2014

Effects of Imagery on Effort Perception and Cycling Endurance

Selen Razon
West Chester University of Pennsylvania, srazon@bsu.edu

Kyle Mandler
Florida State University

Guler Arsal
Florida State University

Umit Tokac
Florida State University

Gershon Tenenbaum
Florida State University

Bibliographic Information:
Journal of Imagery Research in Sport and Physical Activity, Vol. 9 Issue 1 (23–38)

Recommended Citation
Razon, S., Mandler, K., Arsal, G., Tokac, U., & Tenenbaum, G. (2014). Effects of Imagery on Effort Perception and Cycling Endurance. *Journal of Imagery Research in Sport and Physical Activity, 9*(1), 23-38. http://dx.doi.org/10.1515/jirspa-2013-0011

Selen Razon*, Kyle Mandler, Guler Arsal, Umit Tokac and Gershon Tenenbaum

Effects of Imagery on Effort Perception and Cycling Endurance

Abstract: The effect of associative and dissociative imagery was tested on a range of psychological-, physiological-, and performance-related variables during a progressive cycling task using a quantitative approach. Participants ($n = 45$) were randomly assigned to dissociative imagery, associative imagery, and no imagery conditions and performed a progressive cycling task at 10% above anaerobic threshold up to the point of volitional fatigue. Rate of perceived exertion (RPE), attention focus, and heart rate were monitored and assessed at 1-min intervals. Lactic acid (LA) accumulation was recorded at RPE = 5 (i.e. "strong effort") and at the point of volitional fatigue. A series of repeated measures analysis of variance indicated that relative to their counterparts who were not using imagery, participants who used imagery accumulated higher levels of LA in blood. Despite some of the non-significant results, present effect sizes seemed to indicate that dissociative imagery may help decrease perception of effort, and associative imagery may help increase time on task.

Keywords: imagery, exercise, attention, RPE, lactic acid

DOI 10.1515/jirspa-2013-0011

Imagery is recognized as a self-regulatory strategy for increasing/maintaining exercise behavior (Giacobbi, Hausenblas, & Penfield, 2005; Kim & Giacobbi, 2009; Stanley, Cumming, Standage, & Duda, 2012). Research in exercise imagery has grown in response to Hall's (1995) original assertion that imagery could exert a positive effect on the cognitions and motivations of exercisers. Hall suggested that imagery may facilitate exercise by allowing individuals to visualize themselves participating in preferred forms of exercise and reaching desired goals (i.e. improved appearance, technique, etc.). Subsequently, the development and use of the Exercise Imagery Questionnaire (Hausenblas, Hall, Rodgers, & Munroe, 1999) helped delineate three main types of exercise imagery: (a) appearance imagery (i.e. visualizing oneself becoming healthier and improving physical appearance), (b) energy imagery (i.e. visualizing oneself energized and motivated to exercise), and (c) technique imagery (i.e. visualizing the accurate execution of exercise practice/technique). Individuals who exercise at greater frequency use more exercise imagery (Gammage, Hall, & Rodgers, 2000). Additionally, female exercisers seemed to use more appearance imagery while male exercisers seemed to use more technique imagery during exercise (Gammage et al., 2000).

Experimental research on the affective, cognitive, and behavioral effects of exercise revealed a positive relationship between appearance imagery and intention to exercise (Rodgers, Munroe, & Hall, 2001), energy imagery and feelings of revitalization, tranquility, and positive engagement (Cumming & Stanley, 2009), and technique imagery and task-specific self-efficacy (TSSE; i.e. self-efficacy for successful task completion, Bandura, 1997; Cumming, 2008). Together these results landed support for the notion that each type of exercise imagery can be used to produce unique exercise-related thoughts, feelings, and behaviors (Cumming & Stanley, 2009).

Of relevance to this study, attention focus during exercise can also be an important factor for mediating exercise-related thoughts and feelings. Specifically, attention focus can mediate exercise-related effort sensations (Hutchinson & Karageorghis, 2013; Hutchinson & Tenenbaum, 2007). Early work that addressed the role of attention for mediating effort sensations termed *association* as a cognitive strategy in which the performer focuses his/her attention on the body's internal cues including muscle tension, breathing, and/or task-related

***Corresponding author: Selen Razon,** School of PE, Sport and Exercise Science, Ball State University, Muncie, IN 47306, USA, E-mail: srazon@bsu.edu
Kyle Mandler, Department of Nutrition, Food and Exercise Sciences, Florida State University, Tallahassee, FL, USA, E-mail: kyle.mandler@gmail.com
Guler Arsal: E-mail: ga07c@fsu.edu, **Umit Tokac:** E-mail: ut08@my.fsu.edu, **Gershon Tenenbaum:** E-mail: gtenenbaum@fsu.edu, Department of Educational Psychology and Learning Systems, Florida State University, Tallahassee, FL, USA

cues, such as speed and distance covered. *Dissociation* on the other hand was termed as a cognitive strategy in which the performer focuses his/her attention on task unrelated cues including problem solving, day dreaming, and/or listening to music (Schomer, 1986). Thus, association refers to an intentional or unintentional effort to direct attention focus to potentially aversive sensory cues while dissociation refers to an intentional distancing of attention focus from potentially aversive sensory cues (e.g. exercise-induced fatigue; Masters & Ogles, 1998).

Both associative and dissociative attentional strategies can be beneficial in exercise. Dissociative strategies decrease the rate of perceived exertion (RPE) and increase the positive affective responses to exercise (Masters & Ogles, 1998), and although associative strategies increase RPE, they also appear to extend time on task and optimize task performance (e.g. Masters & Lambert, 1989; Scott, Scott, Bedic, & Dowd, 1999; Tammen, 1996). To that end, the term *attentional flexibility* denotes an individual's ability to shift between dissociation and association. A key mechanism underlying *attentional flexibility* is the phenomenon known as *Dissociation/Association shift* (D/A shift; Tenenbaum, 2001). D/A shift denotes a critical transition point wherein greater workloads and/or increased time spent on task disrupt attentional flexibility and render dissociation ineffectual. Following the D/A shift associative attentional focus dominate the focal awareness, i.e. sensory information from the body exerts greater influence on the individual's subjective perception of effort and fatigue and the cessation of the applied effort becomes imminent (Lind, Welch, & Ekkekakis, 2009; Pandolf, 1978). An area that warrants further research consideration are intervention aimed to help modulate attention and possibly delay of the D/A shift in exercise (see Hutchinson & Karageorghis, 2013; Lind et al., 2009). Indeed, delaying the shift may allow for longer distraction from task, hence potentially help lower RPEs and extend time on task in exercise (see Razon, Basevitch, Land, Thompson, & Tenenbaum, 2009). While recognizing its potential, findings from the extant literature have been equivocal on the effects of a delayed D/A shift, and additional studies were warranted for further modulating attention focus in exercise (Razon et al., 2010a, 2010b).

Scant research conceived the use of imagery for mediating attention to influence effort and performance in exercise. In response to calls for additional research on imagery and exercise (Trethewey, 2013), the purpose of the present study was to examine the effect of two types of imagery, associative and dissociative, on levels of perceived effort and time on task within exercise settings. Razon and colleagues' (2010a, 2010b) findings revealed that imagery use leads to ergogenic effects by mediating attention, thereby delaying the onset of fatigue, reducing perception of effort, and increasing time on task. *Distraction* (i.e. divergence of attention from unpleasant sensations associated with the exercise task) was argued to underlie these effects. From a parallel processing perspective (Rejeski, 1985), distraction strategies decrease fatigue by occupying the limited channel capacity, which otherwise brings the somatic sensory cues into the focal awareness. It is also important to note that attention is a dynamic process thereby amenable to cognitive manipulations (Rejeski, 1985). In fact, the notion of a dynamic competition between internal and external cues, together with a constant feeding of sensory and somatic input in and off from the individual's focal awareness, is central for the dual-mode model of affective responses to exercise (Ekkekakis, 2003) and social-cognitive model of perceived effort (Tenenbaum, 2001). The models postulate that at higher levels of effort, *bottom-up processes* direct attention more intensely than *top-down processes*. That is, as the exercise intensifies, internal sensory cues call for attention, even when the individual is deliberately attempting to distract attention from effort and sensory cues (Hutchinson & Tenenbaum, 2007).

Consistent with this conceptualization, results from studies testing the effects of imagery use on effort perception and time on task in strength-endurance protocols provide evidence for a *load-dependent hypothesis* (see Razon et al., 2010a, 2010b). From a load-dependent perspective, imagery is less influential in moderating attention at high workloads that exceed a critical transition point during exercise. The ventilatory threshold is likely to best represent this critical transition point during aerobic-type tasks (Ekkekakis, 2003; Karageorghis & Terry, 1997).

It is important to note that the notion of the critical transition dovetails with the phenomenon of D/A shift (Tenenbaum, 2001) that marks the disruption of attentional flexibility (Lind et al., 2009) and accelerates the ending of the applied effort (Pandolf, 1978). The phenomenon of D/A shift is relevant to the present study, and at least partly accounts for the observation that interventions including imagery appear to mediate attention and reduce the RPE at low to moderate exercise intensities only (Nethery, 2002; Razon et al., 2010a, 2010b).

The use of imagery contents to prime either associative or dissociative attention focus during exercise at high workload intensity can provide a framework to study the dynamics of attention focus and its effects on exercise-related responses. Drawing from early research (Razon et al., 2010b) within the current study, mental visualization to prime a dissociative focus of attention was termed *dissociative imagery*. Dissociative imagery included contents that are unrelated to the experimental task and/or sensory inputs related to it. Mental visualization to prime an associative focus of attention was termed *associative imagery*. Associative imagery included contents that are related to the experimental task and/or sensory inputs related to it.

Thus, the purpose of the present study was to examine the effects of associative and dissociative imagery on D/A shift, RPE, and time on task during cycling at 10% above anaerobic threshold (AT). In an effort to further add to the extant research, the present study also considered accumulation of lactic acid (LA) and heart rate (HR) given that LA and HR are correlates of RPE (Borg, 1998; Lagally et al., 2002; Lambrick, Faulkner, Rowlands, & Eston, 2009), and they were not considered in previous works into the effects of imagery use on RPE (see Razon et al., 2010a, 2010b). Specifically, in the present study given that all the participants were set to perform under relatively equal physical workloads, HR served as a process measure for controlling the physical workload. Given that the amount of LA in the blood is a direct indicator of effort expenditure (Borg, 1998), LA concentration in the present study served as a dependent variable for measuring effort and work output.

Consistent with the results from the bourgeoning literature pertaining to the use of differential imagery for mediating attention and effecting perceived effort and time on task (Razon et al., 2010a, 2010b), we hypothesized that (1) both imagery use would result in longer time on task compared to a control condition and (2) dissociative imagery use would result in lower RPEs and longer delay of the D/A shift compared to associative imagery use and control condition. Although there is no research to date examining the effects of imagery on the physiological markers of fatigue, because LA accumulation is considered a reliable marker of muscle fatigue (Cairns, 2006), we expected that (3) the use of either imagery would result in higher concentration of LA – as a direct result of longer cycling time. Finally we expected that HR would remain similar across groups due to the identical physiological load set for all participants (i.e. 10% above AT).

Method

Sampling procedure and participants

Sample size for repeated measures multiple analysis of variance (RM MANOVA) was determined by means of a power analysis using the G*Power 3 program (Faul, Erdfelder, Lang, & Buchner, 2007). With moderate effect size (Cohen's $d = 0.50$), a design incorporating two experimental and one control groups, power ($1 - \beta$) of 0.80, and five repeated measurements, the required sample size was determined to be 44. Accordingly, 45 participants were recruited, and stratified-randomly assigned to three groups: control (six males and nine females), associative imagery (seven males and eight females), and dissociative imagery (nine males and six females). Stratification was performed with respect to the maximum aerobic capacity, thus resulting in slightly different gender proportion in each group. For the stratified random protocol, participants' VO_{2max} values were initially listed in a descending order; then, each participant was assigned in sequence to each of the three groups (see protocol). Participants were physically active with an average exercise participation rate > 4 days per week ($M = 4.12$, SD = 2.04). Participants were recruited from college recreational teams and centers, and their age range was 18–54 years ($M = 23.69$, SD = 6.51). There was no significant difference ($p > 0.05$) among the three groups in fitness level, exercise participation rate, daily duration of exercise, and daily exercise intensity (see Table 1). Prior to participation, participants were administered a health and lifestyle questionnaire (see measures), and signed an informed consent form. Ethical guidelines as defined by the university's institutional review board were followed. Based on the health and lifestyle questionnaire, no participant presented any history and/or current conditions against exercise testing; thus, all the participants took part in the study.

Apparatus

A calibrated handgrip dynamometer (Lafayette 78010) was used for familiarizing the participants with imagery use during task performance. The squeezing range for the dynamometer was 0–100 kg. The handgrip dynamometer included a hand bar connected to a steel spring, which moved a dial when compressed. Participants' applied force was recorded in kilograms via the dial on the front of the apparatus.

A cycle-ergometer (Monark Ergomedic 874 E) was used for the VO_{2max} testing and for the experimental (cycling) task. The ergometer included a modified seat post to accommodate a racing saddle. The ergometer's fully adjustable seat allowed for easy calibration of pendulum balance. The workload resistance on the ergometer was in Newtons or kilo/pounds and brake power

Table 1 Participants' demographic statistics by experimental condition and one-way analysis of variances (ANOVAs)

Variable/experimental condition	*M*	SD	*F*(2,42)	*p*
Age (years)				
Associative	26.07	9.77	1.54	.225
Dissociative	22.40	3.92		
Control	22.60	3.62		
Total	23.69	6.51		
Exercise frequency (days)				
Associative	3.93	1.83	0.55	.582
Dissociative	4.62	1.40		
Control	3.86	2.70		
Total	4.12	2.04		
Duration of exercise per day (h)				
Associative	1.20	.34	0.07	.933
Dissociative	1.28	.68		
Control	1.25	.70		
Total	1.24	.58		
Intensity of exercise (0–10 scale)				
Associative	6.77	1.12	2.31	.115
Dissociative	6.96	1.01		
Control	6.04	1.26		
Total	6.55	1.19		
VO_{2max} (ml kg^{-1} min^{-1})				
Associative	46.64	10.13	0.98	.383
Dissociative	47.08	8.76		
Control	46.18	12.56		
Total	46.63	10.59		

in watts at 50 and 60 rpm. The ergometer's electronic meter that displays rpm, HR, time, speed, distance, calorie consumption, and power in watts were occluded from the participants' vision to prevent distraction, and secure focus on imagery scenes.

Health, demographic, and psychological measures

Health and life style questionnaire (British Colombia Department of Health, 1975)

The form included items pertaining to cardiovascular and respiratory health (e.g. heart conditions, emphysema, bronchitis, etc.), as well as musculoskeletal conditions (e.g. arthritis, joint problems, etc.), and relevant recent history (e.g. dizziness, chest pain, etc.) that could present issues for exercise testing. The items of the form were answered in a dichotomous (YES–NO) format.

Demographic information form

The form included demographic items such as age, gender, number of days per week spent exercising, type of exercise, and intensity of exercise.

Rate of perceived exertion (Borg, 1962, 1982)

RPE was assessed by means of RPE 11-point category-ratio scale ranging from 0 (nothing at all) to 10 (extremely strong). The scale was used extensively during the last 60 years and proven to be a valid and reliable measure of perceived exertion (Borg, 1962, 1982). The scale also correlates highly with select physiological indices including HR and VO_2 (Borg, 1982, 1998).

Attention focus (Tammen, 1996)

Attention focus was assessed by using the Tammen's single-item attention scale, following procedures outlined in detail by Baden, McLean, Noakes, and St. Clair Gibson (2005). Participants were instructed to rate their attention focus using the 11 anchors, ranging from 0 (dissociative attention – external thoughts and daydreaming) to 10 (associative attention – internal thoughts, bodily sensations, and breathing). Previous findings have indicated that participants' use of association and dissociation varies along a continuum and that the one-item measures are effective in capturing participants' attention focus (Baden et al., 2005; Okwumabua, Meyers, & Santille, 1987). Masters and Ogles (1998) have also reported that the use of single-item measure is effective in capturing participants' attention focus immediately following an experimental session. In similar studies (Connolly & Tenenbaum, 2010; Hutchinson & Tenenbaum, 2007; Tenenbaum & Connolly, 2008), the use of attention scale confirmed the notion that during physical effort attention focus shifts from dissociative to associative mode of attention as a function of the workload intensity and/or time on task.

Task-specific self-efficacy (Bandura, 1997)

Self-efficacy for successful task completion was assessed by means of the TSSE scale. The items of the scale gauged the extent to which participants believed in their physical capacity to endure the cycling task and tolerate the physical exertion associated with it. The scale included three items rated on an 11-point scale ranging from 0 (not at all) to 10 (very much). Total TSSE score corresponded to the average rating of the three items. The format and the content of the TSSE scale paralleled measures previously used to examine self-efficacy in similar exercise settings (McAuley, Talbot, & Martinez, 1999). In the current study, Cronbach's alpha of the three items was 0.92 for the squeezing task and 0.96 for the cycling task.

Commitment check

A task commitment check scale was developed to measure participants' self-reported commitment levels to the cycling task. Low score on the commitment check would result in eliminating the data of the participant from the final analyses. The check included three items: (1) How committed were you to performing the task? (2) How well do you think you tolerated the effort associated with the task? And (3) how much effort did you invest in the task? Each of the three items was rated on a scale ranging from 0 (none/not at all) to 5 (very much/very well). Cronbach's alpha of the three items in the current study was 0.91 for the squeezing task and 0.95 for the cycling task.

Manipulation check-imagery/control

Imagery ability was assessed by means of an imagery check scale. The scale included ten items evaluating imagery's vividness, controllability, kinesthetic, motivational properties, ease, and speed of generation, as well as its duration and the participant's perceived level of involvement with the mental images. Each item was rated on a scale ranging from 0 (not clear at all, no control at all, etc.) to 10 (very clear, very high control, etc.). The items of the scale were gathered from a number of imagery scales including Sheehan Questionnaire of Mental Imagery (Sheehan, 1967), Vividness of Visual Imagery Questionnaire (Marks, 1973), Gordon Test of Visual Imagery Control (Gordon, 1949), Vividness of Movement Imagery Questionnaire (Isaac, Marks, & Russell, 1986), Movement Imagery Questionnaire (Hall, Pongrac, & Buckolz, 1985), Sport Imagery Questionnaire (Martens, 1982), and Sport Imagery Ability Measure (Watt & Morris, 1998). The questionnaire was developed as a result of the authors' observation that none of the existing questionnaires covers all the important aspects of imagery. The selected items shared sound face validity as they were identified and agreed upon by four sport psychologists well versed with the imagery practice and literature. Based on the current data, the scale's Cronbach's alpha internal consistency was 0.82 for the squeezing task and 0.87 for the cycling task. To ensure that the mental images promoted either a dissociative or an associative focus of attention, and to control for any ironic effects that may have resulted from the imagery training, an open-ended item for participants to describe their mental images was added to the scale.

For ensuring that the control group used no imagery, a control check was administered. The two open-ended items developed by the authors included: (1) what have you been thinking while squeezing/cycling and (2) please describe your thoughts at the moment when you first started feeling fatigued. Data from the imagery and control check measures were not subjected to statistical analysis but were used for the purpose of checking effective imagery use in experimental conditions and the absence of imagery use in the control condition.

Imagery/control log

Consistent practice of imagery use and control activities was assessed by means of an imagery log. The imagery log mirrored the imagery manipulation check scale. Each day, following the practice of their imagery, participants completed the log. Mirroring the imagery check scale, the log included ten items rated on a scale ranging from 0 (not clear at all, no control at all, etc.) to 10 (very clear, very high control, etc.). Additionally, the onset and finishing time of the daily imagery practice were reported using the log.

Consistent practice of control activities was assessed by means of a control log. On the control log, participants summarized daily assigned health-related excerpts (see procedure). Data from the logs were used for purposes of ensuring consistent follow up with the assigned activities.

Physiological measures

Maximal oxygen uptake (VO_{2max})

Participants' fitness level was determined by means of a VO_{2max} test performed at the testing center, under the supervision of a trained exercise physiologist. The test consisted of a graded cycling task to volitional fatigue. Graded exercise testing using a cycle-ergometer provides safety and monitoring advantages over alternative protocols such as treadmill (Mitchell, Kist, Mears, Nalls, &

Ritter, 2010) hence, its selection for the current study. Prior to the onset of the VO_{2max} test, participants' height and weight were recorded. Indirect calorimetry was performed, and the ergometer seat height was adjusted to allow for 5–10° of knee flexion at the bottom of each stroke. For the purposes of this test, participants were instructed to cycle for 3 min at 50 rpm with 0.5 kg resistance (24.6 W) as a warm up. After this warm up period, resistance was increased by 0.5 kg (24.6 W) every 2 min until the participants could no longer maintain the 50 rpm pace for 10 consecutive seconds, or volitional fatigue. RPE was measured every 2 min, and HR was measured every 1 min. Participants' VO_{2max} was estimated as the point at which the individual met at least three of the following four criteria: RPE ≥ 17 (Very Hard), VO_2 (change < 2.1 ml kg^{-1} min^{-1}), RER > 1.15, and HR at or above 95% of predicted HR_{max} (see American College of Sport Medicine; ACSM, 1995 for guidelines). AT was determined using the D_{max} method (Cheng et al., 1992). The target mean VO_2 values for the associative, dissociative, and control groups were 36.62, 37.48, and 33.42 ml kg^{-1} min^{-1} – all equal to a 0.79 ratio (VO_2/VO_{2max}).

Heart rate

During the cycling protocol, HR was measured using a Polar HR monitor (Polar F4). HR was monitored continuously and recoded at 1-min intervals for the purposes of statistical analysis.

Lactic acid

Lactic acid accumulation was measured by using a finger pick blood draw analyzed via a lactometer (Accutrend Lactate). An expert exercise physiologist in exercise testing performed all the samplings.

Experimental conditions

The study included three conditions: (1) associative imagery, (2) dissociative imagery, and (3) control (i.e. no imagery). Following the VO_{2max} test, participants in the experimental conditions (i.e. associative, dissociative imagery conditions) were provided with the imagery training. Imagery training consisted of an individual session of 45 min. One researcher provided imagery training to all the participants assigned to either imagery groups. Drawing from the *model of imagery ability in relation to sport* (Watt, Morris, & Andersen, 2004), imagery training included the definition of imagery, appropriateness of its use, and critical aspects to its effectiveness (i.e. vividness of image, control over image, external and internal perspective to imagery, multisensory involvement, and importance of frequent practice). Participants in either imagery groups received identical imagery training, but the instructions pertaining to the associative and dissociative scenes remained specific (see training protocol). Imagery training was followed by a 5- to 10-min practice of dissociative and associative imagery scenes. Although the participants were consistently provided with examples of suitable imagery scenes, they were also encouraged to generate personalized imagery scripts since using personalized imagery scripts was shown to be more effective (Lang, 1985) and particularly so in the motor domain (Smith, Wright, Allsopp, & Westhead, 2007). To help ensure best imagery practice, following a brief practice of imagery, participants responded to the imagery check questionnaire and performed a handgrip squeezing task while using their imagery.

PETTLEP framework

Research into the effectiveness of motor imagery has denoted that motor imagery is beneficial to the extent that it produces neural responses that are functionally equivalent to the ones generated during the actual motor behavior (Holmes & Collins, 2001). Holmes and Collins's PETTLEP framework concurs with the notion of functional equivalence and highlights the notion that to maximize the effectiveness of motor imagery, the functional equivalence between the imagery content and actual motor behavior should be considered on seven dimensions: *physical* (i.e. equivalence in kinesthesis), *environment* (i.e. equivalence in settings), *task* (i.e. equivalence in task type), *timing* (i.e. equivalence in task pace), *learning* (i.e. equivalence in learned skills), *emotion* (i.e. equivalence in generated affects), and *perspective* (i.e. equivalence in internal vs external perspective adopted by the performer) (PETTLEP). To maximize the effectiveness of imagery use, throughout the current imagery training and practice, contents to reflect a number of the seven principles of PETTLEP were emphasized.

Associative imagery training

Participants in the associative imagery condition were instructed to visualize a scene that was related to the upcoming motor tasks (handgrip and cycle-ergometer tasks). Examples of associative imagery scenes for the handgrip squeezing task included visualizing the squeezing hand getting bigger and stronger. Examples of associative scenes for the cycling task included visualizing cycling legs getting more forceful and powerful. For both tasks, participants were instructed to also visualize themselves confident and in complete control of the task despite the aversive sensations that eventually arise as a result of sustained increased time spent on task. Also, consistent with the functional equivalence (Kosslyn, Ganis, & Thompson, 2001) and PETTLEP approaches (Holmes & Collins, 2001), participants were instructed to be fully engaged in the task and attend to the somatic (i. e. physical) sensations associated with the invested effort. Finally, participants were instructed to produce images from an internal perspective. Thus, the associative scenes remained congruent with the nature and requirements of the handgrip and cycling tasks.

Dissociative imagery training

Participants in the dissociative imagery condition were instructed to visualize a scene that is irrelevant to handgrip and cycling tasks. Examples of dissociative scenes included picturing oneself as listening to a “psych up” song, accomplishing desired goals (e.g. in academic and social realms), and/or coming up with innovative ways to overcome a long-standing problem. Although motivational in nature, dissociative images were incongruent with the handgrip and cycling tasks and aimed at allowing distraction from effort-related sensations.

Control session

Participants in the control group did not receive imagery training. Instead, they were instructed to read a health-related excerpt and briefly elaborate on it using a blank sheet that was handed to them. The main topic to the excerpt was the benefits of physical activity on health. Each control session lasted ~45 min and was provided by the same researcher who provided the imagery training.

Procedures

Participation in this study included two sessions. Each of the sessions lasted ~1 h. An interval of one week was allowed in between the two sessions. At session one, participants were provided with a broad description of the study. The health history along with an informed consent form and demographic form was obtained from each participant. At the first session participants completed a VO_{2max} test on a cycle-ergometer. Prior to the onset of the VO_{2max} test, participants’ height and weight were recorded, indirect calorimetry was performed, and the ergometer seat height was adjusted to allow for 5–10° of knee flexion at the bottom of each stroke. As per the ACSM (1995) guidelines for sub-maximal cycle-ergometer testing for VO_{2max} prediction, participants were instructed to cycle for 3 min at 50 rpm with 0.5 kg resistance (24.6 W) as a warm up. After this warm up period, resistance was increased by 0.5 kg (24.6 W) every 2 min until the participants could no longer maintain the 50 rpm pace for 10 consecutive seconds, or volitional fatigue. RPE was reported every minute, and HR was averaged every minute.

Following the VO_{2max} test, 45 participants were assigned to each of the three conditions. Based on their assignment to either one of the conditions, participants received associative or dissociative imagery training, or read a health-related excerpt. At the end of the training sessions, participants in the imagery conditions briefly practiced their imagery and answered the imagery manipulation check scale. Upon completing the reading of the assigned excerpt, participants in the control condition summarized the reading excerpt on a blank sheet that was handed to them. Next, to ensure participants’ ease for implementing imagery during effort expenditure, participants in the imagery groups performed a handgrip squeezing task with their dominant hand at 30% of the individual maximal contraction value up to the point of volitional fatigue. Maximal contraction value corresponded to the participants’ highest contraction score of the three consecutive squeezing attempts that preceded the handgrip squeezing task. They were instructed to use their respective imagery during the handgrip squeezing task. Participants in the control group performed the squeezing task with no instruction of imagery use. Prior to the squeezing task, all participants responded to the TSSE scale. During the squeezing task, RPE and attention were measured every 30 s. The test was completed when the participant failed to maintain the target value for 10 s or upon reaching volitional fatigue. Next, participants responded to the imagery check, control check, and commitment check scales.

At the completion of session one, participants in the imagery group were instructed to practice their imagery scenes every day (i.e. for seven consecutive days) until session two. This was consistent with the notion that regular practice of imagery is known to best achieve its desirable effects on task performance (Watt et al., 2004), and seven days were deemed sufficient to meet this purpose in the present study. At this point, participants received the imagery practice log to bring back at session two. Participants in the control group received a total of seven health-related excerpts. They were instructed to read one excerpt per day. Participants in the control group were provided with a control log to fill in daily and were instructed to bring their log back at session two. To best ensure participants' follow up with their practices and reporting, daily e-mail reminders were sent to each participant.

Participants returned to the testing center one week following session one. Their height and weight were recorded. After being seated for at least 5 min, participants were administered the TSSE scale. Participants were instructed to cycle for 3 min at 50 rpm with 0.5 kg resistance (24.6 W). Cycling cadence for the duration of the test was 50 rpm. Participants began the test by cycling with low resistance (0.5 kg or 24.6 W) for 3 min to warm up. After 3 min, resistance was increased to 55% of AT for 1 min. At minute 4, resistance was increased to 110% of AT and the timer started. Resistance at 55% and 110% of AT was calculated from session one. The test was stopped when the participant failed to maintain 50 rpm for 10 s or reached volitional fatigue. RPE and attention (0–10 scale) were recorded every minute following the warm up. Blood lactate was measured when participants reported RPE ≥ 5 (strong), and at the completion of the test. Imagery check, control check, and commitment check scales were administered following the final lactate measurement.

Design

A mixed experimental design with one grouping factor (experimental condition – two imageries and a control), and RM as a within factor were used to test the study's hypotheses. The main dependent variables in the present study included RPE and attention focus (measured repeatedly throughout the task), time on task (i.e. adherence, measured at task completion), time to RPE = 5 (strong), time to D/A shift, and LA accumulation (measured twice, i.e. at RPE = 5 (strong) and at the point of volitional fatigue). To control for noise and internal validity, participants reported on task commitment, TSSE, and imagery use. Additionally, participants' HR was monitored throughout the entire cycling task.

Statistical analysis

Several statistical procedures were used to test the study's hypothesis. One-way ANOVA was performed on variables which were measured once, i.e. task commitment score, VO_{2max}, duration of cycling time, time lap to RPE = 5 (strong), time lap until the D/A shift (D/A = 5), and mean HR across the entire cycling task. MANOVA was performed for variables which were measured by several items, i.e. the commitment items and the specific self-efficacy items. Mixed RM ANOVA was performed for variables which were measured repeatedly through five time intervals, i.e. RPE, HR, attention focus, and LA (two times). When appropriate ANOVAs were performed for variables (LA) at single time intervals followed by Scheffe post hoc multiple mean comparison test. Cohen's *d* values were used to describe the between experimental conditions effect sizes along with the means and SDs descriptive statistics. When sphericity violation was observed (HR values which share small variance) Greenhouse–Geisser (GG) non-sphericity method replaced the Wilks' λ multivariate coefficient. Time effects were not reported due to the obvious significant effect for all the study's dependent variables.

Results

Controlling for experimental conditions' equality and manipulation checks

Testing initial differences between the groups

Prior to testing the study's hypotheses several statistical tests were performed to detect any possible violations related to the study's internal and external validity. A one-way ANOVA revealed non-significant effect for experimental condition on participants' maximal oxygen uptake capacity (i.e. VO_{2max}), F (2, 42) = 0.98, $p = 0.383$, $\eta_p^2 = 0.05$, $M_{overall} = 46.63$ ml kg^{-1} min^{-1}, SD = 10.59.

Data from the imagery log were not subjected to statistical analysis. All participants in the two experimental groups completed and handed their imagery log to the researcher. The comprehensive data set indicated that participants in both imagery groups practiced their assigned imageries daily with either stable or progressively increasing self-evaluations of imagery ability.

MANOVA test revealed non-significant experimental condition effect on perceived levels of TSSE, Wilks' λ = 0.93, $F\,(6, 80) = 0.47$, $p = 0.832$, $\eta_p^2 = 0.03$. Participants in all conditions reported high absolute level (>7.0) of TSSE (i.e. self-belief for tolerating the effort associated with the cycling task) as evidenced by the average ratings of 7.40–8.07 on the 10-point scale. MANOVA tests performed on the three items of the commitment scale resulted in non-significant experimental condition effect, Wilks' $\lambda = 0.88$, F (6, 80) = 0.89, $p = 0.509$, $\eta_p^2 = 0.06$. One-way ANOVA tests on the total scale score revealed a non-significant experimental condition effect on participants' commitment to perform the cycling task, F (2, 42) = 0.72, $p = 0.491$, $\eta_p^2 = 0.03$. Participants across the three conditions reported high absolute level (>4) of task commitment ($M = 4.19$–4.46 on the 5-point scale). Thus, results indicated that participants in the three experimental conditions did not differ in VO_{2max}, perceived self-efficacy, and commitment to the cycling task.

Testing for gender and group by gender equality

Because the stratified random assignment to the experimental and control groups consisted of VO_{2max} values, the gender ratio among the groups was not identical. To examine for gender bias effect on the main findings of this study, the gender and gender by experimental condition effects were tested on all the variables of interest. Mixed RM ANOVA on five-intervals RPE during the cycling task resulted in non-significant gender, Wilks' $\lambda = 0.75$, $F(5, 35) = 0.11$, $p < 0.98$, $\eta_p = 0.02$, and experimental by gender effects, Wilks' $\lambda = 80$, $F(5, 35) = 0.71$, $p < 0.71$, $\eta_p = 0.10$. Related analysis for attention allocation yielded similar results for gender, Wilks' $\lambda = 0.87$, $F(5, 35) = 0.57$, $p < 0.52$, $\eta_p = 0.13$, and gender by experimental condition, Wilks' $\lambda = 0.74$, $F(5, 35) = 1.12$, $p < 0.47$, $\eta_p = 0.26$. The RPE and attention allocation during the handgrip squeezing tasks resulted in similar non-significant statistics. The LA for males and females taken at RPE = 5, and immediately after volitional fatigue, resulted in non-significant gender effect, Wilks' $\lambda = 84$, $F(2, 34) = 2.07$, $p < 0.12$, $\eta_p = 0.16$, and experimental condition by gender effect, Wilks' $\lambda = 75$, $F(4, 34) = 1.73$, $p < 0.23$, $\eta_p = 0.15$. MANOVAs have indicated that gender and gender by experimental condition were non-significant ($p > 0.05$) for task commitment and self-efficacy items. ANOVAs indicated the same for VO_{2max} and AT.

Testing for physiological protocol equality among the conditions

Heart rate

RM MANOVA was performed on the HR values using five time intervals as RM and experimental condition assignment as a grouping BS factor. The analysis revealed a non-significant time by experimental condition effect on HR, GG = 0.584, F (4.672, 93.445) = 0.45, $p < 0.797$, $\eta_p^2 = 0.022$, as well as non-significant experimental condition effect, F (2, 40) = 0.11, $p < 0.899$, $\eta_p^2 = 0.005$, indicating similar physiological load for all participants. On average participants in the dissociative imagery condition ($M = 122.24$, SD = 4.31) recorded similar mean HR values across the five time intervals as those participants in the control ($M = 119.73$, SD = 4.17) and associative imagery conditions ($M = 119.90$, SD = 4.31).

Testing for the imagery and control conditions contents during cycling

Based on the two open-ended items administered after completing cycling with and without the designated imageries, the participants in the associative imagery group wrote the following sample of imageries/thoughts: “saw myself cycling hard, getting stronger and fighting, centering on my breathing, telling myself to overcome the physical challenges, feeling my strides and muscles.” The participants in the dissociative imagery group reported the following: “saw myself running away from thieves, directing a marathon race, had an argument which escalated to a boxing fight, riding a horse, working on a dream job, defending a thesis in front of professors, focusing on solving problems in an exam, while surfing – waiting for a wave, attending public hearing and defending own position.” The participants in the control conditions reported the following: “Thought about my finger hurt, nothing much – a bit about the test I have after, not a lot early on, my appointment next week, a song stuck in my head, how long it would last, first though about a grocery list and then when became harder paid attention to the discomfort and pain”.

Without exception, participants in all the three conditions reported that when the cycling got harder they shifted attention to the physical sensations, exertion, and pain associated with the cycling. The sample of thoughts and images given by the participants indicates that the participants in the two imagery conditions *imaged* themselves associating and dissociating as taught and instructed, and the participants in the control conditions had random *thoughts* – none reported about any image. When feeling “strong” exertion, all the participants shifted attention to the painful and exertive bodily sensations.

Considering the two imagery conditions for an RM ANOVA procedure along with descriptive statistics of the imagery questionnaire administered at three occasions (practice, squeezing task, and cycling) resulted in mean values ranging between 6 and 8 (of 10) for the imagery's vividness, controllability, engagement, motivated to reduce exertion, easiness of generating, belief in imagery for tolerating the effort exertion, and duration of holding the imagery. The length of time for the imagery scene to appear was very short (2–3 on the 10-point scale). The ANOVAs pertaining to each of the items and total scale by imagery condition were all non-significant ($p > 0.05$). This was the case also for the single items measuring the extent to which participants used associative or dissociative imagery during cycling.

Main findings: testing the study's hypotheses

Duration of the cycling (adherence)

A one-way ANOVA revealed non-significant differences among the three conditions for cycling time, F (2, 42) = 0.06, $p = 0.941$, $\eta_p^2 = 0.00$. Descriptive examination of the results however indicated somewhat longer cycling duration for the participants in the associative imagery condition (M = 420.40 s, SD = 344.87) followed by the participants in the dissociative imagery condition (M = 405.80 s, SD = 390.26, $d = 0.04$) and the control condition (M = 377.20 s, SD = 290.52, $d = 0.14$).

Rate of perceived exertion

A mixed RM ANOVA revealed significant experimental condition effect on RPE – measured during five time intervals, F (2, 42) = 3.80, $p < 0.030$, $\eta_p^2 = 0.153$. Descriptive examination of the RPE mean values across the first five time intervals indicated that the participants in the associative imagery condition reported on average the highest rates of perceived exertion across the five time intervals (M = 3.60, SD = 0.31) followed by the participants in the control (M = 3.05, SD = 0.36) and dissociative imagery conditions (M = 2.38, SD = 0.29). Moderate to large effect size differences were noted for RPE; participants using associative imagery reported higher RPEs than their counterparts in the dissociative imagery ($d = 1.00$) and the control condition ($d = 0.46$). Moreover, participants in the control condition reported higher mean for RPE than the participants in the dissociative imagery conditions (d = 0.55). The analysis also revealed a non-significant time interval by experimental condition interaction effect, GG = 0.488, F (3.905, 81.997) = 0.97, p = 0.425, $\eta_p^2 = 0.044$. Mean values of reported RPE throughout the five 1-min time intervals by the three experimental conditions are presented in Figure 1. Descriptive results suggested somewhat lower RPE values for the participants in the dissociative imagery condition, while relatively high RPE values were recorded for the participants in the associative imagery condition.

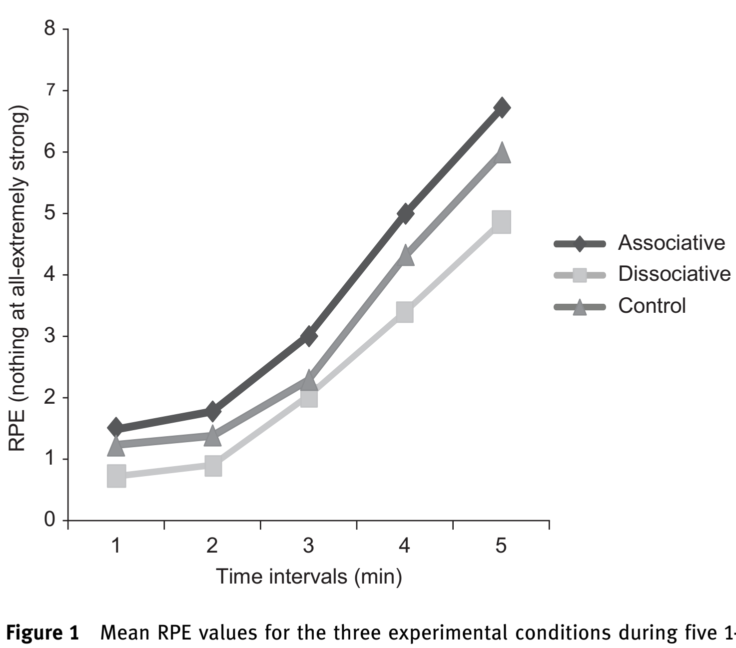

Figure 1 Mean RPE values for the three experimental conditions during five 1-min time intervals

Time to RPE = 5 (strong)

The one-way ANOVA for "time to RPE = 5" (strong) approached significance, F (2, 42) = 2.90, p = 0.07. Descriptive examination of the time lap until participants felt "strong" exertion (i.e. RPE = 5) revealed that the highest average time to RPE = 5 was reported by the participants in the dissociative imagery condition (M = 5 min) followed by the participants in the control condition (M = 4.30 min) and associative imagery condition (M = 4 min). Consequently, participants in the dissociative imagery condition seemed to cycle longest until they reached strong exertion (RPE = 5).

Attention focus

Mixed RM ANOVA was performed for the five times attention focus measures taken through cycling. A main effect for the experimental condition on attention focus was revealed, F (2, 42) = 8.43, p < 0.001, η_p^2 = 0.286. Collapsing the five time intervals, attention focus scores indicated that on average participants in the associative imagery condition reported the highest mean for attention focus (M = 5.42, SD = 0.368) followed by the participants in the control condition (M = 4.02 SD = 0.368) and dissociative imagery condition (M = 3.32, SD = 0.368). Moderate to large effect sizes were noted between participants in the associative and dissociative imagery conditions (d = 1.47), associative imagery and control conditions (d = 0.98), and control and dissociative imagery conditions (d = 0.50) (see Figure 2). However, time interval by experimental condition interaction effect was non-significant, GG = 0.649, F (5.191, 109.018) = 0.90, p = 0.486, η_p^2 = 0.041. Descriptive examination revealed that participants using associative imagery on average seemed to report higher associative attention focus from the onset of the task until minute 5. Conversely, participants using dissociative imagery on average seemed to report higher dissociative attention focus during the same time interval.

Time to D/A shift (attention = 5)

One-way ANOVA applied to the time cycling until attention shifted from a dissociative to an associative mode (i.e. Attention = 5, i.e. initial D/A shift) revealed significant effect for the experimental condition, F (2, 41) = 5.61, p < 0.007. Longer average time spent cycling until the initiation of the shift was noted for the participants using dissociative imagery (M = 5.2 min), followed by their counterparts in the control condition (M = 4 min) and those using associative imagery (M = 2.7 min).

Lactic acid

Mixed RM ANOVA for LA was performed to the values recorded at RPE = 5 and immediately following the

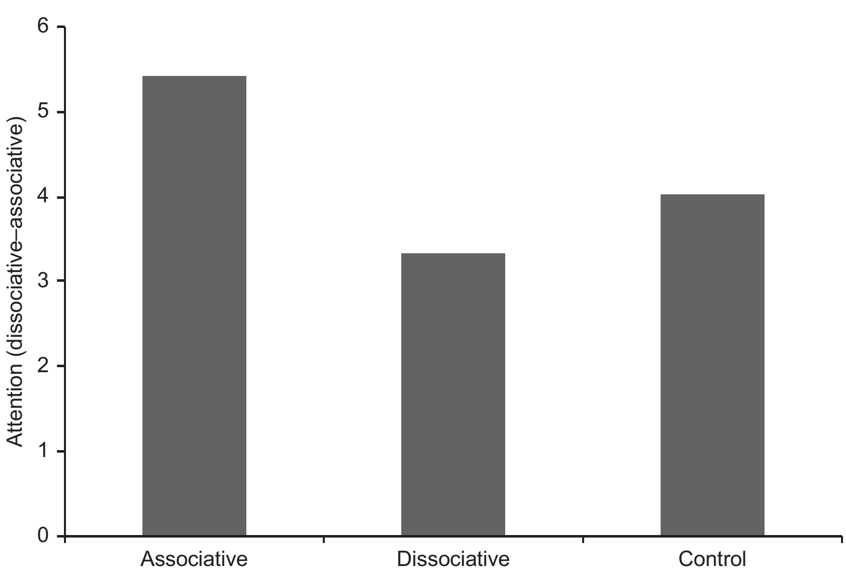

Figure 2 Mean attention values for the three experimental conditions during five 1-min time intervals

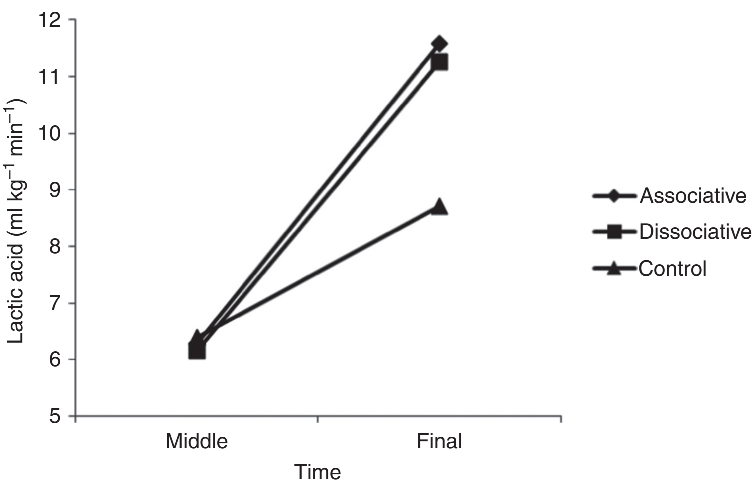

Figure 3 Mean final lactic acid concentration values (ml kg^{-1} min^{-1}) for the three experimental conditions at RPE = 5 (strong) and at volitional fatigue

volitional fatigue (e.g. when the participant could no longer adhere to the cycling task). The analysis revealed non-significant group by time interaction effect, Wilks' $\lambda = 0.89$, F (2, 39) = 2.42, $p < 0.102$, $\eta_p{}^2 = 0.11$. Following one-way ANOVA tests revealed non-significant group effect on participants' level of LA accumulation at RPE = 5, F (2, 39) = 0.32, $p = 0.970$. However, a significant difference was revealed at task completion, F (2, 39) = 4.469, $p = 0.017$. Scheffe post hoc multiple mean comparison tests indicated a significant ($p < 0.033$) experimental condition difference between the two imagery and control conditions, while non-significant difference ($p > 0.05$) was indicated between associative and dissociative imagery conditions.

Descriptive examination indicated similar LA concentration at RPE = 5 for participants in the associative imagery condition (M = 6.28, SD = 2.77), dissociative imagery condition (M = 6.15, SD = 3.14), and control condition (M = 6.40, SD = 2.28). Minimal effect sizes were noted between the associative and dissociative imagery conditions (d = 0.04), control and associative imagery conditions (d = 0.09), and control and dissociative imagery conditions (d = 0.002). Examination of the final LA concentration values seemed to indicate somewhat substantial increase in lactic acid in participants using associative imagery (M = 11.59, SD = 2.64) and dissociative imagery (M = 11.27, SD = 3.03), but less for participants in the control condition (M = 8.71, SD = 2.98). Small d values were recorded between the associative and dissociative imagery conditions (d = 0.11), while large d values were recorded between the associative imagery and control conditions (d = 1.02) and dissociative imagery and control conditions (d = 0.85). The d values remained unchanged after controlling for the lactic acid accumulation differences at the middle stage of the effort (RPE = 5). Mean final lactic acid concentration values across conditions are presented in Figure 3.

Discussion

The purpose of the current study was to examine the effects of associative and dissociative imagery on the D/A shift, RPE, and time on task during a cycling task at 10% above AT. In an effort to further add to the extant research, the present study also measured the accumulation of LA given that LA is a stable correlate of RPE (Borg, 1998; Lagally et al., 2002) and was not considered in previous works into the effects of imagery use on RPE.

We have hypothesized that (1) both imagery use would result in longer time on task compared to no imagery use and (2) dissociative imagery use would result in lower RPEs and longer delay of the D/A shift compared to associative imagery and no imagery use. Although there is no research to date examining the effects of imagery on the physiological markers of fatigue, because LA accumulation is a marker of muscle fatigue (Cairns, 2006), we expected that (3) the use of either imagery would result in higher concentration of LA – as a direct result of longer time spent on task. Finally, we expected that HR, as a control variable would not change across groups due to the identical physiological load set for all participants (i.e. 10% above AT).

Participants using either imagery did not cycle significantly longer than participants who were not using imagery. Only descriptively however, participants using either associative or dissociative imagery seemed to remain on task somewhat longer than the participants using dissociative imagery or no imagery (d range = 0.04–0.14). Specifically, participants using associative imagery seemed to persevere on task the longest (M = 420.40 s) followed by the participants using dissociative imagery (M = 405.80 s) and the participants using no imagery (M = 377.20 s). While this observation is not statistically significant, research would benefit from investigating the effectiveness of associative imagery use in prolonging task endurance. Associative imagery may have potentials to facilitate longer time on task because of its task-relevant content and increased likelihood to provide greater functional equivalence to the task at hand (see, Holmes & Collins, 2001). Given that imagery can serve a motivational function (Paivio, 1985), associative imagery in the present study may have also been particularly motivating because of its high functional equivalence to the cycling task. Previous research into the effectiveness of cognitive strategies revealed that associative thoughts are more beneficial than dissociative ones for extending time on task in rowing (Connolly & Janelle, 2003) and a sub-maximal cycle-ergometer task (Goudas, Theodorakis, & Laparidis, 2007). Within elite sports settings, associative cognitive strategies were also shown to allow more optimal regulation of effort and pace (Lind et al., 2009) and extend task endurance (Baden et al., 2005).

Similarly, for our second set of expectations participants using dissociative imagery neither reported significantly lower RPEs nor distracted the longest from the somatic sensations and fatigue. Only descriptively, however, these participants seemed to report decreased RPEs and slightly delayed reach of strong exertive sensations compared to participants using no imagery and associative imagery. While these tentative observations are not significant, potentials hold by dissociative imagery may be worth pursuing in that, Stanley, Pargman, and Tenenbaum (2007) indicated that the use of dissociative strategies may lead participants to perceive tasks as less daunting; hence decreased perception of effort invested in the task. These assertions also concur with previous reports suggesting the effects of associative strategies for increasing the perception of task-related fatigue (Baden et al., 2005).

In regards to our third set of hypothesis however, participants using either imagery accumulated significantly higher concentration of LA at the point of volitional fatigue. To the extent that blood lactate levels define muscle fatigue and effort output (Borg, 1998; Cairns, 2006), this finding should be considered an objective indication of imagery's benefit for increasing effort on task despite the presence of fatigue. Thus, imagery use may have motivated participants to persevere longer on task (see Paivio, 1985). Drawing upon the present descriptive findings that seem to indicate longer time on task for participants using imagery, it could be the case that the imagery use may have helped these participants to endure longer on task resulting in higher concentration of LA in the blood at the point of volitional fatigue. Lastly, it is important to note that HR levels did not differ across conditions providing evidence that all participants underwent relatively similar physical load during effort expenditure (i.e. 10% above AT).

To explicate some of the results herein, it should be noted that several studies failed to identify any RPE differences between associative and dissociative strategies including imagery during physical effort expenditure (Connolly & Janelle, 2003; Razon et al., 2010b). It is important however to consider that in the present study, participants practiced and self-reported on their imagery use for seven consecutive days prior to performing the cycling task. Consistent practice of imagery is known to best increase its desirable effects on task performance (Watt et al., 2004); thus, the practice of imagery in the present study may have underlined some of the more promising findings than the ones previously reported. However, it is important to note that alternative accounts from sport psychology literature have included longer period of imagery practice for observing performance effects (Guillot, Genevois, Desliens, Saieb, & Rogowski, 2012), hence extended imagery practice periods could potentially reveal more beneficial effects. Drawing back to the significant increase in the LA concentration associated with imagery, the use of differential imagery during effort expenditure may prove beneficial. To that end, research should test the effectiveness of imagery contents priming a dissociative focus of attention to help reduce perception of exertion, and delay the initiation of the D/A shift, as well as the potentials of imagery contents priming an associative focus of attention to help prolong time on task. Arguably, most optimal effects may also be achieved by means of hybrid imagery designs that would combine the effort perception reducing effects of dissociative strategies and the task-prolonging effects of associative strategies.

To reiterate the earlier assertions of Hall (1995), imagery's benefits may be transferable from sport to exercise settings. This said, the design and use of imagery contents that share high functional equivalence on each of the physical, environmental, task, timing, learning, emotional, and perspective dimensions with the subsequent motor tasks would be most likely to allow optimal psychological and performance outcomes in exercise settings (see Holmes & Collins, 2001). Previous research examining attention modulation via visual (Razon et al., 2009) and auditory stimuli (Razon et al., 2009) has shown separate potential benefits of these modalities in decreasing perception of effort and increasing time on task. Thus, one can argue that combining these interventions with imagery can help stimulate more than one sensory modality and allow more beneficial results than the use of single modalities.

Despite the significant finding in LA concentration and some of the encouraging observations, a number of limitations should be acknowledged: (1) this study was a single task design, and the effects of imagery were tested on a cycling protocol only, (2) although individualized, the imagery scripts were restricted to two types, i.e. associative and dissociative imagery, (3) most of the participants in the present study were young and fit individuals; older and more sedentary populations were not comprised within the present study's sample, (4) to satisfy the requirements of the random stratified assignment, participants' aerobic capacity (VO_{2max}) and not gender was the criterion of stratification; hence gender was not ideally balanced within the current study, and finally (5) as opposed to some account that would advise for more extensive imagery practice for observing sport performance effects (i.e. twice per week for six weeks; Guillot et al., 2012), participants in this study practiced imagery once per day for one week.

In view of these limitations and boundaries, additional inquiries including a larger array of tasks of divergent nature and requiring diverse muscle unit recruitment would serve higher practical utility. Investigations may also benefit from different and more ecologically valid protocols which may include running and weight training procedures among others. Moreover, alternative imagery scripts to blend both associative and dissociative elements or represent some aspects of the appearance, technique, and energy imagery may allow greater effects and more decisive conclusions. To that end, regardless of the specific imagery type, an area that warrants future research consideration may involve the effectiveness of imagery scripts that progress from a dissociative-motivational focus to an associative-motivational one.

Also, replication of these trials with clinical or less fit populations would likely allow more extensive and comparative conclusions for the effectiveness of differential imagery use in exercise settings. Given that ideal sampling procedures should achieve balanced gender representations, similar studies would benefit from stratifying both on gender and on the aerobic capacity. Finally, additional research is needed to determine the ideal length of imagery practice sessions for observable effects in exercise settings.

As a final word of conclusion, it should be noted that although the higher concentration of LA in participants using imagery might indicate higher levels of effort invested by these participants, replicating this finding as well as some of the tentative and non-significant observations herein would strengthen the implications of the current study. It may be the case that there are potentially more helpful aspects of imagery use to mediate attention focus and produce both psychological and physiological effects in sport and exercise settings and these should be explored.

References

Accutrend Lactate [Apparatus]. (2006). Indianapolis, IN: Roche Diagnostics.

American College of Sports Medicine. (1995). *Guidelines for exercise testing and prescription* (5th ed.). Baltimore, MD: Williams & Wilkins.

Baden, D. A., McLean, T. L., Noakes, T. D., & St. Clair Gibson, A. (2005). Effect of anticipation during unknown or unexpected exercise duration on rate of perceived exertion, affect, and physiological function. *British Journal of Sports Medicine*, *39*, 742–746. doi:10.1136/bjsm.2004.016980

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY: Freeman.

Borg, G. (1962). A simple rating scale for use in physical work tests. *Kungliga Fysiografiska Sallskapets I Lund Forhandlinger*, *32*, 7–15.

Borg, G. (1982). Psychophysical bases of perceived exertion. *Medicine and Science in Sport and Exercise*, *14*, 377–381.

Borg, G. (1998). *Borg's perceived exertion and pain scales*. Champaign, IL: Human Kinetics.

British Columbia Department of Health. (1975). *The physical activity readiness questionnaire: Validation report for the 1975 modified version*. Vancouver, BC: Author.

Cairns, S. P. (2006). Lactic acid and exercise performance: Culprit or friend? *Sports Medicine*, *36*, 279–291. doi:10.2165/00007256-200636040-00001

Cheng, B., Kuipers, H., Snyder, A. C., Keizer, H. A., Jeukendrup, A., & Hesselink, M. (1992). A new approach for determination of ventilatory and lactate thresholds. *International Journal of Sports Medicine*, *13*, 518–522. doi:10.1055/s-2007-1021309

Connolly, C. T., & Janelle, C. M. (2003). Attentional strategies in rowing: Performance, perceived exertion, and gender considerations. *Journal of Applied Sport Psychology*, *15*, 195–212. doi:10.1080/10413200305387

Connolly, C. T., & Tenenbaum, G. (2010). Exertion-attention-flow linkage under varying workloads. *Journal of Applied Social Psychology*, *40*, 1123–1145. doi:10.1111/j.1559-1816.2010.00613.x

Cumming, J. (2008). Investigating the relationship between exercise imagery, leisure-time exercise behavior, and self-efficacy. *Journal of Applied Sport Psychology*, *20*, 184–198. doi:10.1080/10413200701810570

Cumming, J., & Stanley, D. M. (2009). Are images of exercising related to feeling states? *Journal of Imagery Research in Sport and Physical Activity*, *4*, Article 1. doi:10.2202/1932-0191.1033

Ekkekakis, P. (2003). Pleasure and displeasure from the body: Perspectives from exercise. *Cognition & Emotion*, *17*, 213–239. doi:10.1080/02699930302292

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavioral Research Methods*, *39*, 175–191. doi:10.3758/BF03193146

Gammage, K. L., Hall, C. R., & Rodgers, W. M. (2000). More about exercise imagery. *The Sport Psychologist*, *14*, 348–359.

Giacobbi, Jr., P. R., Hausenblas, H. A., & Penfield, R. D. (2005). Further refinements in the measurement of exercise imagery: The exercise imagery inventory. *Measurement in Physical Education and Exercise Science*, *9*, 251–266. doi:10.1207/s15327841mpee0904_4

Gordon, R. (1949). An investigation into some of the factor that favor the formation of stereotyped images. *British Journal of Psychology*, *39*, 156–167. doi:10.1111/j.2044-8295.1949.tb00215.x

Goudas, M., Theodorakis, Y., & Laparidis, K. (2007). The effect of external versus internal types of feedback and goal setting on endurance performance. *Athletic Insight*, *9*, 57–66.

Guillot, A., Genevois, C., Desliens, S., Saieb, S., & Rogowski, I. (2012). Motor imagery and "placebo-racket effects" in tennis serve performance. *Psychology of Sport and Exercise*, *13*, 533–540. doi:10.1016/j.psychsport.2012.03.002

Hall, C.R. (1995). The motivation functions of mental imagery for participation in sport and exercise. In J. Annett, B. Cripps, & H. Steinberg (Eds.), *Exercise addiction: Motivation for participation in sport and exercise* (pp. 15–21). Leicester, UK: British Psychological Society.

Hall, C. R., Pongrac, C., & Buckolz, E. (1985). The measurement of imagery ability. *Human Movement Science*, *4*, 107–118. doi:10.1016/0167–9457(85)90006-5

Hausenblas, H. A., Hall, C. R., Rodgers, W. M., & Munroe, K. J. (1999). Exercise imagery: Its nature and measurement. *Journal of Applied Sport Psychology*, *11*, 171–180. doi:10.1080/10413209908404198

Holmes, P. S., & Collins, D. J. (2001). The PETTLEP approach to motor imagery: A functional equivalence model for sport psychologists. *Journal of Applied Sport Psychology*, *13*, 60–83. doi:10.1080/10413200109339004

Hutchinson, J. C., & Karageorghis, C. I. (2013). Moderating influence of dominant attentional style and exercise intensity on responses to asynchronous music. *Journal of Sport and Exercise Psychology*, *35*, 625–643.

Hutchinson, J. C., & Tenenbaum, G. (2007). Attention focus during physical effort: The mediating role of task intensity. *Psychology of Sport and Exercise*, *8*, 233–245. doi:10.1016/j.psychsport.2006.03.006

Isaac, A. R., Marks, D. F., & Russell, D. G. (1986). An instrument for assessing imagery of movement: The vividness of movement imagery questionnaire (VMIQ). *Journal of Mental Imagery*, *10*, 23–30. doi:10.1037/t07980-000

Karageorghis, C. I., & Terry, P. C. (1997). The psychophysical effects of music in sport and exercise: A review. *Journal of Sport Behavior*, *20*, 54–68.

Kim, B. H., & Giacobbi, P. R. (2009). The use of exercise-related mental imagery by middle-aged adults. *Journal of Imagery Research in Sport and Physical Activity*, *4*, Article 1.

Kosslyn, S. M., Ganis, G. G., & Thompson, W. L. (2001). Neural foundations of imagery. *Nature Reviews. Neuroscience*, *2*, 635–664. doi:10.1038/35090055

Lagally, K. M., Robertson, R. J., Gallagher, K. I., Goss, F. L., Jakicic, J. M., Lephart, S. M., … Goodpaster, B. R. E. T. (2002). Perceived exertion, electromyography, and blood lactate during acute bouts of resistance exercise. *Medicine and Science in Sports and Exercise*, *34*, 552–559.

Lafayette 78010 Handgrip Dynamometer [Apparatus]. (2004). Lafayette, IN: Lafayette Instrument Company.

Lambrick, D. M., Faulkner, J. A., Rowlands, A. V., & Eston, R. G. (2009). Prediction of maximal oxygen uptake from submaximal ratings of perceived exertion and heart rate during a continuous exercise test: the efficacy of RPE 13. *European Journal of Applied Physiology*, *107*, 1–9.

Lang, P. J. (1985). The cognitive psychophysiology of emotions: Fear and anxiety. In A. H. Tuma & J. D. Maser (Eds.), *Anxiety and the anxiety disorders* (pp. 131–170). Hillsdale, NJ: Lawrence Erlbaum Associates.

Lind, E., Welch, A. S., & Ekkekakis, P. (2009). Do "mind over muscle" strategies work? I. Examining the effects of attentional association and dissociation on exertional, affective, and physiological responses to exercise. *Sports Medicine*, *38*, 2–55. doi:10.2165/11315120-000000000-00000

Marks, D. F. (1973). Visual imagery differences in the recall of pictures. *British Journal of Psychology*, *64*, 17–24. doi:10.1111/j.2044-8295.1973.tb01322.x

Martens, R. (1982). *Imagery in sport*. Paper presented at the conference on Medical and Scientific Aspects of Elitism in Sport, Brisbane, QLD.

Masters, K. S., & Lambert, M. J. (1989). The relations between cognitive coping strategies, reasons for running, injury, and performance of marathon runners. *Journal of Sport and Exercise Psychology*, *11*, 161–170.

Masters, K. S., & Ogles, B. M. (1998). Associative and dissociative cognitive strategies in exercise and cycling: 20 years later, what do we know? *The Sport Psychologist*, *12*, 253–270.

McAuley, E., Talbot, H. M., & Martinez, S. (1999). Manipulating self-efficacy in the exercise environment in women: Influences on affective responses. *Health Psychology*, *18*, 288–294. doi:10.1037/0278-6133.18.3.288

Mitchell, J., Kist, W. B., Mears, K., Nalls, J., & Ritter, K. (2010). Does standing on a cycle-ergometer towards the conclusion of a graded exercise test, yield cardiorespiratory values equivalent to treadmill testing? *International Journal of Exercise Science*, *3*, 117–125.

Monark Ergomedic 874 ECycle [Apparatus]. (2004). Vansbro, Sweden: Monark Exercise AB.

Nethery, V. M. (2002). Competition between internal and external sources of information during exercise: influence on RPE and the impact of the exercise load. *Journal of Sports Medicine and Physical Fitness*, *42*, 172–178. Retrieved from http://search.proquest.com/docview/202683164?accountid=8483

Okwumabua, T. M., Meyers, A. W., & Santille, L. (1987). A demographic and cognitive profile of masters cycleners. *Journal of Sport Behavior*, *10*, 212–220.

Paivio, A. (1985). Cognitive and motivational functions of imagery in human performance. *Canadian Journal of Applied Sciences*, *10*, 22–28.

Pandolf, K. B. (1978). Influence of local and central factors in dominating rated perceived exertion during physical work. *Perceptual and Motor Skills*, *53*, 683–698.

Razon, S., Arsal, G., Nacimiento-Rasor, T., Simonavice, E., Loney, B., Gershgoren, L., … Tenenbaum, G. (2010a). Perceptions of exertive pain, attention allocation, and task adherence in patients with fibromyalgia using imagery. *Journal of Multidisciplinary Research*, *2*, 5–24.

Razon, S., Basevitch, I., Filho, E., Land, W., Thompson, B., Biermann, M., & Tenenbaum, G. (2010b). Associative and dissociative imagery effects on perceived exertion, and task duration. *Journal of Imagery Research in Sport and Physical Activity*, *5*, 1–27. doi:10.2202/1932-0191.1044

Razon, S., Basevitch, I., Land, W., Thompson, B., & Tenenbaum, G. (2009). Perception of exertion and attention allocation as a function of visual and auditory conditions. *Psychology of Sport and Exercise*, *10*, 636–643. doi:10.1016/j.psychsport.2009.03.007

Rejeski, W. J. (1985). Perceived Exertion: An active or passive process? *Journal of Sport Psychology*, *7*, 371–378.

Rodgers, W. M., Munroe, K. J., & Hall, C. R. (2001). Relations among exercise imagery, self-efficacy, exercise behavior, and intentions. *Imagination, Cognition and Personality*, *21*, 55–65. doi:10.2190/UV5C-0HK0-7NYP-235K

Schomer, H. H. (1986). Mental strategies and the perception of effort of marathon runners. *International Journal of Sport Psychology*, *17*, 41–59.

Scott, L. M., Scott, D., Bedic, S. P., & Dowd, J. (1999). The effect of associative and dissociative strategies on rowing ergometer performance. *The Sport Psychologist*, *13*, 57–68.

Sheehan, P. W. (1967). A shortened version of Bett's questionnaire upon mental imagery. *Journal of Clinical Psychology*, *23*, 386–389. doi:10.1002/1097-4679(196707)23:<3386::AID-JCLP2270230328>3.0.CO;2-S

Smith, D., Wright, C., Allsopp, A., & Westhead, H. (2007). It's all in the mind: PETTLEP-based imagery and sport performance. *Journal of Applied Sport Psychology*, *19*, 80–92. doi:10.1080/10413200600944132

Stanley, D. M., Cumming, J., Standage, M., & Duda, J. L. (2012). Images of exercising: Exploring the links between exercise imagery use, autonomous and controlled motivation to exercise, and exercise intention and behavior. *Psychology of Sport and Exercise*, *13*, 133–141. doi:10.1016/j.psychsport.2011.10.002

Stanley, C. T., Pargman, D., & Tenenbaum, G. (2007). The effect of attentional coping strategies on perceived exertion in a cycling task. *Journal of Applied Sport Psychology*, *19*, 352–363. doi:10.1080/10413200701345403

Tammen, V. V. (1996). Elite middle and long distance runners associative/dissociative coping. *Journal of Applied Sport Psychology*, *8*, 1–8. doi:10.1080/10413209608406304

Tenenbaum, G. (2001). A social-cognitive perspective of perceived exertion and exertion tolerance. In R. N. Singer, H. A. Hausenblas, & C. Janelle (Eds.), *Handbook of sport psychology* (pp. 810–822). New York, NY: Wiley.

Tenenbaum, G., & Connolly, C. T. (2008). Attention allocation under varied workload and effort perception in rowers. *Psychology of Sport and Exercise*, *9*, 704–717.

Trethewey, N. (2013). The effects of mental imagery on implementation intentions: Specifically in regards to exercise goal achievement. *The Plymouth Student Scientist*, *6*, 272–288.

Watt, A. P., & Morris, T. (1998). *The sport imagery ability measure: Development and reliability analysis*. Paper presented at the 33rd Australian Psychological Society Conference (October), Melbourne, Australia.

Watt, A. P., Morris, T., & Andersen, M. B. (2004). Issues in the development of a measure of imagery ability in sport. *Journal of Mental Imagery*, *28*, 149–180.