EFFECTS OF COGNITIVE STIMULATION WITH A SELF-MODELING VIDEO ON TIME TO EXERTION WHILE RUNNING AT MAXIMAL AEROBIC VELOCITY: A PILOT STUDY

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Summary.—This study assessed whether video self-modeling improves running performance and influences the rate of perceived exertion and heart rate response. Twelve men (M age = 26.8 yr, SD = 6; M body mass index = 22.1 kg.m⁻², SD = 1) performed a time to exhaustion running test at 100 percent maximal aerobic velocity while focusing on a video self-modeling loop to synchronize their stride. Compared to the control condition, there was a significant increase of time to exhaustion. Perceived exertion was lower also, but there was no significant change in mean heart rate. In conclusion, the video self-modeling used as a pacer apparently increased endurance by decreasing perceived exertion without affecting the heart rate.

The question of which cognitive process is best for coping with exercise in endurance sports has been of great interest to researchers since the study of Morgan and Pollock (1977). The results of such research have been inconsistent, indicating that athletes use different cognitive processes to cope with difficulties and achieve high performance (for a review, see Masters & Ogles, 1998; Lind, Welch, & Ekkekakis, 2009; Salmon, Hanneman, & Harwood, 2010). Morgan and Pollock (1977) reported that the non-elite runners in their study employed a dissociative or distraction strategy (attention directed toward external events) to enhance their endurance. Specifically, they dissociated their attention from their bodily input, whereas the elite runners used an associative strategy by paying attention to their bodily input. Since this first study, where it was “accepted” that fast runners tend to use an associative strategy and slower runners a dissociative strategy (Salmon, et al., 2010), Masters and Ogle (1998) and later Lind, et al. (2009) promoted testing other hypotheses. For example, Morgan, Horstman, Cymerman, and Stokes (1983) and Stevinson and Biddle (1998) postulated an attention allocation focus, whereby a shift occurs from a dissociative to an associative strategy as the function of the intensity of the exercise (for a review, see Tenenbaum & Hutchinson, 2007). Using an unknown or unexpected exercise protocol, Baden, McLean, Noakes, and St Clair Gibson (2005) showed that participants’ associative thoughts

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Some studies that reported an improvement in performance also evaluated changes in rate of perceived exertion (RPE) or physiological parameters (heart rate [HR], maximal oxygen consumption [Vo2 max]). In examining the influence of distraction or association, a significant performance enhancement was found in endurance sports as compared to a control condition. Connolly and Janelle (2003) showed that rowers using an associative strategy performed better than those using a dissociative strategy, but they observed no statistically significant changes in RPE and HR. The effect size (ES) for the increase in rowed distance was medium (ES = 0.53). Morgan, et al. (1983) tested runners and observed that the running time of the athletes using a dissociative strategy was largely enhanced (ES = 1.00). However, RPE and HR showed little change at ES = 0.29 and ES = 0.11, respectively. In the results of their study, Russell and Weeks (1994) reported no statistically significant effect of distraction strategies on HR and RPE. Furthermore, Masters and Ogles (1998) and Razon, Basevitch, Filho, Land, Thompson, Biermann, et al. (2010) concluded that distraction was linked to lower RPE, whereas association was linked to high performance. However, Antonini Philippe, Reynes, and Bruant (2003) and Couture, Jerome, and TiHanyi (1999) found no significant changes in RPE with either strategy. However, the authors of those studies also reported that the choice of one strategy or the other did not influence physiological responses. These inconsistent results may have been due to the use of various experimental designs proposing different intensities of exercises, activities, and distractors; for example, questionnaires, specific tasks like watching a video or focusing on collages consisting of colored objects, shapes, and letters, and interviews (Antonini Philippe, et al., 2003; Connolly & Janelle, 2003; Couture, et al., 1999). Inconsistency reported by Lind, et al. (2009) makes it difficult to propose a definitive recommendation for the use of one strategy or the other while engaging in physical activity. Lind, et al. (2009) stated that both strategies have a place; the question of which strategy to use depends on the intensity of the exercise.

Many studies have used a video as a cognitive stimulation or distraction tool for enhancing performance. Such a research design can employ video feedback of a past action (the entire action is projected), video modeling and/or self-modeling (the subject repetitively watches the sequence of a task representing his or her best performance or that of an expert), or simply a distracting video (giving no supplemental information or having nothing to do with the task); for a review, see Dowrick (1999) and Ives, Straub, and Shelley (2002). In such protocols, the role of the video as a cog-
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Nitive stimulation or distraction tool appears to be effective at improving performance (principally motor skills) across a diverse array of sports, including gymnastics (Baudry, Leroy, & Chollet, 2006; Merian & Baumberger, 2007; Boyer, Miltenberger, Batsche, Fogel, & LeBlanc, 2009), volleyball (Zetou, Tzetzis, Vernadakis, & Kioumourtzoglou, 2002), and golf (Guadagnoli, Holcomb, & Davis, 2002; Bertram, Marteniuk, & Guadagnoli, 2007), as well as basic coordination movement (Hodges, Chua, & Franks, 2003) and endurance (Russell & Weeks, 1994; Scott, Scott, Bedic, & Dowd, 1999). The results of Baudry, et al. (2006) showed an enhancement in gymnasts’ performance using video modeling combined with verbal feedback (ES = 0.88 to 1.63), whereas Merian and Baumberger (2007) found that using video feedback with verbal comments enhanced task performance independent of sex, ranging from a small to a medium effect (ES = 0.21 and 0.41). With respect to endurance performance, Russell and Weeks (1994) found no effect; however, they noted a trend for RPE when using a video that was unrelated to the task at 75% maximal HR. Moreover, in a design where novice participants had to row as far as possible, Scott, et al. (1999) observed that rowing performance increased with the use of a video as a dissociation strategy (ES = 0.74), but this effect was smaller than in the association condition.

Dowrick (1989, 1999) defined a video self-modeling as a structured video replay providing trainees effective behavioral training. Those video sequences should depict performance slightly below the actual capacity and allow the performer to imagine better future skill. Those short video sequences of the person doing a best performance is played repetitively to enable the person to consolidate skills within an adaptive training protocol. Video modeling or self-modeling is a common approach in behavioral intervention in Bandura’s (1977) social learning theory. In sports, the use of video modeling is quite rare compared to other disciplines. This approach is primarily intended to improve technical skills (Baudry, et al., 2006; Boyer, et al., 2009; Steel, Adams, Coulson, Canning, & Hawtin, 2013).

Apparently, no researchers have studied the influence of cognitive stimulation using video self-modeling to investigate its effect on endurance and the physiological and perceptual responses of athletes. Therefore, the goal of the present pilot study was to assess whether video self-modeling could improve running performance by extending the time to exhaustion in trained athletes, and influence the athletes’ perceptual and physiological responses during an exercise that they performed until exhaustion.

Hypothesis. Video self-modeling would decrease runners’ RPE and HR, and increase time to exhaustion.
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Method

Participants

Twelve male participants, all of whom were sport sciences students, who trained 6 to 8 hours per week in different sports (running, soccer, and handball) and participated in regional level competitions, volunteered and gave written consent to participate in this study. The experiments were conducted in compliance with the Helsinki Declaration (1983), and the local ethics committee approved the protocol. Participants were requested to maintain their normal diet and training for the duration of the study. Each participant was familiarized with the testing protocol and equipment, but was not informed of the expected results of the study.

Procedure

As a pre-test, the participants performed a maximal running graded test on a track until exhaustion (VAMEVAL test of Cazorla & Leger, 1993) to measure their maximal aerobic velocity (MAV). Confirming that they had reached MAV relied on the fulfillment of the two following criteria: they were no longer able to keep pace with the soundtrack and they had to attain 100 percent (± 10 bpm) of age-predicted maximal HR. One week later, in line with Billat, Renoux, Pinoteau, Petit, and Koralsztein (1994), the participants were invited to perform two tests—control and video modeling—intended to assess the effect of the video feedback condition. They performed the two tests in random order; i.e., some participants did the control test first and some did the modeling test first. The control condition consisted of a time to exhaustion treadmill running test ($T_{ex}$) in front of a 2m × 2m white screen, where the participants had to maintain 100 percent MAV as long as possible (Billat & Koralsztein, 1996) with a passive coping strategy (i.e., without any specific attention allocation strategy; Tenenbaum & Hutchinson, 2007). The video feedback condition required the participants to perform a time to exhaustion test similar to the control condition, but they had to direct their attention to a video of themselves recorded during the pre-test (external active coping strategy; Tenenbaum & Hutchinson, 2007). The design of this condition replicated a race situation, where the participants could follow a “pace-setter,” sometimes colloquially called a “rabbit.” The video self-modeling consisted of a continuous loop projection of a sequence (30 sec. to 45 sec.) of the athlete himself, recorded during the last level of the maximal graded test. The participants in this cognitive running stimulation had to direct their attention to the screen fixed in front of the treadmill to synchronize their stride with the model. To ensure that the participants correctly synchronized their stride, a camera filmed them with the model on the screen. Each subject’s time to exhaustion was recorded and these data were used to assess effort tol-
erance, as Hutchinson, Sherman, Martinovic, and Tenenbaum (2008) described. In order to create a neutral experimental setting, no attempt was made to motivate the participants through verbal exhortations or to continue once they signaled the desire to stop. At the end of each test, the participants were checked to ensure that they had focused their attention correctly (i.e., without any specific attention allocation strategy and on the synchronization of their stride, in the control and video conditions, respectively). The participants performed the two tests one week apart.

**Measures**

For both tests, the participants ran on a treadmill (Jog forma 2, Technogym, Rimini, Italia) while the authors continually recorded their HR (Polar Vantage, Kempele, Finland). The authors utilized the French version of the RPE 6–20 (Borg, 1998), which was stuck on the wall in front of the participants, to estimate their RPE. This rating scale, which Shephard, Vandewalle, Gil, Bouhlel, and Monod (1992) validated, consists of numbers from 6 to 20, with descriptive words printed ranging from 7: Very, very light to 19: Very, very hard. The participants were instructed to report their overall RPE every 30 sec.

**Data Analysis**

The data comprise the mean (M) and standard deviation (SD). A paired t test was run to compare time to exhaustion in both conditions. As the participants did not attain exhaustion at the same time, the RPE and HR data were represented as percentages (10, 20, 30, 40, 50, 60, 70, 80, 90, and 100%) of the duration of the T_ex recorded in the control condition. For both conditions, an individual regression analysis was conducted to interpolate the perceived exertion data points (Robertson, Goss, Boer, Peoples, Foreman, Dabayebeh, et al., 2000; Robertson, Goss, Bell, Dixon, Gallagher, Lagally, et al., 2002), expressed as a percentage of the control condition. Finally, a two-way analysis of variance (ANOVA) was conducted, 2 conditions (video, control) × 10 measurements (the 10% steps of T_ex) and a Fisher post hoc test (Statview, SAS Institute Inc., version 5). Values were omitted from the video feedback condition if they were above 100 percent of the time in the control condition from the ANOVA. Effect size was calculated using Hedges’ (1982) formula. Cohen’s (1988) definitions of small, medium, and large ES were applied (ES=0.20, 0.50, and 0.80, respectively), and statistical significance was accepted at $p < .05$.

**RESULTS**

All of the participants in the present study attained 100 percent (±10 bpm) of age-predicted maximal HR on the MAV test. They were also able to synchronize their stride with the model, and compared to the con-
trol condition ($M = 217.50$ sec., $SD = 51.36$) they achieved a significant increase ($t = 3.75$, $p < .05$, $ES = 0.93$) in their time to exertion in the video feedback condition ($M = 269.08$ sec., $SD = 60.32$).

The ANOVA showed a significant condition effect ($F_{1,11} = 26.79$, $p < .05$) and a measurement effect ($F_{1,11} = 92.74$, $p < .05$), but no interactions ($F_{1,11} = .29$, $ns$), for perceived exertion. As indicated in Fig. 1, the post hoc tests revealed that RPE recorded in the video feedback condition was significantly lower ($p < .05$; $ES = 0.68$ at 50, .77 at 60, .84 at 70, .93 at 70, .98 at 90, and 1.03 at 100% of the time to exhaustion in the control condition). This difference represents a mean RPE decrease of 1.03 arbitrary units between both conditions.

As regards HR (Fig. 2), no significant effect for condition was observed ($F_{1,11} = .02$, $ns$), but a measurement effect was observed ($F_{1,11} = 8.63$, $p < .05$). Furthermore, no significant interactions were found ($F_{1,11} = .03$, $ns$).

**DISCUSSION**

The most important finding of this preliminary study using the “rabbit” model, which is one of the most common methods for attaining new world records in track and field, is that the cognitive running stimulation,
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namely, focusing attention on a familiar model, allowed the participants to perform a given task longer and increase their resistance to effort as compared to the control condition. The performance improvement of +19.2% is in line with Morgan, et al. (1983), who also observed a significant performance gain (+19%) for running time until exhaustion in participants using a personal monologue as a dissociative cognitive strategy (they had to concentrate on a spot in front of them and repeat a mantra to themselves—the word “down”—in conjunction with each leg movement). However, Morgan, et al. (1983) tested participants while they performed an exercise at moderate intensity (80% of maximal aerobic power). Scott, et al. (1999), who projected a movie of rowing races as an external distraction, detected a 2% improvement in performance level during a 40-min. rowing exercise in novice participants, who had to row as far as possible. In addition, the current results reveal that the increase in endurance was associated with a decrease in perceived exertion. This decrease was observable from the beginning, but it became statistically significant when the participants reached half of their relative performance in the video feedback condition. This finding is in line with Blanchard, Rodgers, and Gauvin (2004), who observed that both the objective demands of an exercise task (i.e., exercise duration) and subjective intrapsychic phenomena (i.e., cognition while running) may aid in explaining exercise-induced feeling state changes by reducing perceived exertion. Blanchard, et al. (2004) concluded that distraction from sensory discomfort enabled the participants to tolerate a greater amount of discomfort for a longer period of time.

In the present study, cognitive stimulation was not only a distraction, but provided significant cues as to the frequency and amplitude of the stride observed on the model that may increase running efficiency. Although this running efficiency did not appear in the physiological responses (i.e., no decrease in HR), it may be possible that the improvement due to movement efficiency that the modeling suggested can evoke better running biomechanics and allow greater endurance without exerting more effort.

Another way to explain the results is that given the limited amount of practice, the participants were not skilled in pacing over a 4- to 5-min. run

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
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<tbody>
<tr>
<td>Age, yr.</td>
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<tr>
<td>Body mass, kg</td>
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<td>Height, m</td>
<td>1.78</td>
<td>0.09</td>
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<tr>
<td>Body Mass Index, kg·m⁻²</td>
<td>22.02</td>
<td>1.19</td>
</tr>
<tr>
<td>Maximal aerobic velocity, km·hr⁻¹</td>
<td>14.78</td>
<td>1.08</td>
</tr>
</tbody>
</table>
at 100% exertion (about a mile). Indeed, pacing, especially at maximum speeds, is an internal skill of controlling one’s technique and effort that becomes much more developed as one increases structured training, and is a characteristic of highly trained athletes. In fact, a great deal of such training involves training the body to generate certain paces, and being highly aware of the internal state and mechanics that produce certain paces, hopefully improving them systematically over a season and career. In the present study, external self-modeling may have allowed these much less trained athletes the external cue to pace better, even though they lacked the internal skill to generate the pace without the modeling. Therefore, an external cue could substitute for an internal skill.

One could also hypothesize that neuronal input, such as mirror neurons and specific neuronal circuits, could influence time to exhaustion and perceived exertion. Indeed, studies have reported that in humans these neurons respond to the sight of particular types of body movements and are involved in understanding motor events (Rizzolatti, Fadiga, Matelli, Bettinardi, Paulesu, Perani, et al., 1996; Buccino, Lui, Canessa, Patteri, Lagravinese, Benuzzi, 2004; for a review, see Calmels, 2009). The authors of such studies have indicated that this mechanism may be due to an individual’s capacity to recognize the presence of another individual performing an action, and the ability to use this information to act appropriately or, in the present study, to run efficiently. The meaning of the observed action results from a matching of the observed action with the motor activity that occurs when the individual performs the same action. This mechanism may be one way to explain why the participants in the present study were able to maintain their running time longer despite the growing feeling of fatigue.

Limitations and Conclusions

This pilot study had several limitations. Indeed, since the participants in both conditions had to rate their perceived exertion every 30 sec. on both tests, this may have been a distraction that may have influenced the time to exhaustion. In addition, other possible sensorial signals (e.g., noise, music, silent investigator or other visual signal, such as a window, investigator moving in the laboratory, temperature of the room, etc.) might have been distractors that diverted the attention of the participants. Finally, as the participants were not high-level athletes, it is probable that some of the variations in the time to exertion were caused by their low experience with running at MAV.

The authors suggest that future research employ experiments using various exercise modes, investigating other variables (e.g., oxygen uptake, blood lactate, and the biomechanical analysis of the stride), controlling actively and more accurately the cognitive strategies, and to be carried out
on athletes trained to run at MAV to check the results of this pilot study and the mirror neuron hypothesis.

The results of this preliminary study make a new and original contribution to the research on the complex mind–body relationship, and show that compared to a control condition cognitive stimulation using oneself as the model while carrying out a running task performed at 100 percent MAV significantly increases the time to exhaustion and endurance, and decreases perceived exertion without affecting HR. This finding, which requires further investigation at different levels of intensity, could provide practical applications for athletes involved in a training program to prepare for competitions performed at MAV (e.g., 1,500 m, 1 mile, etc.) or in physically deconditioned patients (e.g., obese) who need to increase their time to exhaustion at high exercise intensity.

REFERENCES


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