity to the beats per minute, increasing motor performance and endurance (Bishop, 2010; Karageorghis et al., 2012; Karageorghis, & Priest, 2012a, 2012b; Karageorghis, & Terry, 1997; Koc, & Curseit, 2009; Van Dyck, & Leman, 2016). Second, synchronous music can positively affect exercise by reducing perceived exertion, and increase affect, enhancing the overall enjoyment of the exercise experience (Bishop, 2010; Brooks, & Brooks, 2010; Karageorghis et al., 2012; Karageorghis, & Priest, 2012a, 2012b; Karageorghis, & Terry, 1997; Koc, & Curseit, 2009). Third, effects on exercise are present, but less clear for asynchronous (background) music, though it may affect motivation, (Karageorghis, & Priest, 2012b; Karageorghis & Terry, 1997; Koc, & Curseit, 2009). Fourth, “motivational” music can stimulate exercisers to increase work output (Brooks, & Brooks, 2010; Karageorghis et al., 2012; Karageorghis, & Priest, 2012a, 2012b; Karageorghis, & Terry, 1997; Koc, & Curseit, 2009; Van Dyck, & Leman, 2016). Fifth, experimenter-selected music and self-selected music can both have positive effects, but these
results are mixed (Brooks, & Brooks, 2010; Karageorghis, & Priest, 2012b). Sixth, there are more consistent positive effects of music for aerobic exercise than for anaerobic exercise (Brooks, & Brooks, 2010; Karageorghis, & Priest, 2012a, 2012b; Karageorghis, & Terry, 1997; Van Dyck, & Leman, 2016). Last, music lowering perceived exertion is a consistent effect for untrained participants, but not trained participants (Karageorghis, & Priest, 2012a, 2012b; Karageorghis, & Terry, 1997).

The conclusions of these reviews on music’s effects on exercise, as a whole, may be limited in that the majority of the reviews were conducted by one research group (i.e., Bishop, 2010; Karageorghis et al., 2012; Karageorghis & Priest, 2012a; 2012b; Karageorghis, & Terry, 1997), and that the focus of the reviews was on the effects of music on exercise, broadly. Across these review papers, the term exercise was used to mean a wide range of physical activity, and included, but was not limited to: dart throwing (Dorney et al., 1992), bench stepping (Hayakawa et al., 2000), hand grip strengthening (Karageorghis et al., 1996), walking (Karageorghis et al., 2009), cycling or spinning (Nakamura et al., 2010), circuit training (Crust, 2008), karate (Ferguson et al., 1994) aerobic or yoga classes (North & Hargreaves, 1996), and running (Barwood et al., 2009). The generality of these findings may be greatly limited because the topographies and intensities of these activities vary substantially, and the demonstrated effects of music may be specific to the exercise evaluated in each individual study. Indeed, some findings in the literature have described differing outcomes across exercise intensities (e.g., Brooks, & Brooks, 2010; Van Dyck & Leman, 2016). Similarly, varied results may be likely for the differing intensities that are involved with variety of physical topographies (e.g.,
treadmill walking versus running, weight lifting versus cycling, aerobic classes versus circuit training).

Although Van Dyck and Leman (2016) considered evaluations involving music and running, they included the results for music on varied exercise activities, such as walking and cycling to arrive at their conclusion that music has a performance-enhancing effect on running. Likewise, Karageorghis and Priest (1997) concluded from the studies involving both synchronous and asynchronous music that work output may be greatly enhanced; however, not one of the studies using synchronous music included an investigation of running, and only one of the available studies using asynchronous music showed this effect when running was evaluated. Although the mixed findings across these reviews were described as potential differences between trained and untrained participants (Karageorghis & Priest, 2012a, 2012b; Karageorghis & Terry, 1997), as well as disparities with low, moderate, and high exercise levels (Brooks, & Brooks, 2010; Van Dyck & Leman, 2016), it is puzzling as to why these same authors did not suggest that amalgamating findings from a variety of exercise modalities may create similar limitations and contribute to the inconsistencies.

Another limitation to these reviews is the validity of measures used to conclude that music has benefits for improving running. First, the conclusion that music is beneficial to exercise adherence, a commonly cited advantage (Karageorghis et al., 1999; Karageorghis & Priest, 2012b; Koc & Curtseit, 2009), is speculative; there have been no direct evaluations, nor longitudinal studies on the adherence effects of music (Karageorghis et al., 2012). Moreover, the assumed benefits of music on exercise arising from subjective dependent variables such as affect, fatigue, and mood have not been demonstrated to readily correlate with direct
measures of behavior. Self-report measures are often impossible to verify and commonly produce unreliable results, wrought with problems in reactivity that involve expectancy, value judgements, motivation to change the behavior, and timing (Barlow et al., 2009). Further, there is evidence demonstrating that subjective rating scales have low validity when compared to objective behavioral measures (e.g., Iwata et al., 2013; Zarcone et al., 1991). Nevertheless, much of the literature assessing music’s effects on exercise does include some kind of objective measure, and subjective data may be a useful supplement to objective outcomes (Barlow et al., 2009; Miltenberger & Cook, in press), if the subjective data are presented conservatively as complementary measures. Physiological measures likewise present challenges for interpretations on performance improvements (see physiological improvements section below for further explanation).
Chapter Two:

Literature Review on Music’s Effects on Running

In light of the potential erroneous conclusions that may have been formed from using subjective measures and lumping the effects of music across varied exercise topographies, the current paper will evaluate if the same conclusions may be made by limiting a review of the literature to (a) running only, and (b) results that are primarily based on objective performance variables. This review also focused only on literature or the components of the studies that measured effects when music was provided during running (versus the music presented pre- or post-run).

Implications Across Measures

For the purposes of this review, results have been classified under three main categories of dependent variables used across the 33 studies reviewed: (a) physiological, (b) behavioral, and (c) psychological. Physiological variables involve objective measurements of responses that are biological in nature, but are not direct assessments of running performance (i.e., distance, duration, pace, step rate). Studies most commonly collected data on heart rate as a physiological response. Other physiological variables were sometimes measured, such as blood pressure, blood lactate, plasma cortisol, hydration status, skin temperature, oxygen uptake, or respiratory frequency. Behavioral measures, using objectively-defined response definitions, can detect direct changes in running performance; for example, duration on a treadmill (e.g., seconds or minutes), distance ran (e.g., meters), or pace (e.g., km/h, strides per min).
Psychological data include subjective measures that cannot be directly observed, and are collected using rating scales (e.g., ratings of perceived exertion). These measures are always self-reports from the participant, collected before, after, and/or during (at pre-determined intervals) running.

**Physiological Changes**

From the 31 reviewed studies, 21 used measures of physiological changes, with 65% of those studies using heart rate as the most commonly used physiological measure. Although physiological data are objective measures, the conclusions from these data may still be unclear. For example, when music increases heart rate, the outcome may imply a lower efficiency in work output, thus a higher heart rate would be undesirable. Conversely, an increased heart rate may also indicate better caloric expenditure (Birnbaum et al., 2009), which would be desirable if weight management is a goal. Moreover, increased heart rate may indicate the stimulating effects of music, thereby establishing motivation to work harder and perform better (e.g., Brooks, & Brooks, 2010; Karageorghis & Priest, 2012a, 2012b; Koc & Curseit, 2009; Van Dyck & Leman, 2016). Findings from physiological measures can be considered mediating variables indicating the presence of something else less observable. In the current literature, conclusions are often made from physiological data about the implications for running performance or adherence. For example, a decreased heart rate assumes that listening to music has resulted in a more relaxed and less fatigued state. This suggests that the running experience is more enjoyable, increasing performance and establishing exercise as an activity that will be adhered to for those newer to adopting exercise routines (e.g., Barwood et al., 2009; Brownley et al., 1995).
**Performance Changes**

Of the 31 studies on running using music as the independent variable, 23 used an objective behavioral measure. Of those 23 studies, 11 studies reported improvements in running performance (distance, pace, time to exhaustion, cadence), six studies reported no effects, and seven studies had mixed results. For the studies with mixed results, two had improvements for the first part of the run only (Bigliassi et al., 2015; Lima-Silva et al., 2012), one had improvements for the male runners only (Bonnette et al., 2012), two had improvements for the female runners only (Cole & Maeda, 2015; Macone et al., 2006), one study showed that three of 11 runners performed better in the no music condition (Terry et al., 2012), and one study evaluating synchronization showed improvements with music for time to exhaustion, but not for cadence (Bood et al., 2013).

**Self-Selected Music.** For the studies that collected data on objective performance measures, five allowed participants to select their own music for the music condition. All five studies found performance improvements in the music condition. These increases were observed for running duration on a treadmill or track using a time-to-exhaustion measure (Bharani et al., 2004; Bigliassi et al., 2005; Thakare et al., 2017) pace for 20-min sessions on a treadmill (Lee & Kimmerly, 2014), and duration on a 1.5-mile outdoor running course (Bonnette et al., 2012). However, both studies using an outdoor runs had only partial effects. That is, Bigliassi et al. (2015) observed improvements only within the first 800 meters of the run, and Bonnette et al. (2012) recorded effects only for male participants, but not for the female runners. These results suggest participants using their own preferred music is as beneficial, if
not more so, than using a time-consuming music rating tool (BMRI-2) or relying on experimenter-selected music.

**Differences Across the Sexes.** Of the 31 studies reviewed, nine studies included only male participants, two studies had only female participants, and 20 studies used both sexes. Of those 20 studies, 13 investigations used performance measures. As described above, three of those studies (Bonnette et al., 2012; Cole, & Maeda, 2015; Macone et al., 2006) found differences between the sexes; that is one sex showed an effect compared to control, and the other did not. For the other 11 studies incorporating both sexes as participants and objective performance measures, only three studies (Ramji et al., 2016; Thakare et al., 2017; Van Dyck et al., 2015) employed statistical analyses to detect interactions across the sexes. All three studies found positive effects for running using music, but only Van Dyck et al. (2015) found a significantly more pronounced effect for one of the sexes, where female runners were better able to match their running steps to the tempo. In sum, of the seven studies that included an analysis across the sexes, four studies found differences, with three of them providing better results for female participants. These findings may support previous notions that music may differently enhance effects on exercise dependent on person’s sex (e.g., Karageorghis & Priest, 2012b), however, the findings are inconsistent and require further investigation.

**Trained versus Untrained Runners.** Some of the reviews on music and exercise concluded that lower perceived exertion has been a common outcome for untrained participants (Karageorghis & Priest, 2012a, 2012b; Karageorghis & Terry, 1997), thus listening to music while running has been deemed more effective for untrained than trained individuals. Of the 31 studies, three directly tested the effects of music on trained versus untrained runners,
and all three included performance measures. Brownley et al. (1995) required the participants to run to voluntary exhaustion, and found no effects for ratings of perceived exertion nor for duration across groups of trained and untrained participants when music was used. Matestic and Cromarie (2002) collected data on lap pace for 20-min runs with and without music. Consistent with previous reviews, they found that untrained participants scored significantly lower for ratings of perceived exertion, while there were no differences for trained runners. Nevertheless, they found significant improvements in pace for both groups when runners listened to music, suggesting the perceived exertion did not correspond with objective performance measures. Mohammadedzadeh et al. (2008) observed time to voluntary exhaustion for treadmill running when a music condition was compared to a no music condition and found lower levels for perceived exertion for untrained participants. Similar to the two aforementioned studies, they noted no significant effect on performance between trained and untrained groups in the music condition. Overall, although findings from these three studies support the notion that perceived exertion is lower for untrained groups, the implications cannot be extended to improvements in direct performance measures. In other words, ratings for perceived exertion have not corresponded in a meaningful way to a performance measure.

**Correspondence Between Subjective Ratings and Objective Performance Measures**

Across the 31 studies reviewed, 21 used both objective performance measures and subjective rating scales. Four of the other 10 studies used physiological data without any performance data, with three of those four supplementing physiological information with subjective data. Another three of those 10 studies used only performance measures and no additional subjective data. Four studies used only subjective measures, with neither
physiological data nor objective performance data. Out of the 21 studies with performance and subjective measures, there was inconsistent correspondence between both measures. Seven studies showed results for all positive (change detected in the music condition) or all negative (no effects from music) effects. Specifically, two demonstrated improvements, and five studies showed no effects on running. Nine studies showed conflicting results across subjective and objective measures where the rating scale results demonstrated either a positive or negative effect, but the objective performance measure yielded the opposite effect. Surprisingly, six of those nine studies indicated a positive effect for performance measures but a negative effect for the subjective results. Said differently, relying on subjective rating scale measures as an indicator of an effect for music on running has resulted in false negatives. The remaining studies had mixed results, thus it is difficult to determine correspondence across both dependent variables.

**Other Considerations**

Several studies included other variables or methods warranting further investigation. For example, some studies compared music to other forms of auditory stimulation.

Ciccomascolo et al. (1995) used ambient sounds from a basketball game, compared to a music condition, and a no music condition for collegiate basketball players as participants. However, there were no effects across any of the conditions for any measures. In a related study using non-musical auditory stimulation, Fillingim and Fine (1986) evaluated a word-cue condition against a breathing and control condition. In the word-cue condition, runners listened to pre-recoded words, hearing one of several words every 10 s. The word “dog” was played on a variable time schedule of 1 min, and the runner was instructed to count the number of times
they heard the word “dog” among the other random words heard during a given session. The goal of this condition was to promote the runner to focus on a task and create a state of dissociation from feelings of fatigue, the same mechanism used to describe music’s effects on lowering perceived exertion. Although the subjective results indicated a positive effect, there were no effects on performance.

Notwithstanding, Bood et al. (2013) found effects on performance measures when they compared a music and no music condition to a metronome condition. They measured the correspondence of cadence (i.e., step rate) with acoustical stimuli using a footswitch sensor under one shoe. Unexpectedly, the metronome condition was as effective as the music condition for increasing the duration of running; this was compared to a no music control that did not have an effect. Furthermore, the metronome was more effective than music in improving cadence consistency. Similarly, Van Dyck et al. (2015) tested runners’ spontaneous entrainment, the degree to which runners may physically synchronize their cadence to the music when the beats of the music were adjusted. There were significant effects for music tempo influencing spontaneous cadence. The authors also noted a limit in the range of the beats per min for entrainment to occur, or an “entrainment basin,” for these effects of up to approximately 4% in the tempo variation. However, increased cadence may not indicate faster running, as indicated by the results from Ramji et al. (2016). This study compared the number of steps to the stride length measured by a computer. They found that for a faster music track, runners increased the distance ran, but did not increase their pace, suggesting that longer strides occurred. This effect was apparent for both synchronous and asynchronous music, using fast metrical levels. Future researchers should emphasize measure selection as a function of the
direct behavior of interest. In the example above, changes in cadence may be useful to adjust running stride specifically, but may not improve performance in terms of running pace.

Conclusions

Although the reviews to date describe music’s positive role in increasing exercise performance and adherence, the explanations of the mechanisms have been described in terms of hypothetical constructs derived from indirect and subjective self-report measures. Continuing to work off of these constructs as a basis for this literature or future research will likely not lead to objective evidence of the specific components of music interventions that are most likely to affect running. The overall results of the current review, which focused on the objective data, support the conclusion that music may enhance running performance. The analysis of objective data showed that inconclusive results have stemmed from contradictions between objective and subjective reports.

This review also found that the previous literature reviews on music and exercise contradicted the conclusions of the objective evidence of the literature on music and running. First, the need for “carefully-selected” music appears to be an overstated concern. Indeed, all studies using participant-selected music yielded positive performance results. Similarly, there were improved performance effects across studies using both synchronous or asynchronous music. In other words, positive effects on running were more commonly found with the presence of music (versus the absence of music), and type of music did not consistently affect outcomes. Second, when studies used ratings of perceived exertion, results indicated that music had a more pronounced effect for untrained participants; however, when the current review narrowed those same studies to those that only used running as exercise, there were
similar benefits for both trained and untrained participants. Third, previous literature reviews found mixed results across the sexes, mostly favoring female exercisers benefitting from using music, but the current review of running studies found that several studies showed no difference. Ultimately, it is unclear whether a person’s sex contributes the overall effectiveness of music interventions for running.

Studies should continue to investigate whether other stimuli besides music have similar effects on running. While other non-music variables may not enhance motivation, they may play a key role in encouraging dissociation from the effort involved in running. Hutchinson et al. (2015) evaluated the effects of music plus video, music alone, and no music conditions for treadmill running. The authors did not collect performance data, and subjective results primarily indicated no differences. However, the attentional focus scale showed more dissociation with music plus video condition. Miller et al. (2010) compared music to dialogue from auditory books. Performance measures were not collected for this study, but physiological measures and rating scales were used with contradictory results. Respiratory variables indicated that the runners were less fatigued during the audiobooks condition, but their perceived exertion was lower for the music condition. More work should be done with video, podcasts, audiobooks, as well as holding tangible stimulation such as hard copy books and magazines and phone texting. Additionally, there may be significant differences in performance or motivation when a runner is on a treadmill or outside on a track, paved pathway, or trail. Different types of visual stimulation in the environment, or lack thereof, may produce differing results.
Van Dyck and Leman’s (2016) suggested that multimodal music interfaces (e.g., smart music players) can alter a runner’s experience, by providing runners the ability for real-time manipulations of music playlists. Moens et al. (2014) used the D-Jogger smart music player program to train participants how to synchronize music to their own walking. The D-Jogger sensed the individual’s footfalls and made adjustments to bring the music tempo into alignment. These types of strategies may promote entrainment or provide opportunities to set up conjugate reinforcement schedules (see Rapp et al., 2008, for a review of conjugate schedules), whereby preferred music only plays correctly when the runner is moving within a specific pre-determined range of pace. Music’s role in running has garnered much attention in the literature, and technology that is designed and marketed to enhance running should additionally be investigated as an extension to this literature. Virtual coaching, earning badges, or running from virtual zombies should be evaluated. These options are readily available to runners using mobile applications, and their effectiveness should be systematically evaluated. Assessments of the effects of each strategy should also consider the varying behavioral mechanisms involved, including motivating operations, competing contingencies, and reinforcement schedules.

Finally, applied and meaningful outcomes should be considered when designing studies to evaluate running. For instance, the recent advances for increasing stride may be useful for enhancing running technique, and this may be a useful strategy in a rehabilitation setting to avoid or manage injury. Second, self-management strategies may be promoted for starting a new running routine or maintaining adherence to that routine. Third, disseminating effective strategies employing music stimuli may improve tolerance of running for patients requiring
increased exercise intensity for medical treatment (e.g., Thornby et al., 1995; Bharani et al., 2003). Another goal may be to improve techniques for sprinting performance, which may be best suited to a behavioral coaching intervention (e.g., Shapiro & Shapiro, 1985). Finally, targeting an increase in running distance may be most successful with goal setting and feedback strategies (e.g., Wack et al., 2014). In short, each goal may require a different methodological approach for a given running intervention.
Chapter Three:

The Importance of Promoting Running for Exercise

Discovering more about music and other variables that support people to adhere to running routines as a regular exercise regime can benefit some of the current health crises. The national obesity rate was 39.6% for adults in 2015-2016 (Hales et al., 2017). It is estimated that this will increase to 51% by the year 2030, resulting in medical expenditures of $549.5 billion (Finkelstein et al., 2011). Seven of the 10 most common chronic diseases affecting nearly half of Americans can be prevented or greatly improved by consistent exercise. Despite this, about 80% of adults are not meeting national guidelines for regular physical activity (U.S. Department of Health and Human Services, 2018). Adults require 75 to 150 min of vigorous-intensity activity or 150 to 300 min of moderate-intensity activity each week for substantial health benefits, such as promoting a healthy cardiorespiratory system, muscle fitness, and body weight, while also preventing health risks, including cancer, diabetes, and heart disease (U.S. Department of Health and Human Services, 2018). Running activities may be particularly important to promote because persistent runners also have a 29 to 50% lower risk of cardiovascular mortality when compared to nonrunners (Lee et al., 2014). Besides these substantial benefits, running is accessible, cost-effective, and sustainable across the life span. Variables which affect the adherence and performance of running should be well-studied as behavioral principles before they are described for effective practice. Research on these variables, such as music’s role in running, may lead to important strategies for promoting running as a new or ongoing exercise.
for nonrunners, and for trainers (e.g., physical therapists, coaches) who may use music to support running strategies for clients.

The general purpose of this study was to evaluate how music may influence running performance or its potential effects on running adherence. Specifically, a music playlist, a preferred boost song, or another form of auditory stimulation (i.e., podcast) were assessed to determine if there were any immediate or subsequent effects on the pace of running. It is possible that music (or other auditory stimulation) may have little to no effect on performance. This potential outcome would establish the question as to why runners use music at all. Thus, a secondary purpose of this study was to survey a large sample of runners to determine the percentage of runners who use music while running, which may provide some insights to music’s effects on adherence. If performance is not clearly enhanced, and runners continue to use music while running, it may be to add stimulation or decrease the aversiveness during effortful physical output. This investigation was comprised of four studies. Study 1 was an initial survey to learn about the common behavior patterns and preferences of runners, which may also inform the methodology for the following studies. In study 2, three experiments evaluated the effects on running when listening to a form of auditory stimulation. Experiment 1 assessed the effects of a music playlist when compared to no music stimulation as the control. Experiment 2 evaluated a boost song when compared to the music playlist. A podcast was used in experiment 3 to assess the effects of a non-musical auditory source when compared to no auditory stimulation.
Chapter Four:

Study 1: Survey on Running Habits and Preferences

Previous research methodologies designed to assess music’s effects on exercise may have incorporated running or music variables (e.g., running environment, music devices) based only on the experimenter’s perspective. No prior research on music and running has reported using formal surveys, questionnaires, or individual preference assessments to inform researchers about what runners do or think about when it comes to behaviors during or related to running. For instance, studies have been commonly conducted in controlled settings, such as using an indoor environment containing a treadmill. However, indoor treadmill running may not account for multiple variables that affect the applied nature of running. It is unlikely most long-term runners run solely on treadmills, but there is no information to support if they do or do not. Indoor treadmills involve a different environment than a runner may experience outdoors (wind resistance, varied terrain, outdoor visual stimulation, etc.), thus the generality of results from treadmill running may be limited. Additionally, studies have used older or bulky equipment (e.g. mobile CD players), while runners likely use the most recent light-weight technology (smart phones, smart watches). Additionally, determining how many runners use music is important to the main research question, as well as how many of those deem music as a critical aspect to enhance their running or adhere to their running routine.

Runners who successfully adhere to an ongoing running routine may be able to provide valuable information about the type of devices runners use most often, common running
modalities (e.g., indoor, outdoor, track), and the reasons for their choices and current behaviors (how they plan to run and what motivates them or creates challenges for them). Therefore, before conducting formal analyses on the effects of music on running, a large-scale survey was employed to ask current runners about their behaviors (e.g., devices, places they run) and perspectives (e.g., preferences, barriers). The purpose of the survey was to learn what runners commonly do, and use that information to (a) guide future research questions about the variables involved in running adherence and (b) inform the selection of variables and methodology for the subsequent applied experiments in the current study.

Method

Participants

Respondents were active adult runners, defined as any person aged 18 years or older who has run more than 1 day per week, on average, for the past 3 or more months at the time they filled out the survey. Questions about running experience and frequency were incorporated early in the survey (see Appendix A), and the remainder of the survey was bypassed if these eligibility criteria were not met; however these respondents were still eligible for a gift card nomination (see Appendix C). Ineligible surveys were excluded from the final results. Additionally, any participants who did not complete the full survey (excluding questions about social validity, recruitment and gift cards) were also excluded from the results.

Information about identity and geographic location was not collected. The only demographics collected were age and sex. Any English-speaking person from any country that had access to the survey (i.e., encountered it on social media) was able to complete it. Participants had an option to voluntarily provide their e-mail address for the purposes of either (a) learning about
participating in a follow-up study, and/or (b) being eligible for an opportunity to receive a gift card for their participation. E-mail addresses were not used for any purpose other than those described. This survey was available for 26 days and 601 individuals responded. Of those 601 respondents, 555 met criteria and completed the survey.

**Design and Survey Tool**

The cross-sectional survey was designed to be accessed online. Postings on social media were used to recruit participants for the survey. Running groups on Facebook were the primary target, but postings were also made in other groups, networks, or personal pages that may also reach experienced runners. Each post contained a flyer that provided (a) a statement about the purpose of the survey and related information, including the approximate time it would take to complete the survey (b) a direct link and QR code to the survey, and (c) a statement about eligibility for a gift card (every 25th participant). Qualtrics software (https://www.qualtrics.com) provided through USF Health was used to develop and conduct this survey. The survey could be completed on a computer, tablet device, or smart phone.

**Data Collection**

The survey contained rating scales or multiple choice selections, but a large portion of the questions were open-ended to allow for a variety of unanticipated responses (see Appendix A). After the survey closed, all responses from the eligible and completed surveys were categorized for analysis. The ratings and multiple-choice responses were automatically categorized by the Qualtrics software. Open-ended responses were manually categorized, using several broad classifications developed to correspond with all survey answers. For some questions, participants provided multiple responses (e.g., three different reasons that a
particular runner likes running), therefore responses to one question could fit under multiple categories.

**Interrater Reliability**

Reliability data were collected on the categorization of responses. A second independent rater categorized 33.35% of survey responses for all questions, and the mean score for interrater reliability (IRR) was 98.2% across all responses. Exact agreement was calculated on an item-by-item basis. Specifically, each response that was categorized for a participant was coded to match that participant. For example, Respondent 1’s answers were designated “R1” and this code served as a “tally” under the relevant classification for the response. Agreements were scored if both the primary rater and the secondary rater placed an R1 under the same category or if neither rater placed an R1 under a given category. A disagreement was scored if only one of the raters placed an R1 under a given category. Interrater reliability was calculated by dividing the agreements by the agreements plus disagreements for each category using exact agreement for each participant’s responses, and multiplying the quotient by 100%.

**Social Validity and Recruitment Interest**

At the conclusion of the survey, respondents were asked to rate two comments related to the purpose of the survey for social validity (see Appendix B). Both social validity items used a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). When asked to rate a statement about the relevance of questions relating to (a) habits and motivations, and (b) guiding running research, respondents provided mean ratings of 3.95 and 3.94, respectively. The distributions of the ratings are displayed in Figure 1. The social validity ratings were
followed by a question asking if participants were interested in learning about participating as a runner in a subsequent study involving several sessions across several days at the University of South Florida’s campus (see Appendix C).

**Survey Procedures**

Survey items (see Appendix A) broadly targeted (a) current behaviors of runners, such as frequency, distance, and schedule of running, location of runs, the use of devices to track runs or as an auditory source, and (b) the motivational reasons for running and the possible barriers that need to be managed. Following this survey, an applied evaluation on the effects of music on running was carried out, thus this survey also served the express purpose to discover how music is used by runners. Specifically, runners were asked if they use music to run, the genre of music listened to, if they use certain songs for a boost, the devices and apps used for listening to music, if other sources of auditory stimulation are used during runs, and why they chose to listen to music, no music, or another auditory source.
Figure 1

Social Validity Results for Survey of Study 1

I think the answers collected in this survey are important for researchers to learn about the realities of running and may help researchers be more in tune with designing studies about running.

I think this survey had good questions to collect information about actual runners' habits and about motivation related to running (or barriers).
Chapter Five:

Results

Extensive results have been collected for the survey; for brevity, only select survey items which are most relevant for informing Study 2 have been included in these results and the corresponding figures (omitted results are available from the author).

Participant Demographics, Devices, and Running Locations

Figure 2 shows that 79.53% (N=439) of respondents were female, 20.47% (N=113) were male, and a third option was given (i.e., “not listed”) with an open-ended comment option, however, no respondent selected this option. Figure 2 also shows the participant age ranged from 18 to 72 years, with 2.89% (N=16) aged 18 to 24 years, 7.78% (N=43) aged 25 to 29 years, 12.3% (N=68) aged 30 to 34 years, 16.64% (N=92) aged 35 to 39 years, 18.08% (N=100) aged 40 to 44 years, 18.08% (N=100) aged 45 to 49 years, 11.21% (N=62) aged 50 to 54 years, 6.69% (N=37) aged 55 to 59 years, 3.8% (N=21) aged 60 to 64 years, 2.17% (N=12) aged 65 to 69 years, and 0.36% (N=2) aged 70 years or older. Figure 3 shows the reasons that respondents initially began a running routine. The majority responded that they began running for physical health purposes (46.03%, N=336), specifically to lose weight (18.77%, N=137) or for maintaining their fitness levels and getting exercise (27.26%, N=199). Figure 4 shows the results for if and how a device (e.g., iPhone, Fitbit) was used while running, and 95.5% (N=530) of respondents indicated they used a device of some kind, and 77.12% (N=428) at least sometimes looked at the information (graphs, logs, etc.) on their device about their running stats over time. The
upper panel of Figure 5 shows the typical locations that respondents used (respondents could select multiple options). Only one response was provided by 244 runners and the other 311 runners selected multiple locations for running. When accounting for all 947 responses across the 555 respondents, 98.56% (N=547) of runners ran outdoors (neighborhood, park, beach, etc.), 20.9% (N=116) ran on an outdoor track, 4.86% (N=27) ran on an indoor track, and 46.31% (N=257) used a treadmill. The lower panel of Figure 5 displays the single location that 244 runners identified in the above question and the primarily used location for the runners that indicated they used more than one location. Of the latter, some runners indicated they ran equally across two locations, thus there were 571 responses for the 555 runners. The top primary location used by runners was outdoors (88.65%, N=492), followed by treadmills (13.33%, N=74), with only a few who preferred a running track that was located outdoors (0.72%, N=4) or indoors (0.18%, N=1).

Running with Auditory Stimulation

The upper panel for Figure 6 shows that 77.12% (N=428) of runners used music at least sometimes while running. For those that did listen to music, Figure 6 (lower panel) also displays that 25.72% (N=161) used it for motivation, 20.61% (N=129) for distraction, 19.17% (N=120) for tempo (e.g., synchronous running), 17.09% (N=107) to pass the time, 12.46% (N=78) for enjoyable entertainment, 4.15% (N=26) to help with focus, and 0.8% (N=5) used songs to measure the time completed or remaining in the run. Figure 7 shows that, from the respondents using music, 60.98% (N=261) indicated they usually or sometimes used a boost song. For those that used a boost song, 11.67% (N=37) responded they used it at the beginning of their run, 8.83% (N=28) in the middle, 35.02% (N=111) near the end, and 7.57% (N=24) used
it randomly throughout their run. Runners also used a boost song when they were struggling or needed a push (29.34%, N=93), training on hills (2.84%, N=9), speed training (2.84%, N=9), or interval training (1.89%, N=6). Figure 8 shows that 35.5% (N=197) of respondents at least sometimes used a nonmusical audio source, including audio books (30.28%, N=76), podcasts (58.17%, N=146), coaching apps (2.39%, N=6), audio from a video mode such as YouTube (4.78%, N=12), radio (2.79%, N=7), or motivational speeches, meditation speech, or personal recordings (1.59%, N=4). Finally, Figure 9 shows that 18.81% (N=104) respondents preferred not to use an audio source when they ran.
Figure 2

Sex and Age of Survey Respondents

What is your sex?

![Bar chart showing sex distribution]

How old are you?

![Bar chart showing age distribution]
Figure 3

Reason Survey Respondents Began Running

Why Did You Start Running?

Percent of Responses
N=730

- Required for Other Activity
- Fitness or Exercise
- Lose Weight
- Stress Relief
- Encouraged by Someone
- Lifelong (before adulthood)
- New Challenge
Figure 4

*If and How Survey Respondents Use a Device*

**Do you usually track your run on a device?**

<table>
<thead>
<tr>
<th>Percent of Respondents</th>
<th>N=555</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>95%</td>
</tr>
<tr>
<td>No</td>
<td>5%</td>
</tr>
</tbody>
</table>

**Do you usually look at information on your device over time?**

<table>
<thead>
<tr>
<th>Percent of Respondents</th>
<th>N=530</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>98%</td>
</tr>
<tr>
<td>No</td>
<td>2%</td>
</tr>
</tbody>
</table>
Figure 5

*Where Survey Respondents Run (all options) and Top Option for Location*

*Note.* The upper panel includes multiple (2 or more) responses for several of the 555 respondents for a total of 947 responses. The lower panel consists of one primary response for most of the 555 runners, but some provided two equally used primary locations, resulting in 571 responses.
Figure 6

Survey Respondents Use of Music While Running

Do you listen to music when you run?

<table>
<thead>
<tr>
<th></th>
<th>Percent of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>50%</td>
</tr>
<tr>
<td>Sometimes</td>
<td>20%</td>
</tr>
<tr>
<td>No</td>
<td>30%</td>
</tr>
</tbody>
</table>

Why Do You Listen to Music When Running?

<table>
<thead>
<tr>
<th>Reason</th>
<th>Percent of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation</td>
<td>25%</td>
</tr>
<tr>
<td>Distraction</td>
<td>20%</td>
</tr>
<tr>
<td>Tempo</td>
<td>15%</td>
</tr>
<tr>
<td>Pass the Time</td>
<td>10%</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>5%</td>
</tr>
<tr>
<td>Help Focus</td>
<td>2%</td>
</tr>
<tr>
<td>Songs to mark time</td>
<td>1%</td>
</tr>
</tbody>
</table>
**Figure 7**

*If and When Survey Respondents Use a Boost Song*

**Do you save a particular song for an extra boost while running?**

- **Yes**: 45%
- **Sometimes**: 20%
- **No**: 35%

**When Do You Use This Song As a Boost?**

- **Beginning**: 10%
- **Extra push**: 30%
- **End (last miles/kms)**: 35%
- **Randomly (throughout)**: 20%
- **Training on hills**: 5%
- **Speed training run**: 5%
- **Interval training**: 0%
Figure 8

If and What Survey Respondents Use for Nonmusical Audio when Running

Do you listen to something other than audio?

What Do You Listen To (Other Than Music)?

Percent of Responses

Percent of Responses (N=251)

Audio books | Podcasts | Coaching apps | Audio/video (e.g., YouTube) | Motivational speeches | Meditation speech | Radio | Personal recordings

N=555
Figure 9

*If Survey Respondents Prefer No Audio Source During Runs*

Do you prefer to run without listening to anything?

- Yes, always: 15%
- Yes, sometimes: 30%
- No: 55%

N=553
Chapter Six:

Study 2: Within-Subject Experiments Evaluating Music’s Effects on Running

From 30 studies reviewed in this paper (excluding Lane et al., 2011, which used an online self-report measure only), the mean number of participants in a given study was 21 (range, 6 to 50). All studies used a group-comparison analysis. The majority of studies evaluated the effects of music in an indoor environment (i.e., treadmill=22, indoor track=4). The current study will use an outdoor running environment which, as reported by runners in Study 1, is the most commonly utilized environment (98.56%), as well as the most frequently selected, when some of those runners use more than one environment (88.65%). Utilizing a setting that is most similar to that which is already used by runners may be important in determining how experienced runners use music to their advantage. Although it is time-consuming to evaluate multiple individual runners across several sessions using a within-subject design, the experiments from Study 2 met, on average, the minimum number of 6 participants from the group-studies.

The results of survey from Study 1 indicated that listening to music is a highly popular activity during running (77.12%). The purpose of listening to music for runners who already engage in regular running routines with music, and the underlying behavioral principles of music in this context are not clear. Although previous studies have attempted to answer these questions, a reliance on self-report measures and group designs may have contributed to inconsistent conclusions. To date, no study has investigated the effects of music for individual
runners, whereby each runner serves as their own control. Thus, the first purpose of Study 2 was to evaluate the effects that participant-selected music has on running pace across multiple outdoor run sessions for individual runners, using a three-component multiple schedule design (Experiment 1). The second purpose was to assess specific aspects of music on running by further evaluating if song type (boost song) influenced running pace (Experiment 2). The third purpose was to evaluate whether non-musical auditory stimulation (podcast) had any effects on running pace (Experiment 3). If results showed a boost song to have more potent effects on running than a general music playlist, then this may imply that music type (high energy, beats per min, motivational) is an important factor for enhancing running performance. Conversely, results showing that any effects on running using a podcast that are similar (or better) than music may suggest that the “musicality” of the audio source is less important than simply using any type of auditory stimulation (e.g., Rapp et al., 2018). An additional purpose across the three experiments of Study 2 was to determine if objective measures (pace) of running corresponded to subjective self-report measures (perceived exertion) or physiological measures (heart rate).

Method

Participants

Participants were recruited for Study 2 from the pool of 93 survey respondents from Study 1 who indicated they were interested in participating in running research and were local to the research site. While all potential participants would have already had to meet the survey inclusion criterion of running at least once per week for 3 months or more, they were also required to meet this same criterion to be considered an “experienced runner” immediately before the time of recruitment for inclusion in Study 2. A runner would be eligible for a given
experiment (music playlist, boost song, or podcast) depending on their running experience related to auditory stimulation, thus any individual runner may have participated in one, two or all three experiments. In two cases, the runners participated in only two of three experiments that they were eligible for because their schedules were not amenable to continued sessions. In total, eight runners participated: seven runners took part in Experiment 1, six in Experiment 2, and four in Experiment 3. Six participants were women, two were men, and their ages at intake ranged from 21 to 54 years. Table 1 provides specific information about each participant.

**Setting and Materials**

In Study 1, the majority of respondents indicated that they ran in outdoor settings, and all participants recruited for Study 2 indicated they mostly or always ran outdoors. All run sessions for Study 2 were conducted in a 44,100 km² outdoor park setting at the University of South Florida campus (see Figures 10 and 11). The park contained several graded paths that were well lit with light sensor pathway lamps for any early morning or late day run sessions. The pathways were all connected and positioned mostly around the perimeters of two adjacent small lakes containing fountains and two bridges crossing each lake joining components of the pathways. The park consisted of trees, sculptures, benches, and a variety of wildlife including geese, turtles, and fish (see Figure 11). The park was selected as the run setting for safety (graded surfaces, lit pathways), as well as the scenery. The park setting, rather than a track, more closely simulated the visual stimulation and varied running routes encountered in a regular runner’s environment.

Runners used their own devices. All eight runners used smartphones to measure running pace, and six used a smartwatch for heart rate (heart rate data was not collected for
Table 1

Participant Information for Study 2

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age</th>
<th>Years Running</th>
<th>Avg. Days Per Week Running</th>
<th>Occupation</th>
<th>Exercise (excl. running)</th>
<th>Sports (excl. races)</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bertha</td>
<td>21</td>
<td>5</td>
<td>1-2</td>
<td>Student, Behavior Technician</td>
<td>Biking, rollerblading, weights,</td>
<td>Soccer, tennis,</td>
<td>Music playlist</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>spinning, HIIT</td>
<td>basketball, volleyball</td>
<td>Boost song</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Podcast</td>
</tr>
<tr>
<td>Dolly</td>
<td>49</td>
<td>15</td>
<td>3</td>
<td>Facility Operations Manager</td>
<td>Cycling, swimming, weights</td>
<td>None</td>
<td>Music playlist</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Boost song</td>
</tr>
<tr>
<td>Fay</td>
<td>37</td>
<td>16</td>
<td>5-6</td>
<td>Dietician</td>
<td>Circuit training, rowing, weights</td>
<td>None</td>
<td>Music playlist</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Boost song</td>
</tr>
<tr>
<td>Hanna</td>
<td>41</td>
<td>12</td>
<td>3</td>
<td>Community Health Coordinator</td>
<td>Strength Training</td>
<td>Swimming</td>
<td>Music playlist</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Boost song</td>
</tr>
<tr>
<td>Josephine</td>
<td>37</td>
<td>17</td>
<td>3</td>
<td>Commercial Banker</td>
<td>Weights</td>
<td>Soccer</td>
<td>Music playlist</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Boost song</td>
</tr>
<tr>
<td>Arthur</td>
<td>54</td>
<td>20</td>
<td>4</td>
<td>Distribution Coordinator</td>
<td>Cross training, HIIT, weights,</td>
<td>Basketball</td>
<td>Music playlist</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>biking, Pilates</td>
<td></td>
<td>Boost song</td>
</tr>
<tr>
<td>Paulette</td>
<td>46</td>
<td>6</td>
<td>4-5</td>
<td>Academic Librarian</td>
<td>HIIT</td>
<td>None</td>
<td>Podcast</td>
</tr>
<tr>
<td>Eduoard</td>
<td>36</td>
<td>4</td>
<td>4</td>
<td>College Instructor</td>
<td>Weights</td>
<td>None</td>
<td>Music playlist</td>
</tr>
</tbody>
</table>

Note. Participant information is based on the time they entered the study.

two participants). Six of the eight participants used bone-induction headsets, and two used earbuds. A running application (app) was used to track runs, and participants downloaded the app in advance if they did not already have it installed on their device. A unique account was created for each participant for the purposes of this study, and the password was known only to the researchers. Researchers logged into the account at the beginning of each run visit, and
Figure 10

Running Site

Note. Aerial view (upper image) and the east lake in a partial ground view (lower image) of the park used for run sessions. The lake shown in the lower image is the top lake shown in the aerial view (upper image).
logged out at the completion of visit. Runners used their own music or podcasts on their device or streamed through the relevant app. At the beginning of the first session, the researcher oriented the runner to the park perimeter, and suggested several route options they could select which would bring them back to the vicinity of the starting point for each run.

Researchers timed each component and flagged the runner at the end of each one to score their heart rate, their rating of exertion, check the audio played (if applicable), and give instructions for the next component. These scoring periods between components were about
10 to 30 s. Pace data were collected via the running app after the session(s) were completed for the day.

**Data Collection**

The average pace of running (min per km; mpk) was collected for each of the three components within a run session. The running app tracked running distance for every second using the GPS device, and was available to the researcher at any time by logging into the account. Each 5-min component was timed separately by the researcher for 5 min 20 s, to account for the runner’s start up and slowdown of each component and provide a 20-s buffer for data collection. To collect data on running pace, the researcher recorded the distance ran 10 s after the runner began (e.g., 0:10) and again 10 s after the component’s end time (e.g., 5:10). The component interval (3 or 5 min) was then divided by the distance to calculate running pace for each component.

Secondary data were collected for heart rate (beats per minute; BPM) and ratings of perceived exertion (RPE; Borg, 1982). Heart rate was collected from the runner’s smartwatch immediately at the completion of each component, and the runner was asked to rate their RPE on a visual scale shown to them by the researcher (see Appendix G). Perceived difficulty (i.e., RPE) was commonly used as a subjective measure across 84% (N=26) of the 31 reviewed studies, and was typically used as the primary measure. Heart rate was also measured as a physiological dependent variable for 65% (N=20) of the 31 studies. The purpose of collecting heart rate and RPE scores for the current study was to (a) provide supplemental information related to the participant’s perceptions and internal experiences that may be useful for determining possible behavioral mechanisms, (b) compare results to pace data to determine
the validity of supplemental data, and (c) compare self-report and physiological outcomes to those of previous studies.

Device Accuracy

All eight participants’ GPS devices were subject to accuracy assessments for all experiments for 42.35% of run session visits and showed a mean accuracy of 96.67%. Table 2 shows the accuracy measures for each of the eight devices used by the participants. Using a distance wheel, 1 km of specific route in the park was measured in advance. This route was measured with the wheel twice, and the reliability the 1-km route was 99.92%. The route was then used to compare the accuracy for each participant’s device to measure distance with its GPS function. The participant walked or ran on the marked route with their device, and the distance recorded by the app on the device was compared to the 1 km standard route marked by the distance wheel.

Table 2

Accuracy Measures for Each Participant’s Device

<table>
<thead>
<tr>
<th>Participant</th>
<th>Bertha</th>
<th>Dolly</th>
<th>Fay</th>
<th>Hanna</th>
<th>Josephine</th>
<th>Arthur</th>
<th>Paulette</th>
<th>Eduoard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of Visits</td>
<td>43.48</td>
<td>35.71</td>
<td>37.50</td>
<td>57.14</td>
<td>50.00</td>
<td>33.33</td>
<td>50.00</td>
<td>41.67</td>
</tr>
<tr>
<td>Mean Accuracy</td>
<td>97.00</td>
<td>97.40</td>
<td>96.33</td>
<td>96.75</td>
<td>95.75</td>
<td>99.67</td>
<td>94.00</td>
<td>95.40</td>
</tr>
</tbody>
</table>

Note. Each device’s GPS reading relative to a 1-km route (measured with a distance wheel.)
**Interobserver Agreement**

For data collected from the running app, an independent secondary rater scored start and end distance for all three components for individual sessions across all participants. Interobserver agreement (IOA) was calculated for 70.83%, 55.81%, and 65.38% of sessions for Experiments 1, 2, and 3, respectively. An agreement was scored if both the start and end distance of the secondary rater were within 0.01 km of the primary rater’s data for each running component interval. Scoring was compared on an interval-by-interval basis by dividing number of agreements by agreements plus disagreements, and multiplying by 100%. The mean IOA was 98.1% (range, 93.3% to 100%), 100% (range, 100% to 100%), and 100% (range, 100% to 100%) for Experiments 1, 2, and 3, respectively. Table 3 displays the IOA results for each individual participant in each experiment.

**Preference Assessments of Running with Auditory Stimuli**

Ranking and rating forms (see Appendices H through N) were administered to each participant to ask about their preferences for running with each type of auditory stimulation, or lack thereof, as it related to their running before their participation in the study (broadly) and for each experiment. These same questions were asked again after each experiment and the full study, except participants were then asked about their preferences as it related to running with the corresponding audio conditions in the study. The purpose of these assessments was to determine if participants altered their preferences about running with the varying audio or no audio due to several exposures with no auditory stimulation (no audio for 83% of components for Experiments 1 and 3). Additionally, assessment data also provide information about the level of preference (or aversiveness) of the no audio conditions for each participant.
Table 3

*Interobserver Agreement for Each Participant’s Pace Results Across Experiments*

### Experiment 1

<table>
<thead>
<tr>
<th>Participant</th>
<th>Bertha</th>
<th>Dolly</th>
<th>Fay</th>
<th>Hanna</th>
<th>Josephine</th>
<th>Arthur</th>
<th>Paulette</th>
<th>Eduoard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Percent of Sessions</strong></td>
<td>62.5</td>
<td>71.43</td>
<td>83.33</td>
<td>83.33</td>
<td>83.33</td>
<td>66.67</td>
<td>n/a</td>
<td>50</td>
</tr>
<tr>
<td><strong>Percent Agreement</strong></td>
<td>100</td>
<td>93.33</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>93.33</td>
<td>n/a</td>
<td>100</td>
</tr>
</tbody>
</table>

### Experiment 2

<table>
<thead>
<tr>
<th>Participant</th>
<th>Bertha</th>
<th>Dolly</th>
<th>Fay</th>
<th>Hanna</th>
<th>Josephine</th>
<th>Arthur</th>
<th>Paulette</th>
<th>Eduoard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Percent of Sessions</strong></td>
<td>50</td>
<td>37.5</td>
<td>57.14</td>
<td>62.5</td>
<td>83.33</td>
<td>62.50</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Percent Agreement</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

### Experiment 3

<table>
<thead>
<tr>
<th>Participant</th>
<th>Bertha</th>
<th>Dolly</th>
<th>Fay</th>
<th>Hanna</th>
<th>Josephine</th>
<th>Arthur</th>
<th>Paulette</th>
<th>Eduoard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Percent of Sessions</strong></td>
<td>62.50</td>
<td>n/a</td>
<td>n/a</td>
<td>50</td>
<td>n/a</td>
<td>n/a</td>
<td>66.67</td>
<td>83.33</td>
</tr>
<tr>
<td><strong>Percent Agreement</strong></td>
<td>100</td>
<td>n/a</td>
<td>n/a</td>
<td>100</td>
<td>n/a</td>
<td>n/a</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

*Note.* For both Dolly and Arthur in Experiment 1, mean ranges were 66.67% to 100%.

The overall rankings for auditory stimuli changed for only two participants, Dolly and Hanna. Both initially selected music playlist as their number one ranked auditory stimulus while running, with boost song as number two, but both participants reversed the order in their final ranking, placing their boost song as number one. All runners ranked no audio as least preferred
relative to the other stimuli they utilized while running. Although no participant increased their ranking of no audio relative to other stimuli, five participants changed their rating for no audio, and four of those five increased their level of preference after the sessions. When asked to rate the statement, “I enjoyed running with no audio playing,” Hannah increased her score from “disagree” (2) to “agree” (4), Josephine increased it from “strongly disagree” (1) to “neutral” (3), and both Paulette and Eduoard increased their ratings from “disagree” (2) to “neutral” (3). Conversely, Arthur decreased his rating for no audio from “neutral” (3) to “disagree” (2) after participating in the sessions. Overall, all participants preferred an auditory stimulus to no auditory stimulation both before and after the study.

**Experimental Design and Procedures**

A three-component multiple schedule (TCMS) design was employed to assess the effects of a test-sequence condition (e.g., music) compared to a control-sequence condition (e.g., no music). Rapp (2007) and Lanovaz et al. (2010) have outlined the TCMS as a comprehensive method for assessing the immediate and subsequent effects of an intervention, using a within-session and an across-session analysis. For the test sequence, running pace was evaluated in the first component of a session in the absence of the intervention (e.g., absence of music). As the running session continued into the second component, the intervention (e.g., music) was introduced for the same or similar period of time. Third, the intervention was withdrawn (e.g., no music), but observation of the target behavior continued into the third component of that same session, using the same duration of the first component. This within-session analysis allowed for observation of the immediate effects of a given intervention, as well as any potential subsequent effects the intervention may have on running, if any, in the third
component. The control sequence condition allowed for an across-session analysis. Similar to the test sequence, the control-sequence sessions were divided into three components for comparison to the intervention session, but no intervention was provided in the second component (or at any other time). Control sessions were alternated with the intervention sessions. A visual analysis allowed for a comparison of the components for all sessions side-by-side in a multielement design to evaluate if the intervention had any effects (e.g., sustained or deteriorating) immediately after the intervention was removed.

**Experiment 1: Presence of Music.** This experiment incorporated 15-min sessions using three 5-min components. There was at least one session per day (but no more than three), with a minimum of 6 sessions (three data points for each test and control condition). At the start of each 5-min component, the runner was given instructions for that particular run (play music or no music), and then they ran a route that lasted approximately 5 min, stopping when the researcher flagged them. The purpose of Experiment 1 was to evaluate the effects of participant-selected music on running compared to no music across multiple 15-min outdoor running sessions.

**No Music Sequence (Control).** For this condition, the participant ran for three 5-min components without any music playing.

**Music Sequence (Test).** This condition was identical to the no-music condition, except the participant was instructed to play their music at the start of the second 5-min component of the run, and then instructed to return to no music playing for the third component.

**Experiment 2: Using a Boost Song While Running to Music.** The results from the survey of Study 1 indicated that 60.98% of respondents used a designated “boost” song while running
to music to help motivate them to run. The respondent reports varied as to how they used their boost songs, ranging from playing it at the beginning, middle, or end of the run, to just when they felt they needed it. It is possible that a designated song self-selected by a runner may have an enhanced effect on running for a short burst of time. Although previous studies have evaluated the effects of high tempo versus low tempo music (e.g., Atan, 2012; Birnbaum et al., 2009; Brownley et al., 1995), motivational versus odeterous (neutral) music (e.g., Bigliassi et al., 2015; Simpson & Karageorghis, 2006; Terry et al., 2012), preferred versus non-preferred music (e.g., Cole & Maeda, 2015), quiet versus loud music (e.g., Edworthy & Waring, 2006), and music’s effects in the first half versus the second half of the run session (Lima-Silva et al., 2012), no study has evaluated the effects of a one-time short burst song that was specifically chosen by the participant for the purposes of a “boost” while running. A number of runners use this method (i.e., Study 2), and boost songs have been an available option provided in some of the popular running apps (e.g., the “powersong” setting in the adidas® Runtastic Running® app® or the Nike+ Run Club® app); therefore an evaluation of the short-term effects of a participant-selected boost song was warranted to provide further insight into the effects of a specific aspect of music.

The purpose of Experiment 2 was to compare the presence of the preferred music playlists that each runner used in Experiment 1 against a participant-selected designated boost song. Participants were included in this phase if they reported a running history using a boost song. Experiment 2 was conducted in the same manner as Experiment 1, except the first and third components of the test sequence were comprised of 5-min of music from the runner’s usual playlist, and the second component consisted of only the boost song. The duration of the
second component for Experiment 2 was 3 min, the average duration of a hit song. Using a 5-min component may have produced a false positive because participants would have longer exposure to a highly motivating song than they would in their typical runs. Moreover, previous research has shown identical effects using a 2.5-min second component when compared to a 5-min second component for the same intervention variable and participant (Rapp et al., 2016). Participants were asked to select a boost song that was around 3 min. If the boost song was slightly shorter than 3 min, the participant would repeat the beginning of the song until the component ended.

**Music Sequence (Control).** This condition was identical to the control condition of Experiment 1, except (a) the runners used their regular running playlists from Experiment 1 for all three components of the session, and (b) the duration of Component 2 was 3 min, so that is was yoked to the duration of Component 2 of the test-sequence sessions.

**Boost Song Sequence (Test).** This condition was identical to the test condition of Experiment 1, except (a) the second component of the run contained the boost song and was 3 min in duration, and (b) the first and third components were comprised of running with music from the runner’s regular playlists (also used in the control sequence).

**Experiment 3: Presence of a Preferred Non-Musical Auditory Source.** More than one third of the survey respondents (35.5%) of Study 1 indicated that they either sometimes or always listened to another auditory source besides music when they ran. This was a surprising result considering much research has emphasized the potential benefits of music during running (e.g., Karageorghis & Priest, 2012a, 2012b; Van Dyck, & Leman, 2016), while very few researchers have considered other non-musical auditory sources. When other auditory sources
were included in studies, they were often auditory sources not typically used by runners. For example, studies have evaluated word cues (Filingim & Fine, 1986), metronome beeps (Bood et al., 2013), static noise (Lee & Kimmerly, 2014; Ramji et al., 2016), and sounds from a basketball game (Ciccomascolo et al., 1995). As an exception, Miller et al. (2010) evaluated the effects of an auditory book versus music on running. Although the self-report measures in their study showed more favorable outcomes for running with music, the physiological measurements (respiratory variables) showed better results for participants who ran with the auditory book.

The survey of Study 1 indicated that for the 197 respondents that used an auditory source other than music, 91.24% listened to a preferred podcast, e-book, or talk radio. The purpose of this study was to evaluate running pace while the participant listened to a preferred podcast for participants that have a history of using podcasts when running. Experiment 3 was conducted in identical manner to Experiment 1, with 5-min components for each of the 15-min test or control sequences, but with the following modifications.

**No Podcast Sequence (Control).** This condition was identical to the control condition of Experiment 1; that is, there was an absence of any auditory stimulation (e.g., no music, no podcast) throughout the duration of the three components.

**Podcast Sequence (Test).** This condition was identical to the test condition of Experiment 1, except the runners used a preferred podcast for the second component. Similar to Experiment 1, the first and second components consisted of no sound; i.e., no podcast.
Chapter Seven:

Results

Table 4 shows a summary of outcomes (effects) for all three experiments and measures. The individual TCMS analysis for three experiments involved both an across- and within-session comparison. A within-session analysis compared the results of Components 1, 2, and 3 for the series of individual sessions. An effect may have been detected if there were different levels in the test sequence for Component 2 relative to the test sequence of Component 1. Additionally, a subsequent effect (carry-over) may have been detected for the test sequence in Component 3 relative to Components 1 and 2. A subsequent effect of increased pace may suggest the test variable (e.g., music) had a robust motivational effect in Component 2, which persisted into Component 3 after the intervention (e.g., music) was removed. An across-session analysis involved a comparison of the test (e.g., music) versus control (e.g., no music) sequences in Component 2, the only component that the intervention (e.g., presence of music) is effect for in either sequence. A separation of the data paths in Component 2 suggests an effect of the intervention (e.g., music), when combined with an effect detected for the within-session analysis (i.e., test sequence of Component 1 versus test sequence of Component 2).

Although the measure of interest was an objective performance measure (running pace), perceived exertion and heart rate were also included for each participant (excluding heart rate for Bertha and Fay). The RPE scale of 6 to 20 was designed to correlate with an
Table 4

Summary of Results for Participants Across Experiments and Measures

<table>
<thead>
<tr>
<th>Participant</th>
<th>Experiment 1: Music Playlist</th>
<th>Experiment 2: Boost Song</th>
<th>Experiment 3: Podcast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pace: No effect</td>
<td>RPE: Negative effect</td>
<td>HR: Not collected</td>
</tr>
<tr>
<td>Bertha</td>
<td>Pace: No effect</td>
<td>RPE: No effect</td>
<td>HR: Not collected</td>
</tr>
<tr>
<td>Dolly</td>
<td>Pace: Positive effect</td>
<td>RPE: No effect</td>
<td>n/a</td>
</tr>
<tr>
<td>Fay</td>
<td>Pace: No effect</td>
<td>RPE: No effect</td>
<td>n/a</td>
</tr>
<tr>
<td>Hanna</td>
<td>Pace: No effect</td>
<td>Pace: Positive effect</td>
<td>RPE: No effect</td>
</tr>
<tr>
<td>Josephine</td>
<td>Pace: No effect</td>
<td>RPE: No effect</td>
<td>RPE: No effect</td>
</tr>
<tr>
<td>Arthur</td>
<td>Pace: Positive effect</td>
<td>RPE: No effect</td>
<td>n/a</td>
</tr>
<tr>
<td>Paulette</td>
<td>n/a</td>
<td>n/a</td>
<td>RPE: No effect</td>
</tr>
<tr>
<td>Eduoard</td>
<td>Pace: No effect</td>
<td>RPE: No effect</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Note. Presence or absence of an immediate effect detected during Component 2, when the auditory stimulation was present.
exerciser’s heart rate, which will typically fall in the range of 60 to 200 (Borg, 1982). For example, a perceived exertion rating of 13 reported by an exerciser should represent a corresponding heart rate of about 130 bpm. Thus, the degree of correspondence between RPE scores and heart rate were also noted. Table 5 shows the mean scores for all participants for Experiment 1. What follows is a description of individual pace, RPE, and heart rate (when applicable) measures for each participant.

Results for Experiment 1: Music Playlist Test Sequence Versus No Music Control Sequence

Bertha

Figure 12 shows the results for Bertha’s running pace (upper three panels) and ratings of perceived exertion (lower three panels) during the first, second, and third components of the no music control sequence and the music test sequence of Experiment 1. An evaluation of Bertha’s pace data in the top panels shows that there was no difference in pace between the music and no music sequences of Component 2 and there was no difference in pace for the music sequence in Component 2, relative to Component 1. This suggests a lack of any evidence that music influenced pace. An evaluation of Bertha’s RPE scores in the bottom panel show slightly more perceived exertion in the music sequence compared to the no music sequence in Component 2, and to the music sequence in Component 1. This suggests, that for Bertha, there was a possible effect of music on perceived exertion. Bertha did not have a smart watch at the time of this study, thus we did not collect heart rate data for her sessions.

Dolly

The results for Dolly, represented in Figure 13, show her running pace in the top panels. A comparison of the music and no music sequences in Component 2 shows a faster pace when
### Table 5

**Summary of Means for Experiment 1**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Participant</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No Music Sequence</td>
<td>Music Sequence</td>
<td>No Music Sequence</td>
</tr>
<tr>
<td><strong>Pace (Min/km)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bertha</td>
<td>6.33</td>
<td>6.19</td>
<td>6.67</td>
<td>6.53</td>
</tr>
<tr>
<td>Dolly</td>
<td>7.08</td>
<td>6.97</td>
<td>6.73</td>
<td>6.24</td>
</tr>
<tr>
<td>Fay</td>
<td>6.68</td>
<td>6.06</td>
<td>6.37</td>
<td>5.80</td>
</tr>
<tr>
<td>Hanna</td>
<td>6.12</td>
<td>5.82</td>
<td>5.89</td>
<td>5.74</td>
</tr>
<tr>
<td>Arthur</td>
<td>5.95</td>
<td>5.96</td>
<td>5.90</td>
<td>5.52</td>
</tr>
<tr>
<td>Eduoard</td>
<td>5.38</td>
<td>5.50</td>
<td>5.48</td>
<td>5.50</td>
</tr>
<tr>
<td><strong>RPE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bertha</td>
<td>12.00</td>
<td>12.67</td>
<td>12.00</td>
<td>14.33</td>
</tr>
<tr>
<td>Dolly</td>
<td>11.00</td>
<td>12.00</td>
<td>13.67</td>
<td>12.50</td>
</tr>
<tr>
<td>Fay</td>
<td>12.00</td>
<td>11.33</td>
<td>11.00</td>
<td>11.33</td>
</tr>
<tr>
<td>Hanna</td>
<td>11.67</td>
<td>13.00</td>
<td>12.00</td>
<td>12.33</td>
</tr>
<tr>
<td>Josephine</td>
<td>13.00</td>
<td>11.67</td>
<td>14.00</td>
<td>13.67</td>
</tr>
<tr>
<td>Arthur</td>
<td>9.00</td>
<td>12.20</td>
<td>10.00</td>
<td>13.00</td>
</tr>
<tr>
<td>Eduoard</td>
<td>10.67</td>
<td>10.67</td>
<td>12.00</td>
<td>11.67</td>
</tr>
<tr>
<td><strong>Heart Rate (BPM)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dolly</td>
<td>133.67</td>
<td>131.00</td>
<td>145.67</td>
<td>149.00</td>
</tr>
<tr>
<td>Hanna</td>
<td>129.00</td>
<td>139.67</td>
<td>135.33</td>
<td>142.67</td>
</tr>
<tr>
<td>Josephine</td>
<td>170.00</td>
<td>159.00</td>
<td>173.33</td>
<td>169.00</td>
</tr>
<tr>
<td>Arthur</td>
<td>134.00</td>
<td>151.60</td>
<td>140.50</td>
<td>152.60</td>
</tr>
<tr>
<td>Eduoard</td>
<td>158.67</td>
<td>158.33</td>
<td>173.33</td>
<td>171.33</td>
</tr>
</tbody>
</table>
Figure 12

Experiment 1: Effects of Music Playlist Versus No Music for Bertha

Note. Pace* (upper panels) and ratings of perceived exertion (lower panels) for Bertha across the three 5-min components for the music (test) and no music (control) sequences. For the music sequences, music was available only in Component 2.
*For pace, lower data points indicate a faster speed.

Dolly listened to music. A comparison of her pace in Component 2 relative to Component 1 also shows a faster pace. These results suggest that the presence of music affected Dolly’s running performance. The middle three panels show a slight subsequent effect for Dolly’s perceived exertion. Although she reported similar levels of exertion for the music sequence of Components 1, 2, and 3, her RPE scores in Component 3 were consistently lower in the music sequence than the no music sequence. In short, she ran faster when music was present, but reported feeling less exertion for each session immediately following music’s removal. In other words, it is reasonable that she would report higher levels of exertion in the no-music sequence.
Figure 13

Experiment 1: Effects of Music Playlist Versus No Music for Dolly

Note. Pace* (upper panels), ratings of perceived exertion (middle panels), and heart rate (lower panels) for Dolly across the three 5-min components for the music (test) and no music (control) sequences. For the music sequences, music was available only in Component 2.
*For pace, lower data points indicate a faster speed.

for the third component (vs the first and second components) of her runs, thus higher levels would likewise be expected for the music sequence of the third component compared to the first and second components. Hence, the similar levels for the music sequence in all components for the within-session analysis may support the across-session analysis in
Component 3, suggesting a minor subsequent effect for her exertion (with no immediate effect in Component 2). The lower three panels show there were no apparent effects of music on Dolly’s heart rate when analyzed within- and across-sessions. The trend of Dolly’s ratings of perceived exertion did not correspond well to her heart rate, and she generally rated her exertion at moderately lower level than her heart rate.

_Fay_

Figure 14 shows the results for Fay across the no music and music sequences for pace and RPE. Although she had a smart watch, it was initially not displaying heart rate; thus heart rate data were not collected for Fay’s sessions. Fay’s mean pace indicates she ran faster in the music-sequence sessions than the no-music-sequence sessions for all components across sessions. However, visual analysis of Fay’s data demonstrates high variability with a clear absence of differentiation across the no music and music sequences. Additionally, there are no differences within sessions, depicted by the similar overall levels in pace for music sequence in Component 2 relative to Component 1. Fay’s exertion data show no differences in level of pace using a within-session analysis (music sequence of Component 1 versus music sequence of Component 2) or differentiation across the no music and music sequences. Taken together, these results suggest there are no effects of music on Fay’s running pace or level of exertion.

_Hanna_

Hanna’s results for running pace, RPE, and heart rate are depicted in Figure 15. The results for her pace show faster runs in the music sequence compared to the no music sequence in the first component, suggesting any differences across no music and music
**Figure 14**

*Experiment 1: Effects of Music Playlist Versus No Music for Fay*

*Note.* Pace* (upper panels) and ratings of perceived exertion (lower panels) for Fay across the three 5-min components for the music (test) and no music (control) sequences. For the music sequences, music was available only in Component 2.*

*For pace, lower data points indicate a faster speed.

sequences in Components 2 and 3 should be interpreted with caution to avoid a false positive. A within-session analysis for the first session (Component 1 vs. Component 2) indicates she ran faster in the presence of music, but this effect was not maintained for the subsequence sessions. Further, the no-music control sequence in Component 2 was also generally lower than the no music sessions in the first component, and ultimately, the test and control sequences were undifferentiated for Component 2. Hanna’s reports of perceived exertion were undifferentiated across the no music and music sequences, and no differences were detected for the music sequence when comparing Component 1 to Component 2 (and no difference in
Component 3). In the same way, within- and across-session analyses did not detect any differences in Hanna’s heart rate when she listened to music. The trend and level of Hanna’s RPE scores closely corresponded to that of her heart rate.

Figure 15

Experiment 1: Effects of Music Playlist Versus No Music for Hanna

Note. Pace* (upper panels), ratings of perceived exertion (middle panels), and heart rate (lower panels) for Hanna across the three 5-min components for the music (test) and no music (control) sequences. For the music sequences, music was available only in Component 2. *For pace, lower data points indicate a faster speed.
Josephine

Figure 16 depicts the results for Josephine’s running pace, RPE, and heart rate for the no music and music sequences. A within-session analysis shows no difference in the level of pace for the music sequence when compared across all three components. An across-session analysis shows that pace was undifferentiated across no music and music sequences for all components. These results indicate listening to music did not affect Josephine’s running pace. Likewise, the within- and across-session analyses showed a lack of effect for music on Josephine’s level of exertion and heart rate. Although there were matching trends when comparing Josephine’s RPE and heart rate data, the levels were substantially different across the two measures. That is, her heart rate was at an overall higher level compared to her reported levels of exertion.

Arthur

Figure 17 shows Arthur’s pace, RPE, and heart rate for the no music and music sequences for all three components. There were no differences for Arthur’s pace between the no music and music sequences in the first and third components. A within-session analysis revealed a faster pace for the music sequence in the second component compared to the music sequence in the first and third components. A separation of data was also detected between the music and no music sequences for Component 2, with the music sequence at a noticeably lower (quicker) level. In short, the presence of music positively affected Arthur’s running performance. Arthur rated his perceived exertion generally lower for the no music sequence compared to the music sequence for Component 2. However, a within-session analysis show the Component 2 RPE levels replicated those from baseline assessments in Component 1,
Figure 16

*Experiment 1: Effects of Music Playlist Versus No Music for Josephine*

Note. Pace* (upper panels), ratings of perceived exertion (middle panels), and heart rate (lower panels) for Josephine across the three 5-min components for the music (test) and no music (control) sequences. For the music sequences, music was available only in Component 2. *For pace, lower data points indicate a faster speed.

precluding any effect that may have been interpreted across no music and music sequences in the second component. Arthur’s heart rate was consistent and stable for the no music and music sequences in all components, with no discernable differences detected using a within-
and across-session analysis, demonstrating listening to music did not affect his heart rate while running. There was a lack of correspondence for Arthur’s RPE scores and heart rate.

Figure 17

*Experiment 1: Effects of Music Playlist Versus No Music for Arthur*

*Note.* Pace* (upper panels), ratings of perceived exertion (middle panels), and heart rate (lower panels) for Arthur across the three 5-min components for the music (test) and no music (control) sequences. For the music sequences, music was available only in Component 2. *For pace, lower data points indicate a faster speed.*
**Eduoard**

Figure 18 shows the results for Eduoard’s running pace, RPE, and heart rate for the no music and music sequences. A within-session analysis shows no changes in the level of pace for the music sequence when compared across all three components. An across-session analysis shows that pace was undifferentiated across no music and music sequences for all components. In short, listening to music did not affect running pace for Eduoard. Similarly, a within- and across-session analyses did not detect an effect for Eduoard’s perceived exertion and heart rate. The trends for Eduoard’s RPE and heart rate closely matched, but he rated his exertion at a substantially lower level than his heart rate.

**Results for Experiment 2: Boost Song Test Sequence Versus Music Playlist Control Sequence**

Table 6 shows the mean scores for all participants for Experiment 2. Individual outcomes for pace, RPE, and heart rate (when applicable) measures for each participant are described hereafter.

**Bertha**

Figure 19 shows the results for Bertha’s running pace and perceived exertion for the boost song sequence when compared to the music playlist sequence for the three components. For running pace, no differences were apparent between the music playlist and boost song sequences in Component 1. In the second component of the first four sessions, there was a clear separation for pace across the playlist and boost sequences; however as more sessions were implemented, this separation narrowed to an undifferentiated outcome. Additionally, pace in the music sequence in Component 2 increased in level (i.e., slower pace) compared to the music sequence for Component 1 for the final two test sessions. Although a separation of
**Figure 18**

*Experiment 1: Effects of Music Playlist Versus No Music for Eduoard*

Note. Pace* (upper panels), ratings of perceived exertion (middle panels), and heart rate (lower panels) for Eduoard across the three 5-min components for the music (test) and no music (control) sequences. For the music sequences, music was available only in Component 2.

*For pace, lower data points indicate a faster speed.

playlist and boost sequences can be observed for Component 3, with a faster pace in the boost song sequence, there is little confidence an effect is present. The differentiation is slight with only two data points outside of the mean range for the control sequence, and the pattern closely corresponds to the undifferentiated outcome from the first component.
### Table 6

**Summary of Means for Experiment 2**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Participant</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Playlist Sequence</td>
<td>Boost Song Sequence</td>
<td>Playlist Sequence</td>
</tr>
<tr>
<td>Pace (Min/km)</td>
<td>Bertha</td>
<td>6.17</td>
<td>6.01</td>
<td>6.48</td>
</tr>
<tr>
<td></td>
<td>Dolly</td>
<td>6.88</td>
<td>6.59</td>
<td>6.32</td>
</tr>
<tr>
<td></td>
<td>Fay</td>
<td>7.01</td>
<td>6.52</td>
<td>6.85</td>
</tr>
<tr>
<td></td>
<td>Hanna</td>
<td>5.94</td>
<td>5.96</td>
<td>5.81</td>
</tr>
<tr>
<td></td>
<td>Josephine</td>
<td>6.27</td>
<td>6.05</td>
<td>5.92</td>
</tr>
<tr>
<td></td>
<td>Arthur</td>
<td>6.51</td>
<td>6.43</td>
<td>5.59</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Participant</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Playlist Sequence</td>
<td>Boost Song Sequence</td>
<td>Playlist Sequence</td>
</tr>
<tr>
<td>RPE</td>
<td>Bertha</td>
<td>12.25</td>
<td>12.00</td>
<td>12.75</td>
</tr>
<tr>
<td></td>
<td>Dolly</td>
<td>11.25</td>
<td>12.00</td>
<td>11.50</td>
</tr>
<tr>
<td></td>
<td>Fay</td>
<td>10.50</td>
<td>10.33</td>
<td>9.75</td>
</tr>
<tr>
<td></td>
<td>Hanna</td>
<td>11.75</td>
<td>12.25</td>
<td>12.00</td>
</tr>
<tr>
<td></td>
<td>Josephine</td>
<td>13.33</td>
<td>13.33</td>
<td>14.00</td>
</tr>
<tr>
<td></td>
<td>Arthur</td>
<td>10.33</td>
<td>13.00</td>
<td>13.67</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Participant</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Playlist Sequence</td>
<td>Boost Song Sequence</td>
<td>Playlist Sequence</td>
</tr>
<tr>
<td>Heart Rate (BPM)</td>
<td>Dolly</td>
<td>131.75</td>
<td>127.50</td>
<td>135.75</td>
</tr>
<tr>
<td></td>
<td>Hanna</td>
<td>135.50</td>
<td>158.50</td>
<td>140.25</td>
</tr>
<tr>
<td></td>
<td>Josephine</td>
<td>169.00</td>
<td>169.33</td>
<td>173.33</td>
</tr>
<tr>
<td></td>
<td>Arthur</td>
<td>148.00</td>
<td>157.67</td>
<td>149.00</td>
</tr>
</tbody>
</table>
Bertha rated her perceived exertion as nearly the same for the music playlist and boost song sequences of Components 1 and 2. A moderate effect was observed in Component 3 for the music playlist and boost song sequences, whereby Bertha consistently rated lower exertion for run segments that occurred after her boost song was removed (but the music playlist was present). Although Dolly demonstrated a similar outcome to Bertha for Experiment 1, the differences in mean scores across test and control sequences for Dolly (M= 1.5) was double that for Bertha’s mean difference (M=0.75). Thus any conclusion of a subsequent effect of music on Bertha’s perceived exertion should be interpreted conservatively.

**Figure 19**

*Experiment 2: Effects of Boost Song Versus Music Playlist for Bertha*

- **Note.** Pace* (upper panels) and ratings of perceived exertion (lower panels) for Bertha across the three components (5 min, 3 min, 5min) for the boost song (test) and music playlist (control) sequences. For the boost song sequences, boost song was available only in Component 2.
  *For pace, lower data points indicate a faster speed.*
**Dolly**

Figure 20 shows that Dolly generally started her runs at a slower pace and sped up through the remainder of her run after her first 5 min. Despite her first two music playlist control sessions in the second component showing marked increase (lower level) in pace for Dolly, she ran her quickest pace in the second component when she listened to her boost song (third session). However, this effect did not maintain with the implementation of further control and test sequence sessions. In short, any potential effect on pace noted with the within-session analysis for the music sequence was negated by the across-session analysis, showing a lack of differentiation between the playlist and boost song sequences in the second component. Dolly’s pace in the third component was comparable to the second component, with no subsequent effects. There were no changes for the boost song sequence in both a within- and across-sequence analysis for RPE and heart rate. Dolly’s perceived exertion was at a level and trend that closely resembled her heart rate data.

**Fay**

Similar to her results from Experiment 1, Figure 21 shows high variability for Fay’s running pace, but no discernable effect across sessions when comparing the music playlist and boost sequences. There was also no within-session changes for the music sequence in Component 2 compared to Component 1. Likewise, a within-session analysis for Fay’s RPE shows the levels of perceived exertion for the boost song here nearly identical for all components. Overall, listening to a boost song did not change Fay’s running pace or perceived exertion.
**Figure 20**

Experiment 2: Effects of Boost Song Versus Music Playlist for Dolly

![Graphs showing experimental data for Dolly across three components (Comp 1, Comp 2, Comp 3).](image)

**Note.** Pace* (upper panels), ratings of perceived exertion (middle panels), and heart rate (lower panels) for Dolly across the three components (5 min, 3 min, 5 min) for the boost song (test) and music playlist (control) sequences. For the boost song sequences, boost song was available only in Component 2.

*For pace, lower data points indicate a faster speed.

**Hanna**

Figure 22 shows a positive effect for the boost song (test) sequence for Hanna’s running pace, as detected by a within- and across-session analyses. A within-session analysis reveals that her running pace was substantially quicker for the boost song sequence in Component 2.
Figure 21

*Experiment 2: Effects of Boost Song Versus Music Playlist for Fay*

**Note.** Pace* (upper panels) and ratings of perceived exertion (lower panels) for Fay across the three components (5 min, 3 min, 5 min) for the boost song (test) and music playlist (control) sequences. For the boost song sequences, boost song was available only in Component 2.

*For pace, lower data points indicate a faster speed.*

than it was for the boost song sequence of Component 1 (and Component 3). An across-session analysis in Component 2 shows that her boost song sequence was run at a faster pace than her music playlist sequence in the same component. There is a slight differentiation across the music playlist and boost song sequences in Component 3. The level of the boost song sequence in Component 3 is also only slightly faster in the third component relative to the first. Although these analyses indicate a possible subsequent effect, the changes detected in both analyses were minimal, and the conclusion of a subsequent effect should be interpreted conservatively.

There were no noticeable differences for the boost song sequence in both a within- and across-
sequence analysis for Hanna’s perceived exertion and heart rate. Her RPE and heart rate had a close correspondence in trend, but RPE and heart rate did not have the same correspondence in level, as they did for Experiment 1.

Figure 22

Experiment 2: Effects of Boost Song Versus Music Playlist for Hanna

Note. Pace* (upper panels), ratings of perceived exertion (middle panels), and heart rate (lower panels) for Hanna across the three components (5 min, 3 min, 5min) for the boost song (test) and music playlist (control) sequences. For the boost song sequences, boost song was available only in Component 2.
*For pace, lower data points indicate a faster speed.
Josephine’s running pace, RPE, and heart rate for the music playlist and boost song sequences are depicted in Figure 23. An across-session analysis reveals that her pace was undifferentiated between the music playlist and boost song sequences for all components. Although Josephine’s quickest pace occurred for the second component of the boost song sequence in Component 2, the other two sessions of her boost song sequence in Component 2 were similar to that of Component 1, precluding any conclusion of a positive effect for music. Furthermore, the result with next quickest pace was in the music playlist (control) sequence of the second component, indicating she generally ran faster in the second component regardless of music’s availability. Josephine’s RPE scores were also undifferentiated for the music playlist and boost song sequences. A within-session analysis shows Josephine’s RPE scores slightly elevated for the boost song sequence in second component compared to the first, but the same change can be observed for the music playlist sequence, indicating she perceived slightly higher exertion in the second component of all of her runs, regardless of the type of music she was listening to. Josephine’s heart rate was also undifferentiated across the music playlist and boost song sequences for the across-session analysis. Likewise, a within-session analysis shows there was a steady heart rate level for the boost song sequence with no changes from Component 1 to Components 2 and 3. In sum, no effects were detected for the boost song versus playlist across all three measures for Josephine. Although her RPE scores had a similar trend to her heart rate, they were generally at a lower level, replicating the RPE and heart rate correspondence patterns observed for Experiment 1.
Experiment 2: Effects of Boost Song Versus Music Playlist for Josephine

Note. Pace* (upper panels), ratings of perceived exertion (middle panels), and heart rate (lower panels) for Josephine across the three components (5 min, 3 min, 5min) for the boost song (test) and music playlist (control) sequences. For the boost song sequences, boost song was available only in Component 2.

*For pace, lower data points indicate a faster speed.

Arthur

Figure 24 shows the results for Arthur’s running pace, perceived exertion, and heart rate for the boost song and music playlist sequences in all components. Arthur’s running pace in Component 1 was variable for both sequences, suggesting an inconsistent pattern was typical.
to the initial part of Arthur’s runs. The overall level of running pace in the second component of the boost song sequence was similar to that of the first component, indicating that listening to the boost song did not affect Arthur’s speed. Although there was a slight increase in pace (i.e., decreased level) for the music playlist sequence in Component 2, no effect is present because a within-session analysis cannot be applied to the control sequence in the same way as the test sequence. Said differently, Arthur was listening to music playlist for all three components of the music playlist sequence. Any change in level for the playlist sequence in the second component compared to the first was likely a result of his usual running pattern. This conclusion is supported by the similar pattern observed for both sequences in each component. In the same vein, an across-session analysis between the music playlist and boost-song sequences in the second component show a slight separation with a faster speed in the music playlist sequence, but the separation is narrow with only one of the three playlist data points depicting any noticeable difference in pace. No subsequent effects on pace were observed within or across sessions for Component 3.

Arthur’s perceived exertion was undifferentiated across sequences for all three components, but his RPE scores were variable for the only first two components. For Component 3, he reported the exact same level of exertion for all sessions and across both sequences. Regardless of the inconsistent trends, a within- and across-session analysis show no effects of the boost song on Arthur’s perceived exertion, when compared to listening to the music playlist. More consistent patterns are observed for Arthur’s heart rate. No effects are detected for the boost song on his heart rate when comparing across sequences and between components. In short, listening to a boost song was no different than a music playlist for
Arthur’s pace, perceived exertion, and heart rate. Similar to the results from Experiment 1, Arthur’s ratings of perceived exertion did not correspond to his heart rate.

Figure 24

Experiment 2: Effects of Boost Song Versus Music Playlist for Arthur

Note. Pace* (upper panels), ratings of perceived exertion (middle panels), and heart rate (lower panels) for Arthur across the three components (5 min, 3 min, 5min) for the boost song (test) and music playlist (control) sequences. For the boost song sequences, boost song was available only in Component 2.
*For pace, lower data points indicate a faster speed.
Results for Experiment 3: Podcast Test Sequence Versus No Podcast Control Sequence

The mean scores for all participants in Experiment 3 are displayed in Table 7. Hereafter, individual outcomes for pace, RPE, and heart rate (when applicable) measures for each of the four participants in Experiment 3.

Table 7

Summary of Means for Experiment 3

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Participant</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No Podcast Sequence</td>
<td>Podcast Sequence</td>
<td>No Podcast Sequence</td>
</tr>
<tr>
<td>Pace (Min/km)</td>
<td>Bertha</td>
<td>7.10</td>
<td>6.99</td>
<td>7.53</td>
</tr>
<tr>
<td></td>
<td>Hanna</td>
<td>5.98</td>
<td>5.98</td>
<td>5.98</td>
</tr>
<tr>
<td></td>
<td>Paulette</td>
<td>6.61</td>
<td>6.59</td>
<td>6.55</td>
</tr>
<tr>
<td></td>
<td>Eduoard</td>
<td>5.32</td>
<td>5.38</td>
<td>5.45</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Participant</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No Podcast Sequence</td>
<td>Podcast Sequence</td>
<td>No Podcast Sequence</td>
</tr>
<tr>
<td>RPE</td>
<td>Bertha</td>
<td>8.77</td>
<td>8.77</td>
<td>9.09</td>
</tr>
<tr>
<td></td>
<td>Hanna</td>
<td>12.33</td>
<td>12.33</td>
<td>13.00</td>
</tr>
<tr>
<td></td>
<td>Paulette</td>
<td>14.00</td>
<td>14.33</td>
<td>15.00</td>
</tr>
<tr>
<td></td>
<td>Eduoard</td>
<td>11.67</td>
<td>11.00</td>
<td>12.67</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Participant</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No Podcast Sequence</td>
<td>Podcast Sequence</td>
<td>No Podcast Sequence</td>
</tr>
<tr>
<td>Heart Rate (BPM)</td>
<td>Hanna</td>
<td>133.00</td>
<td>135.67</td>
<td>134.67</td>
</tr>
<tr>
<td></td>
<td>Paulette</td>
<td>143.67</td>
<td>143.33</td>
<td>151.67</td>
</tr>
<tr>
<td></td>
<td>Eduoard</td>
<td>158.67</td>
<td>159.67</td>
<td>172.00</td>
</tr>
</tbody>
</table>
Bertha

Figure 25 depicts Bertha’s running pace and ratings of perceived exertion for the no podcast and podcast sequences in all components. An across-session analysis in Component 2 shows undifferentiated results for Bertha’s running pace between the no podcast and podcast sequences. A within-session analysis shows no meaningful change for the podcast sequence from Component 1 to Component 2. Although the overall mean of the podcast sequence is higher in the second component than the first, half of the Component 1 sessions are within the same range as all sessions in Component 2. Furthermore, the no podcast control sequence exemplifies the same pattern across Components 1 and 2, supporting the conclusion of no effect for podcast on Bertha’s running pace. Bertha reported RPE scores that were consistent within and across sessions. That is, her exertion closely overlapped across the no podcast and podcast sequences, and her RPE level was similar for the podcast sequence in the second component compared to the first and third components. In sum, listening to a podcast did not change Bertha’s running performance or perceived exertion.

Hanna

The results for Hanna’s running pace, perceived exertion, and heart rate are displayed in Figure 26 for the no podcast and podcast sequences. A within-session analysis shows no change in Hanna’s pace for the podcast sequence in the second component relative to the podcast sequence in first and third components. Likewise, no change can be detected for an across-session analysis between the no podcast and podcast sequences. The results for RPE and heart rate matched that of the pace measures. Overall, there were no effects of podcast for Hanna’s pace, RPE, or heart rate. The correspondence for Hanna’s RPE scores and heart rate were
Figure 25

Experiment 3: Effects of Podcast Versus No Podcast for Bertha

Note. Pace* (upper panels) and ratings of perceived exertion (lower panels) for Bertha across the three 5-min components for podcast (test) and no podcast (control) sequences. For the podcast sequences, podcast was available only in Component 2.
*For pace, lower data points indicate a faster speed.

somewhat similar in trend, but the level of correspondence was more closely aligned across the two measures.

Paulette

Figure 27 depicts results for Paulette’s running pace, ratings of perceived exertion, and heart rate for the no podcast and podcast sequences. An across-session analysis clearly demonstrates no differentiation for running pace across the no podcast and podcast sequences. Although one of Paulette’s fastest times occurs in the second component for the podcast sequence, a within-session analysis shows there was no noticeable change in level for
Figure 26

Experiment 3: Effects of Podcast Versus No Podcast for Hanna

Note. Pace* (upper panels), ratings of perceived exertion (middle panels), and heart rate (lower panels) for Hanna across the three 5-min components for podcast (test) and no podcast (control) sequences. For the podcast sequences, podcast was available only in Component 2. *For pace, lower data points indicate a faster speed.

the podcast sequence when comparing all components. Paulette’s RPE and heart rate scores reflect the same lack of separation between the podcast and podcast sequences for either measure. Likewise, her reports of exertion for Component 2 were similar to those reported for Component 2 and 3; a result replicated for her heart rate. Taken together, Paulette’s results for
pace, RPE, and heart rate indicate that listening to a podcast did not affect any dimension of her running. Although the trend and level of her RPE scores closely aligned to those of her heart rate for Component 2, and mean scores for all components were also well matched, Components 1 and 3 had little correspondence for individual sessions.

Figure 27

Experiment 3: Effects of Podcast Versus No Podcast for Paulette

Note. Pace* (upper panels), ratings of perceived exertion (middle panels), and heart rate (lower panels) for Paulette across the three 5-min components for podcast (test) and no podcast (control) sequences. For the podcast sequences, podcast was available only in Component 2. *For pace, lower data points indicate a faster speed.
Running pace, perceived exertion, and heart rate for Eduoard is shown in Figure 28 for the no podcast and podcast sequences. An across-session analysis indicates Eduoard’s pace had little to no separation for the no podcast and podcast sequences in all components. Additionally, a within-session analysis shows the level of pace was nearly identical in the podcast sequence from Component 1 to Component 2, and no subsequent changes were detected for Component 3, demonstrating that podcast did not affect Eduoard’s running performance. His ratings of exertion and heart rate were similarly undifferentiated and consistent within and across the no podcast and podcast sequences for all components, with no changes for the podcast sequence when comparing components. Thus, as shown with running pace, listening to podcast did not affect Eduoard’s perceived exertion or heart rate. While trends for Eduoard’s RPE generally corresponded to his heart rate, the levels of heart rate were much higher for both sequences.
Figure 28

Experiment 3: Effects of Podcast Versus No Podcast for Eduoard

Note. Pace* (upper panels), ratings of perceived exertion (middle panels), and heart rate (lower panels) for Eduoard across the three 5-min components for podcast (test) and no podcast (control) sequences. For the podcast sequences, podcast was available only in Component 2. *For pace, lower data points indicate a faster speed.
Chapter Eight:

Discussion

Results from the survey of Study 1 indicated that 46% (N=336) of experienced runners initially began running to lose weight (19%) or for general exercise to maintain their weight or fitness levels (27%). Survey respondents ranged in age from 18 to 72, but 82% were 30 to 59 years old. Taken together, these results suggest that running is a viable mode of exercise effective at supporting the health and wellbeing of adults, and may be maintained as an exercise over long periods of time. Indeed 97.48% (N=541) of adults that responded to the survey had run for more than one year, and had continued to run for an average of 12.13 years (range, 1 to 47). Nearly all studies from the body of literature reviewed in this study included college-aged participant samples, and the participant age (when specified) averaged in the early-20s. Despite the reasonable approach of recruiting young adults as a sample population for fitness literature, data from Study 1 suggest that future research should consider using populations that are more representative of the higher age demographics of runners. As such, this information guided recruitment methods for Study 2 to seek runners from the general population. The mean age of the eight participants for Study 2 was 40 years old, exactly matching that of the survey sample.

The survey results of 555 runners also indicated that 77.12% (N=428) of runners listen to music while they run and of those, 60.98% (N=261) use a boost song to amplify music’s effects within their run. Moreover, 35.5% (N=197) of runners listen to a podcast (or similar) while
running. To that end, we evaluated the effects of (a) music playlist, (b) boost song, and (c) podcast on running for Study 2. Despite all participants reporting a preference for listening to music when they run, Experiment 1 demonstrated that music had an effect on running pace for only two of six participants, Dolly and Arthur. Interestingly, Bertha’s reports of exertion were higher for the music condition versus the no music condition, suggesting the music components felt harder to her; but there was no difference for her running pace across those same conditions. Another surprising result was a possible effect on Dolly’s perceived exertion in the third component, after she had listened to music in the previous component. Specifically, Dolly reported that she felt less exertion after running the final component during the music sequence (5 min after she heard music) than for the no-music sequence (music absent throughout).

Despite music having no effect for Hanna’s running pace in Experiment 1, the assessments of Experiment 2 showed that a self-designated boost song did increase the speed of her running. Furthermore, this effect maintained into the third component after music exposure was withdrawn. These results suggest that specific songs are more likely to function as an establishing operation evoking faster running for Hanna in particular, and the boost song continued to influence her running for at least a brief period after its cessation, though to a lesser degree. Behavior persistence or momentum may be responsible for the subsequent effect. Hanna’s chosen boost song played at 88 BPM, a song pace considered to be substantially lower than the widely recommended >120 BPM to achieve the motivational effects of music (Karageorghis & Preist, 2012b). Furthermore, the mean BPM of the comparative control for her second component was 125 BPM (range, 66 BPM to 142 BPM), indicating that the BPM was
likely not a factor in producing the EO related to the boost song. The body of literature reviews on music and exercise, broadly, suggests that a song’s BPM is an important component for an effect (e.g., Bishop, 2010; Karageorghis et al., 2012; Karageorghis, & Priest, 2012a, 2012b; Karageorghis, & Terry, 1997; Koc, & Curseit, 2009 Van Dyck, & Leman, 2016). However, Hanna’s results provide further evidence for the literature on music that is specifically related to running (not exercise, broadly), which has contrarily found changes in running regardless of the level of BPM used for the songs (e.g., Copeland & Franks, 1991; Simpson & Karageorghis, 2006). Consistent with the abundance of behavioral literature demonstrating the reinforcement effects of preferred stimuli (e.g., Davis et al., in press), music preference, as selected by the runner, is likely responsible for any motivational effects related to running. There was no differentiation in pace for any of the other participants for the boost-song evaluations.

For the evaluations in Experiment 3, playing a podcast did not affect running pace, perceived exertion, or heart rate for any participant. This may suggest that any effects of audio stimulation on running are due to the musicality involved in listening to songs, rather than simply having an auditory source to improve the effortful experience. However, any conclusions from these findings are limited for at least two reasons. First, only four participants were included in this experiment, with only two participants (Eduard and Hanna) having results that could be objectively compared to their music analyses. Paulette did not participate in either music experiment, thus we cannot compare her results to outcomes with music. It is possible that music also may not have had an effect on her running. Although Bertha did participate in all three experiments, she served as a pilot participant and did not fully meet the eligibility requirements for the podcast experiment; that is, she did not run with podcast in her usual runs
prior to the study. As a result, her podcast evaluations did not assess potentially effective methods that she already used, as was done for the other participants. Therefore, any comparisons made between her music and podcast analyses may not be representative of runners who already use both modalities in their runs.

Second, an effect on pace was not observed for Hanna or Edouard when they listened to music in Experiment 1. Nonetheless, Hanna ran faster when she heard her boost song in Experiment 2, supporting that an aspect of highly preferred music (a specific song) likely had a motivational effect versus various preferred songs in rotation or a non-musical auditory stimulus. The purpose of listening to podcast for runners may not be for motivation, but rather for enjoyment (running is a convenient activity that allows them to listen to a podcast) or to lessen the aversive aspect involved in effortful activities. Indeed, participants reported that they use podcast to “focus on something besides running,” for “low-key easy runs,” to be able to “attend to the (podcast) dialogue” and “distract from the run,” to stay “occupied,” and to “pass the time.” Following the study, Bertha reported using podcast for some of her runs despite the fact she did not use them prior to the study, and after she learned that neither music nor podcast affected her running pace.

As a whole, no effects were detected for heart rate across all participants in all experiments of Study 2. Additionally, with the exception of Bertha in Experiment 1, auditory stimulation (music, podcast) did not affect the participants’ perceived exertion for any experiment. The correspondence between ratings of perceived exertion and heart rate was assessed for each individual, and there was some alignment for several participants, lending some support to the validity of RPE scale. However, correspondence typically related to trend
across individual sessions rather than level. For example, an RPE score of 12 did not necessarily correspond to a heart rate 120 BPM. Borg (1982) suggested that there will be individual variances in correspondence, depending on context and activity. Nevertheless, the correspondence between heart rate and RPE was inconsistent within and across participants for all experiments in Study 2, even though all runners were assessed only for only one exercise (running) and all used the same context (outdoor park setting).

For instance, there was very low correspondence between RPE and heart rate for Arthur. In reporting scores using the visual RPE scale, he tended to select only the salient numbers on the scale, 9, 13, and 17, each of which were supplemented with a textual description. Moreover, another participant, Fay likely deviated from the intended interpretation for scoring RPE. Though we did not collect data for her heart rate, Fay rated her RPE substantially lower than other runners, and the typical range for an active heart rate during running. Furthermore, Bertha reported substantially lower RPE means for Experiment 3 than she did for Experiments 1 and 2. However, there was a 4 month lag between Experiments 2 and 3 during a public lockdown due to the COVID-19 pandemic, thus there may have been a drift for her interpretation of reporting RPE scores from the first two experiments to the podcast assessment. Regardless, any drift would not account for inconsistent correspondence within participants for Hanna’s levels in Experiment 2 versus her ratings in Experiments 1 and 3. It’s also noteworthy that there was an effect on Hanna’s pace in Experiment 2, but this effect was not reflected in her ratings of exertion or heart rate. Individual interpretations of self-report assessments may contribute to threats to validity for subjective measures. Moreover, heart rate did not provide any useful indicators of performance, thus self-reports of exertion that
correspond to heart rate have limited utility. The implications of observing a change in heart rate are not clear, and indeed may be contraindicated. A decrease in heart rate may suggest a more relaxed state during high exertion thus better likelihood of adherence, but it also results in lower calorie expenditure (Birnbaum et al., 2009).

Positive effects of auditory stimulation on running performance were found for only three of the 18 analyses (for pace) in Study 2, and measuring pace as the primary dependent variable was imperative to detect these effects. Had this study used only RPE or heart rate as a primary measure, as previous studies have done, results would have yielded three false negatives (Dolly, Arthur, and Hanna). That is, no effects would have been found for running when there are indeed evidence of three. The lack of correspondence between RPE and heart rate measures with running pace indicate that self-report and physiological measures may not be valid indicators of improvements in running performance. Despite these findings supporting similar conclusions in the literature (e.g., Yu & Bil, 2010), RPE is a widely accepted and utilized measure in the fitness arena (Centers for Disease Control and Prevention, 2020; The Nutrition Source, n.d.). As suggested by these results, runners who seek to improve the speed of their run should collect data using a specific performance measure, such as pace.

The results of Study 2 also highlight the sensitivity of the TCMS design for detecting effects or non-effects for individual runners. An across-session analysis of Bertha’s pace in Component 3 of Experiment 1 may indicate that previous exposure to music was responsible for mostly faster running; however a combined within- and across-session analysis illuminates that there were indeed no differences because she ran most of the test-sequence sessions faster than the control-sequence sessions before she was exposed to music. In other words, she
coincidentally ran faster overall on music-sequence days, regardless of the presence or absence or music. Similarly for Fay, the mean pace of her runs in Experiment 1 widely differed for each sequence across sessions but, for the most part, her pace was highly consistent for the entirety of each session as shown using a within-session analysis comparing the three components for individual sessions. Said differently, she ran with a consistently quicker pace on some days than others. For both Bertha and Fay, an across- and within-session analysis exposes the lack of effect, averting any false positive outcomes that may have been interpreted by a single analysis or a difference in means.

Contrarily, a within-session analysis for Bertha’s pace in Experiment 1 may suggest that music had a deleterious effect on her pace because her running progressively slowed during and after music; however an across-session analysis shows the same within-session running trend across every run session; in short, Bertha ran with an initially quick pace that slowed over the course of that run. Likewise, a within-session analysis incorrectly shows an effect for Josephine’s runs in Experiment 2. Within-session data suggest that she ran slightly faster in the second component of the music sequence, when music was present compared to the first and third components when music was absent. However, the combination of a within- and across-session analysis demonstrates that she similarly ran faster in the second component of the no music sequences, thus faster running in Component 2 was not the result of music. Additionally, Hanna’s results in Experiment 1 and Bertha’s results in Experiment 2 showed an initial effect with music for each participant in Component 2, but additional sessions depict that these effects did not maintain differentiation both within and across sessions. This highlights the importance of repeated measures using within-subject designs to reliably demonstrate
functional control of a specific variable, such as music, when individualized improvement is the primary interest.

Relatedly, when researchers evaluate a specific intervention to determine its effectiveness and findings are mixed, a series of individual assessments may better detect idiosyncratic effects and the extent of its generality across individuals. A within-subject design provides sensitivity in detecting changes that may go unnoticed, or be over-emphasized, by averages used in group designs. For example, a statistical two-tailed T-test shows the second component of the music condition for Experiment 1 to be statistically significant ($p<0.05$) when compared to no-music condition of the second component of the control sequence ($p=0.0279$). Nonetheless, the within-subject TCMS analysis shows an effect for only two of seven participants. In other words, a group design would suggest an effect for the presence of music for increasing running pace, but an individual analysis shows a music intervention as effective for only 28.57% of the runners for whom it was evaluated. The same statistical analysis shows no significant effect for all other experiments and measures across each Component 2 comparison; however, the TCMS detected individual effects on pace for one participant in Experiment 2, and in RPE for one participant in Experiment 1. In sum, using single-subject experimental designs may be highly valuable to assess and make intervention decisions for individuals in contexts such as sport and fitness (Barker et al., 2011).

Overall, the results of Study 2 indicate that music’s effects on running pace are likely idiosyncratic across individuals. This is further supported by the results of the survey in Study 1, which indicated 35.5% ($N=197$) of runners reported they use non-musical auditory stimuli and 18.81% ($N=104$) always prefer no audio in their runs, while 30.56% ($N=169$) sometimes prefer
no audio on their runs. These results may indicate that audio, or lack thereof, serves a different function across runners.

One possible limitation to these results is that the three components of each session included a brief break between Components 1 to 2 and 2 to 3. These breaks were to collect heart rate, RPE, and provide clear delineations of each component in the app to collect pace data. It is unknown if results would differ had the participants continued running throughout the entire 15-min (or 13-min) session. Nevertheless, brief breaks are typical practice when using a series of a repeated condition (e.g., Querim et al., 2013). Furthermore, interval training is a common method used in running for efficient weight loss (e.g., Maillard et al., 2017) and cardiovascular improvements (e.g., Wisloff et al., 2009). Future research should consider methods to employ continuous components compared to repeating the series of a condition to determine if music effects are different when runs are continuous versus carried out in intervals.

A second limitation is that heart rate was collected at the end of each component instead of using the average BPM throughout the component. This was done to provide a metric comparable to RPE, a rating which is designed to simulate a heart rate measure. Because RPE is provided as a single score reported at the end of each condition, heart rate was collected in the same manner. However, once the runner stops, the heart rate slows and this variable may have differed across a few seconds. Furthermore, reporting RPE at the same time as heart rate may have influenced the runner’s self-evaluation of their RPE. Additionally, heart rate data were collected from each runner’s own device, and the accuracy of the heart rate values were not assessed. Thus, future studies should (a) evaluate if the average component’s heart rate is
comparable post-component scoring within a few seconds, and (b) measure RPE using a standard high-accuracy monitor that does not require the runner to report it, and potentially influencing an RPE score. Both of these strategies could be accomplished by using an optical heart rate sensor that a runner wears on their forearm, but is connected only to the experimenter’s software application.

Last, the analysis of these results may have been limited because only three sessions for each test- and control-sequence were implemented for several analyses. Lanovaz et al. (2019) evaluated the validity of visual analysis for alternating treatment designs using a Monte Carlo technique, as well as a validation using non-simulated data. Their results indicated that at least five data points sufficiently controls for errors with visual analysis. Hanna’s results from Experiment 1 and Josephine’s results from Experiments 1 and 2 may have benefitted from additional sessions to determine if a separation of data would become apparent. However, any changes in all three analyses would describe a Type II error, and Lanovaz et al. (2019)’s results assessed validity only for Type I errors. Furthermore, for any analyses that involved more than three data points per condition (e.g., Bertha, Dolly, and Arthur for Exp. 1; Bertha and Hanna for Exp. 2), the expected outcomes at three data points persisted with additional assessments. These extended assessments were conducted for analysis that with and without an effect. Furthermore, using five sessions per condition would require a minimum of 10 sessions per participant, which may not be practical for some research settings. Nevertheless, future studies may consider an extended analysis using a minimum of five sessions per condition for increased confidence of results.
In conclusion, the results of the survey of Study 1 informed the methods for Study 2 in several ways including selection location, devices, music, other audio sources, and participant ages. One limitation to Study 1 was that respondents were recruited using primarily Facebook pages, potentially limiting the demographics of the respondents. For example, the survey indicated that 20.47% (N=113) of runners were male. This may reflect that more women are on Facebook, women are more likely to respond to surveys on social media, and or several of the respondents found the survey in Facebook groups targeting female runners. However, U.S. national statistics indicate that 60% of runners that participate in road races are women (Running USA, 2020). Additionally, if using social media, researchers should consider using other platforms targeting demographics from different age categories or social media preferences (e.g., Instagram, TikTok). Information from the survey was gathered largely using open-ended questions to control for experimenter anticipation of responses. Future surveys should build upon the results of Study 1 as a baseline to develop more precise questions that could be closed-ended and more efficient. The latter can encourage responses and completion of full surveys because the time and effort involved is reduced. Another area for future research involving surveys is to develop questions that may assess the function of music as a running adherence factor.

The results from Study 2 found that (a) objective behavioral measures (i.e., pace) are imperative for forming conclusions about performance effects, (b) a within-subject analysis has advantages over group analyses for music’s effects on running, and (c) music’s effects on running are idiosyncratic to the runner. The latter finding suggests the role of music in a runner’s regimen may involve multi-functional mechanisms such as enhancing performance or
promoting exercise routine adherence (i.e., improving the experience of running). The underlying principles of music’s varying role in running are unclear; future studies should further investigate the mechanisms involved. Similar to prior research on music and running, Study 2 evaluated the effects of music as an antecedent intervention, presented continuously and simultaneously with the running activity. In addition to the previous recommendations for future studies, researchers should also consider using music in a consequent arrangement to further investigate if contingent music can influence running performance.
References


https://go-gale-com.ezproxy.lib.usf.edu/ps/i.do?p=AONE&u=tamp44898&id=GALE|A284323921&v=2.1&it=r


https://go.gale.com/ps/anonymous?id=GALE%7CA361184664&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=10979751&p=AONE&sw=w


https://www.cdc.gov/physicalactivity/basics/measuring/exertion.htm


https://pubmed.ncbi.nlm.nih.gov/27314136/#:~:text=Listening%20to%20SM%20during %20the,1%2C%20P%3C0.05)


https://doi.org/10.2466/pms.103.1.285-295


Miltenberger, R. G., & Cook, J. L. (in press). Strategies for measuring behavior change. In L. Bambara & L. Kern (Eds.), *Individualized supports for students with problem behaviors: Designing positive behavior plans (2e).*

103
http://facta.junis.ni.ac.rs/pe/pe200801/pe200801-07.pdf

https://doi.org/10.1371/journal.pone.0114234


https://doi.org/10.1111/j.2044-8295.1996.tb02607.x


106


Appendices
### Appendix A

**Survey Questions for Study 1**

<table>
<thead>
<tr>
<th>Survey Question</th>
<th>Answer Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Why did you start running?</td>
<td>Open Ended</td>
</tr>
<tr>
<td>*Note: this answer may be different than why you currently run.</td>
<td></td>
</tr>
<tr>
<td>Here, just answer why you initially took up running.</td>
<td></td>
</tr>
<tr>
<td>2. Have you been running more than one year?</td>
<td>Multiple Choice (2 options)</td>
</tr>
<tr>
<td>- Yes ... go to 2b</td>
<td></td>
</tr>
<tr>
<td>- No ... go to 2c</td>
<td></td>
</tr>
<tr>
<td>2b. Approximately how many years’ experience (in total) do you have in running?</td>
<td>Open Ended</td>
</tr>
<tr>
<td>2c. Approximately how many months experience do you have in running?</td>
<td>Multiple Choice (11 options)</td>
</tr>
<tr>
<td>- 1 through 11</td>
<td></td>
</tr>
<tr>
<td><strong>If 1 or 2, skip to end of survey (ineligible)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>If 3 through 11, continue survey</strong></td>
<td></td>
</tr>
<tr>
<td>3. When considering your runs over the last 3 months, how many days per week do you run on average?</td>
<td>Multiple Choice (8 options)</td>
</tr>
<tr>
<td>- Less than 1</td>
<td></td>
</tr>
<tr>
<td>- 1 through 7</td>
<td></td>
</tr>
<tr>
<td><strong>If less than 1, skip to end of survey (ineligible)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>If 1 or more, continue survey</strong></td>
<td></td>
</tr>
<tr>
<td>4. When considering your runs over the last 3 months, what is the average distance you run each week?</td>
<td>Fill In</td>
</tr>
<tr>
<td>_____ miles OR _____ kilometres</td>
<td></td>
</tr>
<tr>
<td>5. How do you plan or schedule your runs?</td>
<td>Open Ended</td>
</tr>
<tr>
<td>6. Do you plan to go on a run by at least one day in advance of that run?</td>
<td>Likert 1-4</td>
</tr>
<tr>
<td>- Never</td>
<td></td>
</tr>
<tr>
<td>- Sometimes</td>
<td></td>
</tr>
<tr>
<td>- Usually</td>
<td></td>
</tr>
<tr>
<td>- Always</td>
<td></td>
</tr>
<tr>
<td>7. When you plan to run, do you sometimes find that you don't follow through with that run?</td>
<td>Multiple Choice (2 options)</td>
</tr>
<tr>
<td>- Yes ... go to 7b</td>
<td></td>
</tr>
<tr>
<td>- No ... skip to 8</td>
<td></td>
</tr>
<tr>
<td>7b. What are the reasons that you sometimes don't follow through with your planned run? *List as many reasons that you can remember</td>
<td>Open Ended</td>
</tr>
<tr>
<td>8. For the days you plan NOT to run, why not? *List as many reasons that you can remember</td>
<td>Open Ended</td>
</tr>
<tr>
<td>9. Do you usually run with someone else?</td>
<td>Likert 1-6</td>
</tr>
<tr>
<td>- Always</td>
<td></td>
</tr>
</tbody>
</table>
### 9b. Who do you run with?
- **Open Ended**

### 10. Where do you run? *select all that apply*
- **Multiple Choice (any or all 4 options)**
  - Outdoors (park, neighborhood, beach, etc.)
  - Outdoor track
  - Indoor track
  - Treadmill

### 10b. From the above choices, where do you run the most often?
- **Open Ended**

### 11. What is your pattern during a particular run? (select all that apply)
- **Multiple Choice (any or all 4 options)**
  - Run the entire time
  - Run, but sometimes walk when tired, on a regular basis
  - Run, but sometimes walk when tired - only when I have not run in a long time and I’m re-training
  - Run in planned intervals (i.e., use Interval Training)

### 12. Do you take anything (energy drink/shot, protein, medication, etc.), intended to enhance or assist your running?
- **Multiple Choice (3 options)**
  - Yes ... go to 12b
  - Sometimes ... go to 12b
  - No ... skip to 13

### 12b. What do you take (e.g., consume) to enhance or assist with running?
- **Open Ended**

### 13. Do you typically track your running on a device (e.g., phone, watch, shoe device, etc.)?
- **Multiple Choice (2 options)**
  - Yes ... go to 13b
  - No ... skip to 14

### 13b. What type (and brand) of device do you currently use while running?
- **Open Ended**

*Example answers: iPhone, FitBit Activity Tracker, Garmin Forerunner Watch, Under Armour HOVR smart shoes, etc.*
<table>
<thead>
<tr>
<th>Question</th>
<th>Multiple Choice (5 options + Open Ended)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13c. Where do you usually keep your device when you run?</td>
<td>- Wrist</td>
</tr>
<tr>
<td></td>
<td>- Arm band</td>
</tr>
<tr>
<td></td>
<td>- Pocket</td>
</tr>
<tr>
<td></td>
<td>- Hold in hand</td>
</tr>
<tr>
<td></td>
<td>- Other (please describe) ... OE</td>
</tr>
<tr>
<td>13d. What application do you currently use on your device when you run?</td>
<td>Multiple Choice (10 options + Open Ended)</td>
</tr>
<tr>
<td></td>
<td>- Nike+ Run Club</td>
</tr>
<tr>
<td></td>
<td>- Strava</td>
</tr>
<tr>
<td></td>
<td>- Runkeeper</td>
</tr>
<tr>
<td></td>
<td>- Map My Run</td>
</tr>
<tr>
<td></td>
<td>- Endomondo</td>
</tr>
<tr>
<td></td>
<td>- Runtastic</td>
</tr>
<tr>
<td></td>
<td>- Couch-to-5k</td>
</tr>
<tr>
<td></td>
<td>- Zombies, Run!</td>
</tr>
<tr>
<td></td>
<td>- Other __________ ... OE</td>
</tr>
<tr>
<td></td>
<td>- No application required for my device (e.g., FitBit watch)</td>
</tr>
<tr>
<td>13e. Do you usually look at information your device tracked about your runs over time? (e.g., logs, graphs, etc)</td>
<td>Multiple Choice (2 options)</td>
</tr>
<tr>
<td></td>
<td>- Yes</td>
</tr>
<tr>
<td></td>
<td>- No</td>
</tr>
<tr>
<td>14. Do you listen to music when you run?</td>
<td>Multiple Choice (2 options)</td>
</tr>
<tr>
<td></td>
<td>- Yes ... go to 14b</td>
</tr>
<tr>
<td></td>
<td>- Sometimes ... go to 14b</td>
</tr>
<tr>
<td></td>
<td>- No ... skip to 15</td>
</tr>
<tr>
<td>14b. What type or genre of music do you listen to when you run?</td>
<td>Open Ended</td>
</tr>
<tr>
<td>14c. Do you listen to this same genre when not running?</td>
<td>Multiple Choice (3 options)</td>
</tr>
<tr>
<td></td>
<td>- Yes</td>
</tr>
<tr>
<td></td>
<td>- Sometimes</td>
</tr>
<tr>
<td></td>
<td>- No</td>
</tr>
<tr>
<td>14d. Why do you listen to music when running?</td>
<td>Open Ended</td>
</tr>
<tr>
<td>*14e. What source do you select your running music from?</td>
<td>Multiple Choice (4 options + Open Ended)</td>
</tr>
<tr>
<td></td>
<td>- My own playlist</td>
</tr>
<tr>
<td></td>
<td>- Streaming (self-selected music; please specify app)OE</td>
</tr>
<tr>
<td>Question</td>
<td>Response Options</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Do you save any particular song(s) for an extra boost while running?</td>
<td>Multiple Choice (3 options)</td>
</tr>
<tr>
<td></td>
<td>- Yes</td>
</tr>
<tr>
<td></td>
<td>- Sometimes</td>
</tr>
<tr>
<td></td>
<td>- No</td>
</tr>
<tr>
<td>When do you use this song as a boost? (e.g., beginning of run, end of</td>
<td>Open Ended</td>
</tr>
<tr>
<td>run, when you need extra energy, etc.)</td>
<td></td>
</tr>
<tr>
<td>Do you listen to something other than music when you run (e.g.,</td>
<td>Multiple Choice (3 options)</td>
</tr>
<tr>
<td>audiobooks, podcasts)?</td>
<td>- Yes go to 15b</td>
</tr>
<tr>
<td></td>
<td>- Sometimes go to 15b</td>
</tr>
<tr>
<td></td>
<td>- No skip to 16</td>
</tr>
<tr>
<td>What do you listen to?</td>
<td>Open Ended</td>
</tr>
<tr>
<td>Do you prefer to run without listening to anything (i.e., no music,</td>
<td>Multiple Choice (3 options)</td>
</tr>
<tr>
<td>no podcasts, etc)?</td>
<td>- Yes, always go to 16b</td>
</tr>
<tr>
<td></td>
<td>- Yes, sometimes go to 16b</td>
</tr>
<tr>
<td></td>
<td>- No skip to 17</td>
</tr>
<tr>
<td>Why?</td>
<td>Open Ended</td>
</tr>
<tr>
<td>What do you like most about running? *List all that apply</td>
<td>Open Ended</td>
</tr>
<tr>
<td>What do you like least about running? *List all that apply</td>
<td>Open Ended</td>
</tr>
<tr>
<td>What is your sex?</td>
<td>Multiple Choice (3 options + Open Ended)</td>
</tr>
<tr>
<td></td>
<td>- Male</td>
</tr>
<tr>
<td></td>
<td>- Female</td>
</tr>
<tr>
<td></td>
<td>- Not listed (please list) ... OE</td>
</tr>
<tr>
<td>How old are you?</td>
<td>Open Ended</td>
</tr>
<tr>
<td>Please tell us anything else you think we should know related to</td>
<td>Open Ended</td>
</tr>
<tr>
<td>your running (optional).</td>
<td></td>
</tr>
</tbody>
</table>

Note. All survey questions, excluding social validity, recruitment, and gift card option. Not all respondents were shown all questions; see details in “Answer Type” for flow of questions provided.
### Social Validity Rating Questions for Study 1 Survey

<table>
<thead>
<tr>
<th>Statement</th>
<th>Likert Rating Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I think this survey had good questions to collect information about</td>
<td>- Strongly disagree</td>
</tr>
<tr>
<td>actual runners' habits and about motivation related to running (or</td>
<td>- Disagree</td>
</tr>
<tr>
<td>barriers).</td>
<td>- Neither disagree or agree</td>
</tr>
<tr>
<td></td>
<td>- Agree</td>
</tr>
<tr>
<td></td>
<td>- Strongly agree</td>
</tr>
<tr>
<td>2. I think the answers collected in this survey are important for</td>
<td>- Strongly disagree</td>
</tr>
<tr>
<td>researchers to learn about the realities of running and may help</td>
<td>- Disagree</td>
</tr>
<tr>
<td>researchers be more in tune with designing studies about running</td>
<td>- Neither disagree or agree</td>
</tr>
<tr>
<td></td>
<td>- Agree</td>
</tr>
<tr>
<td></td>
<td>- Strongly agree</td>
</tr>
</tbody>
</table>

*Note.* Social validity statements provided at the end of the survey.
## Appendix C

### Recruitment Question and Gift Card Option for Survey of Study 1

<table>
<thead>
<tr>
<th>Question</th>
<th>Response Options</th>
</tr>
</thead>
</table>
| Do you live within the vicinity of the University of South Florida? If so, would you be interested in learning more about voluntarily participating in a study involving active running? Participation in this upcoming study involves running outdoors at the USF campus with researchers present. Each running session would last about 15 minutes, and several sessions may be required (but only one session occurs on a given day). Before beginning the study, you would learn more about the benefits and risks of the study and what you would be required to do. We will only then ask for your written consent to participate (or you may choose to decline). | - Yes, please contact me with more details about an upcoming study that I can take part in as a runner ... go to next question  
- No thanks, I'm not interested ... skip to gift card option |

Thank you for your interest! Please enter your e-mail address.  
***Entering your e-mail address here is for the sole purpose to contact you for an upcoming study. It will not be used in a mailing list or for any other purposes.***

Enter e-mail address

OPTIONAL:  
A $10 Amazon gift card will be automatically provided to every 25th survey participant. If you would like to accept a gift card should you be a survey respondent that falls within that category (25th, 50th, 75th, etc), please enter your e-mail address below.  
***Entering your e-mail address here is for the sole purpose to contact you if you are a gift card recipient. It will not be used in a mailing list or for any other purposes.***

Enter e-mail address

**Note.** These questions were provided after social validity questions at the end of the survey.
Appendix D

Session Checklist for Experiment 1

Date: ______________________

| Participant: __________________ | Researcher: ______ | Session # ___ | Primary [ ] Secondary [ ] |

<table>
<thead>
<tr>
<th>#</th>
<th>Session Implementation Checklist for Experiment 1: Music Playlist</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inform runner before run if accuracy measure will be required or not</td>
</tr>
<tr>
<td>2</td>
<td>Sign into NRC app</td>
</tr>
</tbody>
</table>
| 3 | Settings → Audio feedback on, but all options toggled off except count down  
  → Units of measure to metric |
| 4 | Music settings → no music *If music sequence, check that music is available for Comp 2 setup |
| 5 | Remind runner what to do if needing to stop (come back and/or flag researcher) |
| 6 | Set 2 timers to 5:20 (e.g., 2 researchers or phone + watch) |
| 7 | Start timers 3-5 seconds after runner begins |
| 8 | Note the direction/loop runner takes |
| 9 | Guide runner after first loop (when applicable) |
| 10 | Flag runner at 5:20 |
| 11 | After Component 1  
  i. Ask runner to stop run on app  
  ii. Show RPE visual, ask for HR, and record scores  
  iii. Give component 2 instructions |
| 12 | Set 2 timers to 5:20 (e.g., 2 researchers or phone + watch) |
| 13 | Start timers 3-5 seconds after runner begins |
| 14 | Note the direction/loop runner takes |
| 15 | Guide runner after first loop (when applicable) |
| 16 | Flag runner at 5:20 |
| 17 | After Component 2  
  i. Stop run on app  
  ii. Show RPE visual, ask for HR, and record score  
  iii. *If music sequence, confirm played songs & take pic (ensure no music set next)  
  iv. Give component 3 instructions |
| 18 | Set 2 timers to 5:20 (e.g., 2 researchers or phone + watch) |
| 19 | Start timers 3-5 seconds after runner begins |
| 20 | Note the direction/loop runner takes |
| 21 | Guide runner after first loop (when applicable) |
| 22 | Flag runner at 5:20 |
| 23 | After Component 3  
  i. Stop run on app  
  ii. Show RPE visual, ask for HR, and record scores |

**If accuracy measure required**

<table>
<thead>
<tr>
<th>#</th>
<th>Session Implementation Checklist for Experiment 1: Music Playlist</th>
</tr>
</thead>
</table>
| 24 | i. Give instructions to runner to walk/run accuracy laps  
  ii. Start app on start line  
  iii. Guide runner to stop exactly on end line (use flags and chalk to mark)  
  iv. Pause and stop |
| 25 | Sync (pull down home screen) and log out of app |
| 26 | Ask runner to log in to own app if they use NRC |
### Appendix E

**Session Checklist for Experiment 2**

Date: ___________________________

<table>
<thead>
<tr>
<th>#</th>
<th>Session Implementation Checklist for Experiment 2: Boost Song</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inform runner before run if accuracy measure will be required or not</td>
</tr>
<tr>
<td>2</td>
<td>Sign into NRC app</td>
</tr>
<tr>
<td>3</td>
<td>Settings → Audio feedback on, but all options toggled off except count down → Units of measure to metric</td>
</tr>
<tr>
<td>4</td>
<td>Music → Playlist/Streaming on *If Boost Song sequence, check that boost song ready for Comp 2</td>
</tr>
<tr>
<td>5</td>
<td>Remind runner what to do if needing to stop (come back and/or flag researcher)</td>
</tr>
<tr>
<td>6</td>
<td>Set 2 timers to 5:20 (e.g., 2 researchers or phone + watch)</td>
</tr>
<tr>
<td>7</td>
<td>Start timers 3-5 seconds after runner begins</td>
</tr>
<tr>
<td>8</td>
<td>Note the direction/loop runner takes</td>
</tr>
<tr>
<td>9</td>
<td>Guide runner after first loop (when applicable)</td>
</tr>
<tr>
<td>10</td>
<td>Flag runner at 5:20</td>
</tr>
</tbody>
</table>

#### After Component 1

i. Ask runner to stop run on app  
ii. Show RPE visual, ask for HR, and record scores  
iii. Confirm played songs from playlist for comp 1  
v. Give component 2 instructions *Note shorter run interval (3 min)*

<table>
<thead>
<tr>
<th>11</th>
<th>Set 2 timers to 3:20 (e.g., 2 researchers or phone + watch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Start timers 3-5 seconds after runner begins</td>
</tr>
<tr>
<td>13</td>
<td>Note the direction/loop runner takes</td>
</tr>
<tr>
<td>14</td>
<td>Guide runner after first loop (when applicable)</td>
</tr>
<tr>
<td>15</td>
<td>Flag runner at 3:20</td>
</tr>
</tbody>
</table>

#### After Component 2

i. Stop run on app  
ii. Show RPE visual, ask for HR, and record scores  
iii. *If Playlist sequence (control), confirm played songs from comp 2  
v. Give component 3 instructions *Note longer run interval (5 min)*

<table>
<thead>
<tr>
<th>17</th>
<th>Set 2 timers to 5:20 (e.g., 2 researchers or phone + watch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Start timers 3-5 seconds after runner begins</td>
</tr>
<tr>
<td>19</td>
<td>Note the direction/loop runner takes</td>
</tr>
<tr>
<td>20</td>
<td>Guide runner after first loop (when applicable)</td>
</tr>
<tr>
<td>21</td>
<td>Flag runner at 5:20</td>
</tr>
</tbody>
</table>

#### After Component 3

i. Stop run on app  
ii. Show RPE visual, ask for HR, and record score  
iii. Confirm played songs from playlist for comp 3

#### **If accuracy measure required**

i. Give instructions to runner to walk/run accuracy laps  
ii. Start app on start line  
iii. Guide runner to stop exactly on end line (use flags and chalk to mark)  
v. Pause and stop

<table>
<thead>
<tr>
<th>24</th>
<th>Sync (pull down home screen) and log out of app</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Ask runner to log in to own app if they use NRC</td>
</tr>
</tbody>
</table>
### Appendix F

**Session Checklist for Experiment 3**

<table>
<thead>
<tr>
<th>#</th>
<th>Session Implementation Checklist for Experiment 3: Podcast/Audiobook</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inform runner before run if accuracy measure will be required or not</td>
</tr>
<tr>
<td>2</td>
<td>Sign into NRC app</td>
</tr>
<tr>
<td>3</td>
<td>Settings → Audio feedback on, but all options toggled off except count down</td>
</tr>
<tr>
<td></td>
<td>→ Units of measure to metric</td>
</tr>
<tr>
<td>4</td>
<td>Music settings → no music. *If podcast sequence, check that podcast is available for Comp 2 setup</td>
</tr>
<tr>
<td>5</td>
<td>Remind runner what to do if needing to stop (come back and/or flag researcher)</td>
</tr>
<tr>
<td>6</td>
<td>Set 2 timers to 5:20 (e.g., 2 researchers or phone + watch)</td>
</tr>
<tr>
<td>7</td>
<td>Start timers 3-5 seconds after runner begins</td>
</tr>
<tr>
<td>8</td>
<td>Note the direction/loop runner takes</td>
</tr>
<tr>
<td>9</td>
<td>Guide runner after first loop (when applicable)</td>
</tr>
<tr>
<td>10</td>
<td>Flag runner at 5:20</td>
</tr>
</tbody>
</table>

**After Component 1**

11  | Ask runner to stop run on app                                 |
11.i | Show RPE visual, ask for HR, and record scores                |
11.ii| Give component 2 instructions                                |

12  | *If podcast sequence (test component), ask runner to go to podcast app |
12.i | Ask runner to select audio, take pic of episode/book title and podcaster/author |
12.ii| Ask runner to start podcast to get beyond ads, then pause until starting run |

13  | Set 2 timers to 5:20 (e.g., 2 researchers or phone + watch)    |
14  | Start timers 3-5 seconds after runner begins                   |
15  | Note the direction/loop runner takes                           |
16  | Guide runner after first loop (when applicable)                |
17  | Flag runner at 5:20                                           |

**After Component 2**

18  | Stop run on app                                               |
18.i | Show RPE visual, ask for HR, and record score                 |
18.ii| *If podcast sequence, confirm played audio                    |
18.iii| Give component 3 instructions                                 |

19  | Set 2 timers to 5:20 (e.g., 2 researchers or phone + watch)    |
20  | Start timers 3-5 seconds after runner begins                   |
21  | Note the direction/loop runner takes                           |
22  | Guide runner after first loop (when applicable)                |
23  | Flag runner at 5:20                                           |

**After Component 3**

24  | Stop run on app                                               |
24.i | Show RPE visual, ask for HR, and record scores                |

**If accuracy measure required**

24  | Give instructions to runner to walk/run accuracy laps         |
24.i | Start app on start line                                      |
24.ii| Guide runner to stop exactly on end line (use flags and chalk to mark) |
24.iii| Pause and stop                                                |

25  | Sync (pull down home screen) and log out of app               |
26  | Ask runner to log in to own app, if they use NRC              |
Appendix G

Ratings of Perceived Exertion (RPE) Form

Rating of Perceived Exertion (RPE) Data Form

Try to appraise your total feeling of exertion as honestly as possible, without thinking about what the actual physical load is.
*Your own feeling of effort and exertion is important, not how it compares to other people's exertion.

<table>
<thead>
<tr>
<th>RPE</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>No exertion at all</td>
</tr>
<tr>
<td>7</td>
<td>Extremely light (7.5)</td>
</tr>
<tr>
<td>8</td>
<td>Very light</td>
</tr>
<tr>
<td>10</td>
<td>Light</td>
</tr>
<tr>
<td>12</td>
<td>Somewhat hard</td>
</tr>
<tr>
<td>14</td>
<td>Hard (heavy)</td>
</tr>
<tr>
<td>16</td>
<td>Very hard</td>
</tr>
<tr>
<td>19</td>
<td>Extremely hard</td>
</tr>
<tr>
<td>20</td>
<td>Maximal exertion</td>
</tr>
</tbody>
</table>

9 “Very light” exercise
- E.g., Walking slowly at my own pace

13 “Somewhat hard” exercise
- A bit hard but I'm okay to continue

17 “Very hard” exercise
- I can go on, but I have to push myself
- It feels very heavy and I'm very tired

19 “Extremely hard” exercise
- This is the most strenuous exercise I have ever experienced

*RPE Table Adapted from the CDC version of the Borg Rating of Perceived Exertion Scale (1998)
www.cdc.gov/physicalactivity/everyone/measuring/exertion.html
Appendix H

Pre- and Post-Study 2 Preference Rankings

Rating of Audio Preference
Pre-Assessment (Phases 1 to 3)

Date: __________________________________________

Participant: ___________________________ Researcher: ______________________

Based on your current running experience, rank your preference of audio sources:

No Audio Source   Boost Song   Podcast   Music Playlist

In ranked order, I prefer to run with:

1. __________________________________________

2. __________________________________________

3. __________________________________________

4. __________________________________________

Rating of Audio Preference
Post-Assessment (Phases 1 to 3)

Date: __________________________________________

Participant: ___________________________ Researcher: ______________________

Based on your experience in this study, rank your preference of audio:

No Audio Source   Boost Song   Podcast   Music Playlist

In ranked order, I preferred to run with:

1. __________________________________________

2. __________________________________________

3. __________________________________________

4. __________________________________________
Appendix I

Pre- and Post-Experiment 1 Preference Ranking

Ranking of Music Preference
Phase 1: Music Playlist Pre-Assessment

Date: 

Participant: ________________________  Researcher: ____________

Based on your current running experience, rank each in order of your preference:

No Music  Music

In ranked order, I prefer to run with:

1. ________________________________

2. ________________________________

Ranking of Music Preference
Phase 1: Music Playlist Post-Assessment

Date: 

Participant: ________________________  Researcher: ____________

Consider your runs during this study so far and rank each in order of your preference:

No Music  Music

In ranked order, I prefer to run with:

1. ________________________________

2. ________________________________

120
Appendix J

Pre- and Post-Experiment 1 Preference Likert Scale

Rating of Music Preference
Phase 1: Music Playlist Pre-Assessment

Date: ____________________________
Participant: _______________________ Researcher: ___________

Based on your current running experience, rate the following two statements:

1. I enjoy running with my music playlist playing.

   1  2  3  4  5
   Strongly Disagree Somewhat Disagree Neither Disagree or Agree Somewhat Agree Strongly Agree

2. I enjoy running with no music playing.

   1  2  3  4  5
   Strongly Disagree Somewhat Disagree Neither Disagree or Agree Somewhat Agree Strongly Agree

Rating of Music Preference
Phase 1: Music Playlist Post-Assessment

Date: ____________________________
Participant: _______________________ Researcher: ___________

Consider your runs during this study so far and rate the following two statements:

1. I enjoyed running with my music playlist playing.

   1  2  3  4  5
   Strongly Disagree Somewhat Disagree Neither Disagree or Agree Somewhat Agree Strongly Agree

2. I enjoyed running with no music playing.

   1  2  3  4  5
   Strongly Disagree Somewhat Disagree Neither Disagree or Agree Somewhat Agree Strongly Agree

121
Appendix K

Pre- and Post-Experiment 2 Preference Ranking

Ranking of Music Preference
Phase 2: Boost Song Pre-Assessment

Date: 

Participant: ___________________________  Researcher: ___________________________

Based on your current running experience, rank each in order of your preference:

Music Playlist  Boost Song

In ranked order, I prefer to run with:

1. ______________________________________

2. ______________________________________

Ranking of Music Preference
Phase 2: Boost Song Post-Assessment

Date: 

Participant: ___________________________  Researcher: ___________________________

Consider your runs during this study so far and rank each in order of your preference:

Music Playlist  Boost Song

In ranked order, I prefer to run with:

1. ______________________________________

2. ______________________________________
Appendix L

Pre- and Post-Experiment 2 Preference Likert Scale

Rating of Music Preference
Phase 2: Boost Song Pre-Assessment

Date: _________________________________

Participant: ___________________________  Researcher: ________________

Based on your current running experience, rate the following two statements:

1. I enjoy running with my boost song playing.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Somewhat Disagree</td>
<td>Neither Disagree or Agree</td>
<td>Somewhat Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

2. I enjoy running with my music playlist playing.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Somewhat Disagree</td>
<td>Neither Disagree or Agree</td>
<td>Somewhat Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

Rating of Music Preference
Phase 2: Boost Song Post-Assessment

Date: _________________________________

Participant: ___________________________  Researcher: ________________

Consider your runs during this study to rate the following two statements:

1. I enjoyed running with my boost song playing.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Somewhat Disagree</td>
<td>Neither Disagree or Agree</td>
<td>Somewhat Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

2. I enjoyed running with my music playlist playing.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Somewhat Disagree</td>
<td>Neither Disagree or Agree</td>
<td>Somewhat Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>
Appendix M

Pre- and Post-Experiment 3 Preference Ranking

Ranking of Auditory Preference
Phase 3: Podcast/Audiobook Pre-Assessment

Date: ____________________________________________

Participant: ___________________________ Researcher: ____________

Based on your current running experience, rank each in order of your preference:

*No Audio*     *Podcast/Audiobook*

In ranked order, I prefer to run with:

1. ____________________________

2. ____________________________

Ranking of Auditory Preference
Phase 3: Podcast/Audiobook Post-Assessment

Date: ____________________________________________

Participant: ___________________________ Researcher: ____________

Consider your runs during this study and rank each in order of your preference:

*No Audio*     *Podcast/Audiobook*

In ranked order, I prefer to run with:

1. ____________________________

2. ____________________________
Appendix N

Pre- and Post-Experiment 3 Preference Likert Scale

Rating of Auditory Preference
Phase 3: Podcast/Audiobook Post-Assessment

Date: ____________________________
Participant: ____________________________ Researcher: ____________________________

Consider your runs during this study and rate the following two statements:

1. I enjoyed running with my podcast or audiobook playing.

   1
   | Strongly Disagree | 2 | Somewhat Disagree | 3 | Neither Disagree or Agree | 4 | Somewhat Agree | 5 | Strongly Agree |

2. I enjoyed running with no audio playing.

   1
   | Strongly Disagree | 2 | Somewhat Disagree | 3 | Neither Disagree or Agree | 4 | Somewhat Agree | 5 | Strongly Agree |

Rating of Auditory Preference
Phase 3: Podcast/Audiobook Pre-Assessment

Date: ____________________________
Participant: ____________________________ Researcher: ____________________________

Based on your current running experience, rate the following two statements:

1. I enjoy running with my podcast or audiobook playing.

   1
   | Strongly Disagree | 2 | Somewhat Disagree | 3 | Neither Disagree or Agree | 4 | Somewhat Agree | 5 | Strongly Agree |

2. I enjoy running with no audio playing.

   1
   | Strongly Disagree | 2 | Somewhat Disagree | 3 | Neither Disagree or Agree | 4 | Somewhat Agree | 5 | Strongly Agree |
Appendix O

IRB Certification for Study 1

Dear Ms. Cook:

On 3/2/2019, the Institutional Review Board (IRB) determined that your research meets criteria for exemption from the federal regulations as outlined by 45 CFR 46.104(d).

(1) Research that only includes interactions involving educational tests/cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including oral or auditory recording) of at least one of the following criteria is met: (a) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects; (b) Any disclosure of the human subjects’ responses outside the research would not reasonably place the subject at risk of criminal or civil liability or of being damaged in the subjects’ financial standing, employability, educational advancement, or reputation; or (c) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by 45 CFR 46.111(a)(7).

As the principal investigator for this study, it is your responsibility to ensure that this research is conducted as outlined in your application and consistent with the ethical principles outlined in the Belmont Report and with USF IRB policies and procedures.

Please note, as per USF IRB Policy, once the exempt determination is made, the application is closed. This does not limit your ability to conduct the research. Any proposed or anticipated changes to the study design that was previously declared exempt from IRB oversight must be submitted to the IRB as a new study prior to initiation of the change. However, administrative changes, including changes in research personnel, do not warrant an Amendment.
Appendix P

IRB Certification for Study 2

University of South Florida

APPROVAL

February 4, 2020

Jennifer Cook
1941 Crape Myrtle Loop
Apt 206
Lutz, FL 33549

Dear Ms. Cook:

On 2/4/2020, the IRB reviewed and approved the following protocol:

<table>
<thead>
<tr>
<th>Application Type:</th>
<th>Initial Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRB ID:</td>
<td>STUDY000263</td>
</tr>
<tr>
<td>Review Type:</td>
<td>Expedited 7</td>
</tr>
<tr>
<td>Title:</td>
<td>The Effects of Music on Running</td>
</tr>
<tr>
<td>Funding:</td>
<td>None</td>
</tr>
<tr>
<td>IND, IDE, or HDE:</td>
<td>None</td>
</tr>
</tbody>
</table>

Approved Protocol and Consent(s)/Assent(s):

- Music and Running Protocol
- Consent Form

Attached are stamped approved consent documents. Use copies of these documents to document consent.

Within 30 days of the anniversary date of study approval, confirm your research is ongoing by clicking Confirm Ongoing Research in BullsIRB, or if your research is complete, submit a study closure request in BullsIRB by clicking Create Modification/CR.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

Various Menzel
IRB Research Compliance Administrator

A PREEMINENT RESEARCH UNIVERSITY

Institutional Review Boards / Research Integrity & Compliance
FWA No. 00001609
University of South Florida / 3702 Spectrum Blvd., Suite 165 / Tampa, FL 33612 / 813-974-5638