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How Much Does Self-Talk Influence Fatigue? A Comparison of Performance, Perceived Exertion, and Neuromuscular Patterns during High-Intensity Power Cleans

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ABSTRACT

Experienced athletes use self-talk (ST) to monitor distress, continue effort, battle fatigue, and enhance performance. The power clean is a strength training exercise used by athletes in many sports that incorporates complex movements and performing several high intensity repetitions challenges athletes to develop cognitive strategies to maintain performance, technique, and persistence. The purpose of this study was to compare the effects of ST to a control group during a session in which experienced weightlifters performed power cleans to fatigue. Multiple dependent variables were assessed that included perceptual, neural, and performance measures. Fit men (N=24, age range 18 to 28 years) experienced in Olympic weightlifting were randomly assigned to a ST and control (CON) group. Participants completed sets of 3 repetitions of power cleans at 85% of 1 rep maximum with three-minutes of rest between sets until fatigue. The ST group was instructed to engage in organic, goal-directed self-talk during exercise. The CON group focused on a neutral attentional focus. The results indicated the ST group achieved more sets, reps, and total weight lifted ($p < 0.05$). Persistence, defined as the number of sets and repetitions performed after reaching a perceptual breakpoint (RPE of "8") was higher for the ST group ($p < 0.01$) by 8.5 repetitions. Analysis of muscle activation via EMG indicated the ST group demonstrated lower activation in target muscle groups despite performing more work. ST enhanced performance by 43% once an RPE of eight was reached, resulted in 63% more repetitions, and demonstrated more efficient muscle activation patterns.

Keywords: Rating of perceived exertion, electromyogram, cognitive strategies

INTRODUCTION

Self-talk (ST) is a cognitive strategy used to enhance self-regulation and performance during sports. Common reasons for using ST include effectively managing attentional focus, promoting emotional energy, managing discomfort, and reducing anxiety before or during competition and exercise (Hatzigeorgiadis et al., 2011). Most often, ST is motivational (e.g., "I can do this!") or instructional (cues that focus attention on desired movement patterns) in nature. Research examining the impact of ST interventions have demonstrated an improvement in performance across motor tasks with an average effect size of 0.48 or about 17% better than a comparison/control group (Hatzigeorgiadis et al., 2011). This is a robust finding across a variety of motor skills and exercises, including vertical jump, golfing, weightlifting, isokinetic exercise, and running (Caudill et al., 1983; Edwards et al., 2008; Hatzigeorgiadis & Biddle, 2008; Hatzigeorgiadis et al., 2011; Ryska, 1998; Tod et al., 2009; Weinberg & Jackson, 1981; Weinberg et al., 1981). In the context of endurance activities or exercise (e.g., performing weight training to fatigue), mechanisms that explain why ST enhances performance may be related to effectively focusing attention, managing effort, and fighting fatigue. Also, studies comparing negative and positive ST during performance have found that negative ST enhanced dart performance while motivational ST was more facilitative in time-trial cycling (Barwood et al., 2015; Van Raalte et al., 1995). However, the impact of ST on fatigue in such high exertion activities is not well understood and requires further analysis.

Most research on ST and physical performance has studies the effects of participants thinking or verbalizing "researcher constructed" ST cues, as opposed to cues typically used by the athlete, or constructed with the athlete's input (Hatzigeorgiadis et al., 2011). It is logical that cues that are familiar or meaningful to the athlete, or those that the athlete was involved in developing would be most effective (Phylactou, 2019). It has also been recognized that various factors may influence the effectiveness of ST, including how individuals are motivated. In this study, Achievement Goal Theory (AGT) was used as a framework for helping athletes create their own ST strategies. People are motivated toward and pursue goal-oriented outcomes, and AGT characterizes goals as either task or ego oriented (Nicholls, 1984; Roberts et al., 2007). In general, individuals motivated toward task-oriented goals focus on task mastery and define success relative to their own effort and self-improvement. By comparison, ego-oriented goal orientation is characterized by comparing one's performance to that of others and the pursuit of being the best or performing better than others. While the beneficial effects of ST on performance are well documented, research has been criticized for its lack of theoretical background (e.g., Hardy et al., 2009; Theodorakis et al., 2012), AGT has been proposed as an appropriate framework, and there is evidence that goal orientation influences ST about competing during physical education classes among youth (Zourbanos et al., 2014).

An additional limitation of existing research is the failure to collect multiples dependent measures that can provide a clearer understanding of the effects of ST. Most research has logically measured physical performance. However, ideally, when studying ST in the context of exercise, data could be collected that evaluates physical performance as well as perceptions of effort and muscular activity.

This study examined the effects of ST on performance, persistence when fatigued, muscle activation, and perceptions of effort while engaging in high intensity power clean (PC) weight training exercise to fatigue. It was expected that athletes using ST, compared to a control condition, would complete more work (repetitions, sets, total weight lifted), have reduced perceptions of effort, continue to persist when the perceptions of exercise intensity were high, and demonstrate more efficient muscle activation patterns.

METHODS

Participants

Participants were 24 males (range 18-28 years) who were regular exercisers and reported at least three years of training using Olympic weightlifting. Prior to the study, all participants signed an informed consent form and participated in screening for inclusion in the study, which included a medical health history form, a demographic survey, and assessment of PC technical proficiency. Participation was limited to individuals who self-reported at least three years of Olympic weightlifting training experience, had no major cardiovascular risk factors or major musculoskeletal injuries, were currently actively participating in training, and were technically proficient (i.e., could perform the PC exercise in increasing loads with good form).

Participants were randomly assigned to a ST group or a control/interference (CON) group. Groups were similar in age, years of Olympic lifting experience, and PC 1 repetition maximum (1RM) (mean ± SD ST group: 21.75±2.67 years of age, 5.01± 1.38 years of Olympic weightlifting experience, 105.68±15.37 kg, 1RM; CON group: 22.27±2.89 years, 4.91±1.58 years of experience, 106.14±12.41 kg 1RM). Groups were also similar with respect to motivation orientation, with 10 higher in task orientation and 2 with balance task and ego orientation. All procedures were reviewed and approved by the university's Institutional Review Board.

Instrumentation

Ratings of perceived exertion

The perceptual measure assessed was rating of perceived exertion (RPE). RPE, or sense of effort, is correlated to heart rate and pain during resistance exercise and represents a robust measure of perceptual changes with exercise intensity (Hollander et al., 2017). RPE was assessed using the category ratio RPE scale (Borg, 1998), a numerical scale with descriptor statements including 0 (*Rest*), 3 (*Moderate*), 5 (*Hard*), 7 (*Very Hard*) and 10 (*Maximal*).

Motivation orientation

The Task and Ego Orientation in Sport Questionnaire (TEOSQ; Duda, 1989) was administered to determine participants' motivation orientation. The scale is frequently used to measure goal orientation and its psychometric properties have been well-established (e.g., Chi & Duda, 1995; Duda et al., 1995). It consists of 13 items to which participants respond along a 5-point Likert scale anchored by (1) Strongly disagree and (5) Strongly agree. Items reflect task orientation (7 items, e.g., "I learn a new skill by trying very hard") or ego orientation (6 items, e.g., "I am the best"). Responses for task and ego orientation items are averaged, and the resultant two scores reflect higher task or ego orientation, or a balanced task/ego orientation.

Muscular activation

Electromyography (EMG) was used to measure activation of specific muscle groups involved in the PC exercise, three muscles of the posterior chain and a major anterior leg extensor: biceps femoris (BF), erector spinae (ES), gluteus maximus (GM), and vastus lateralis (VL). Electrodes were placed as close to the belly of the muscle as possible, 10 mm apart, and parallel to the muscle fibers. EMG recording was sampled at 1000 samples per second via a wireless system (Bioradio, Great Lakes NeuroTechnologies, Cleveland, OH). These procedures were similar to those from previous research using EMG (Arabadzhiev, et al., 2010; Hollander et al., 2017; Rainoldi et al, 2004).

Isometric maximal voluntary contraction (MVC) was measured using a floor-tethered strain gauge (Back-Leg-Chest Dynamometer, manual muscle tester [MMT], Fabrication Enterprises, Elmsford, NY). Participants exerted maximal effort from a mid-thigh deadlift position for 5 seconds; three trials were performed. Isometric MVC amplitude [peak millivolts (mV)] was averaged across the three repetitions. These values were used in later analysis of EMG activity during dynamic PC exercise, with these values expressed as percent of MVC.

Procedures

Two sessions were conducted, both held in a strength training laboratory equipped with Olympic lifting barbells and rubber bumper plates. During Session 1, participants were provided an overview of the study, signed the informed consent document, then completed the medical history and demographic information questionnaire, and the TEOSQ. This was followed by determining their PC 1RM. Following a 15-minute warm-up (stretching and light lifting), participants attempted to perform a PC at 60% of their estimated 1RM. After a successful attempt, the load was increased to 80% of the estimated 1RM. For each subsequent effort, 5 pounds was added. This continued until an attempt was unsuccessful or form was compromised. The last successful attempt was considered the participant's 1RM.

After completing this assessment, the participants were engaged in a conversation with the lead researcher where they were presented information about task and ego orientation and received their TEOSQ results (e.g., higher task orientation, higher ego orientation, or balanced task and ego orientation). The session with participants assigned to the ST group also discussed ST, the kinds of ST they typically used when performing weight training and the PC exercise, and how their preferred motivation orientation might be reflected in their ST. These participants were also instructed to give some thought to the ST cues they would use in the subsequent PC exercise session.

Session 2 was held 3-7 days later. First, EMG electrodes were placed on target muscle groups and the EMG system checked for signal transmission.

After a warm-up, maximum isometric deadlift MVC was collected on three 5-second trials using the strain gauge. Following this assessment, participants rested and received a description of the training session and instructions specific to their group assignment. Those assigned to the ST condition were encouraged to engage in ST between sets as they might to normally during training and gave a confirmation that they had adhered to this condition. Participants in the CON group were informed that between sets, they would be shown a brown piece of paper, should look at it, and verbalize "brown, tan paper." This strategy has previously been used to maintain neutral emotion and prevent ST in control groups (Sutton & Altarriba, 2016). The rationale for this procedure was to try to prevent or block ST from occurring in the control group, which was a caveat of ST research; even though participants were not provided instruction about or encourage to use ST, spontaneous ST was likely (Hatzigeorgiadis et al., 2011).

The PC exercise then began. Participants completed a warm-up of three PC repetitions at 60% of 1RM. This was followed by sets of 3 PC repetitions at 85% of 1RM with 3 minutes rest between sets until failure. Successful repetition required moving the bar from the ground to a catch position at three-quarter height. EMG activity was recorded during each repetition, and RPE was assessed immediately after each set. During the rest between sets, those assigned to the ST group were asked to verbalize their internal ST while those in the control group were asked to stay focused on the "brown, tan paper."

Data Analysis

Data were collected on measures of work performed, RPE, and muscle activation. Total tonnage was calculated as total volume of work by multiplying number of reps, sets, and total amount of weight lifted. In addition to measuring total work, we were interested in comparing perceptions of exercise intensity (RPE), and persistence (the continuation of work when perceptions of exercise intensity were uncomfortable). Therefore, an RPE value of eight was operationally defined as reflecting the perception of difficult training intensity, and the number of repetitions performed after reaching this RPE value was calculated. Differences between ST and CON groups for these dependent variables were examined using independent t-tests. One-tailed t-tests were used since the proposed hypotheses were that ST would enhance work, reduce perceptions of effort, and result in greater persistence. A *p*-value of 0.05 was used to determine statistical significance, and Cohen's *d* was calculated as an indicator of effect size.

EMG activation amplitudes for each muscle group during PC exercise were averaged across the three repetitions of each set, then this value was expressed as the percent of each participant's EMG amplitude during their isometric MVC. Since the number of PC sets varied between participants, three time points during the training session were selected for analysis: Set 1, the mid-session set when individual's peak EMG values were achieved, and their final set. EMG data were analyzed using a 2 (Group) x 4 (Muscle Group) x 3 (Time Points) MANOVA. The significant analysis was followed by comparisons examining EMG activity in each muscle group.

RESULTS

Work Completed

The number of sets and repetitions performed varied considerably among participants, ranging from 18 to 28. On average, participants in the ST condition performed 64% more work than those in the CON group (see Figure 1). Total tonnage was calculated as total volume. Statistical analysis indicated that those in the ST group performed a greater number of total repetitions [$t(22) = 2.02$, $p < 0.05$], total sets [$t(22) = 2.02$, $p < 0.05$], and lifted more total weight [$t(22)=1.96$, $p < 0.05$] than did the CON group. Effect size comparisons between groups indicated large differences for all three measures (Cohen's $d = 0.80$ to 0.82).

RPE and Work Persistence

Perceptions of exercise intensity

RPE changed during the exercise session in an anticipated pattern, with ratings beginning at an average level of 6.46 ± 0.31 on the 10-point scale and increasing gradually and steadily to an average maximum value of 8.96 ± 0.19 on the last set (Figure 2). The maximum RPE achieved by participants in the ST group was significantly higher than that of the CON group [$t(22)=2.64$, $p < 0.01$].

Persistence

Participants typically reached an RPE rating of 8 after 13-15 repetitions. As shown in Figure 2, after

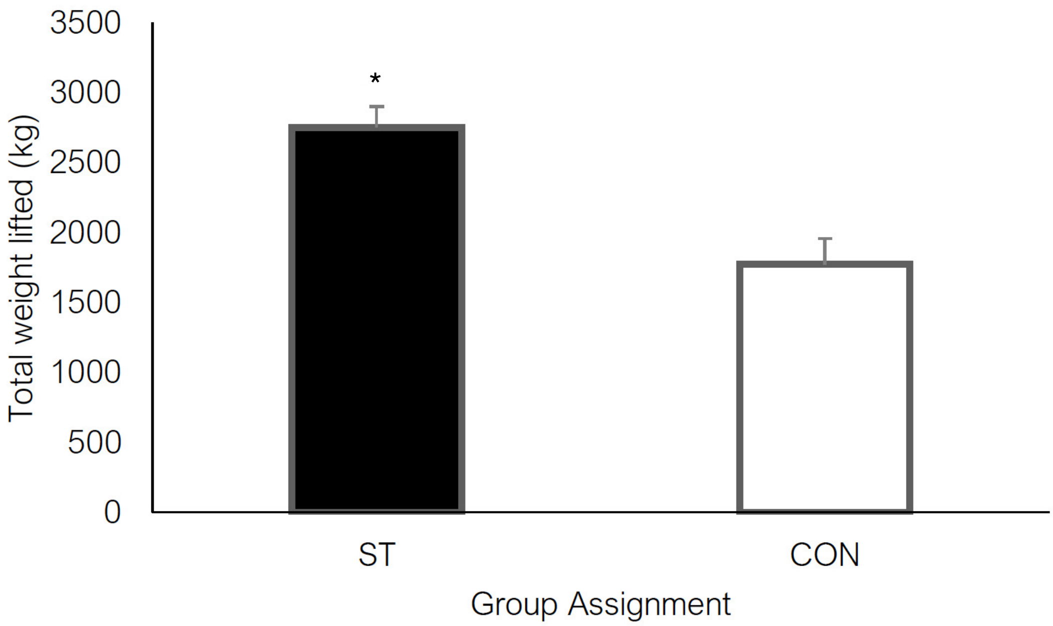

Figure 1. Total weight lifted (KG) during the power clean exercise session by Self-Talk (ST) and Control (CON) groups.
NOTE: Groups significantly different (p<.05). This was a 64% difference.

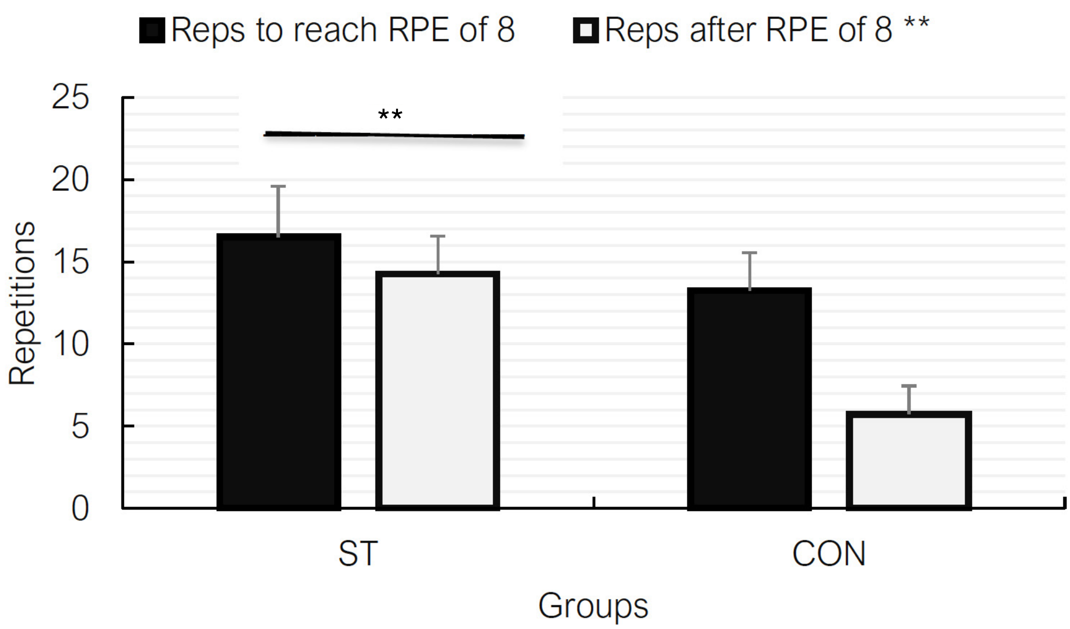

Figure 2. Number of repetitions performed by Self-Talk (ST) and Control (CON) groups prior to and after an RPE of 8.
Note. The ST group performed significantly more repetitions after reaching an RPE of 8, a difference of 43% or p > 0.01.

reaching this level of exercise intensity, the ST group continued lifting longer (mean 14 ± 2.34 reps) than the CON group (6 ± 1.67 reps), a 43% difference in favor of the ST group. Statistical analysis indicated this was a significant difference [$t(22)=2.96$, $p < 0.01$], and effect size calculations were large (Cohen's $d > 1.0$) indicated for both maximum RPE achieved and the number of repetitions performed after an RPE of eight.

Muscle Activation

During exercise, EMG has been shown to display increased amplitude as a function of increased motor unit recruitment, with additional muscle fibers being recruited to support those that become fatigued (Arabadzhiev et al., 2010). In this study, we examined EMG amplitudes in four target muscle groups at three time points during the session: the first set, the set during peak EMG activity, and the last set. Visual inspection of values shows muscle activation during the exercise increased, reached a peak, and then declined during the exercise session as fatigue was realized. This pattern was evident in all four muscle groups (see Figure 3). In addition, EMG activity was higher among participants in the CON group compared to the ST group.

Statistical analysis using a MANOVA revealed a significant Time effect [Wilks' Λ = .34, F=20.50, p<.001, η^2=.66] indicating EMG activity changed over the exercise session, and a significant muscle group effect [Wilks' Λ = .36, F=12.13, p<.001, η^2=.65], indicating EMG activity was significantly different between muscle groups. As shown in Figure 4, EMG activity was highest in the VL and lowest in the ES. The analysis also resulted in a significant group main effect [F(1,22)=6.25, p<.05, η^2=.22], indicating EMG activity was significantly higher in the CON group than the ST group. Follow-up comparisons examining EMG activity in ST and CON groups' using independent t-tests indicated ST participants had significantly lower activation of the ES [t(22)=2.20, p < 0.05], and VL muscle groups [t(22)=2.16, p < 0.05]. Effect size comparisons (Cohen's d) of EMG activity between ST and CON groups were moderate to large (ranging from .22 to .66).

DISCUSSION

The present study examined the effects of ST during high-intensity strength training exercise to fatigue. Participants in the ST group performed 43% more work (sets, repetitions, and total weight moved) than a CON group, and also performed over 60% more sets and reps after reaching an uncomfortable level of exercise intensity (RPE of 8). Analysis of EMG data showed that the ST condition also resulted in lower muscle activity in key muscle groups involved in the PC exercise, suggesting these participants moved the weight using a more efficient action. Our results are in line with several other studies that demonstrated lower activation as a sign of movement efficiency (Arabadzhiev, et al., 2010; Dimitrova et al., 2009). A meta-analysis of ST research (Hatzigeorgiadis et al., 2011) concluded that the strategy has a moderate to large effect size (d = .48 to .90) on performance, and the effect sizes

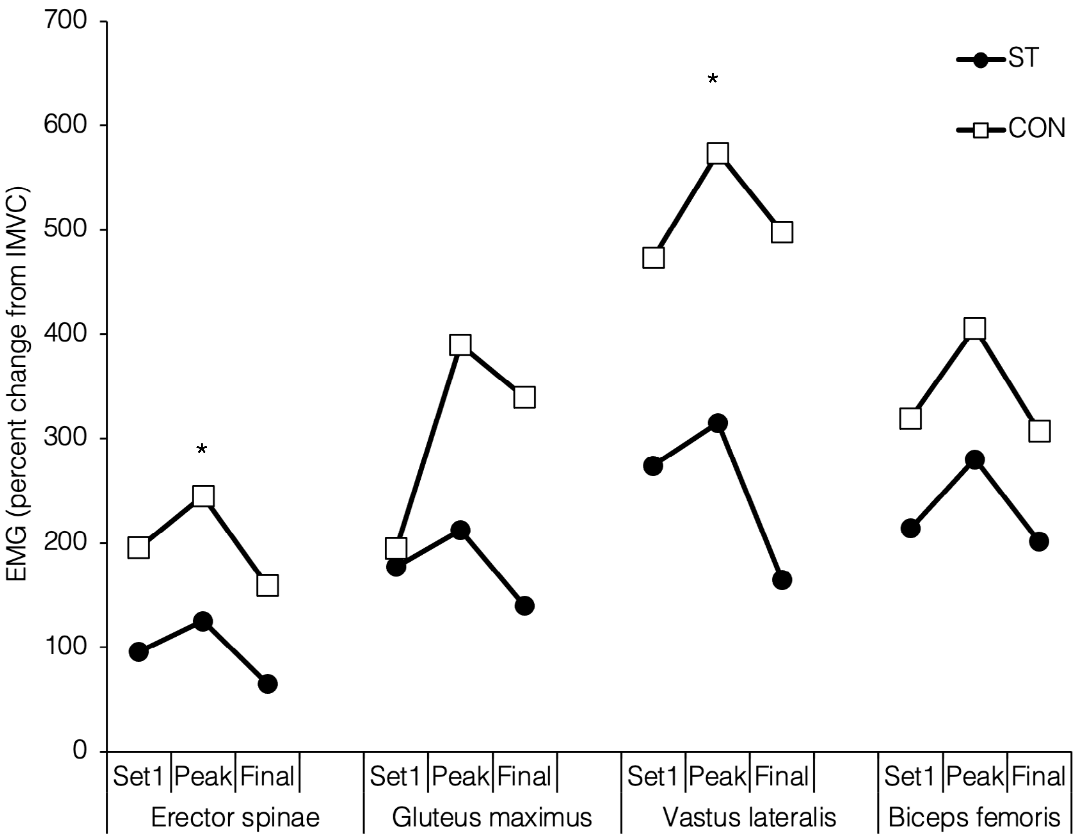

Figure 3. Muscle activation of Self-Talk (ST) and Control (CON) groups.
Note. EMG activity in erector spinae and vastus lateralis were significantly lower in the ST group than the CON group (p<.05).

found in this study are within this range (.80 to .82). Additionally, our results add to existing research demonstrating the performance-enhancing effects of ST on fatiguing strength training tasks.

In addition to examining physical performance measures, we also collected data on perceptions of exercise intensity (RPE). The ST group reached a significantly higher maximum RPE value, and persisted exercising significantly longer when faced with uncomfortable exercise intensities. Previous studies (e.g., Brewer et al., 1990; Hardee et al., 2012) have examined links between performance and power-based movements, and have noted that heighted exertion improves performance (Hardee et al., 2012) . These findings support the view that links perceptions of effort and exercise tolerance (Marcora et al., 2009) and suggests that ST helps moderate exercise intensity perceptions, which thereby facilitates persistence.

We also examined EMG activity in target muscles involved in the action. Typically, EMG amplitudes increase with increases in exercise intensity and fatigue due to increased motor unit recruitment (Dimitrova et al., 2009; Hureau et al., 2014). We hypothesized that task-related ST would result in higher exercise efficiency, reflected in lower EMG activity compared to the CON condition. EMG amplitudes for all muscle groups increased during the training session, then dropped during the last set when fatigue and failure occurred. However, EMG activity was lower for the ST group, indicating they were able to perform the lifts using less muscular activity and were therefore more efficient during the PC. The results suggest that one way ST enhances performance and delays fatigue is via changes in neural activity. Enhanced movement efficiency and lower EMG activity have not been previously reported in ST research, but the results are similar to studies comparing the effects of internal vs. external attentional focus on force production tasks (Lohse et al., 2011; Wulf et al., 2010). These findings open new avenues for ST research and theory.

It is logical that ST cues be meaningful to the performer/athlete, and individual characteristics such as goal orientation influence a person's ST (Zourbanos et al., 2014). In this study, rather than prescribing the ST cues for the task, participants who were experienced with the PC exercise were provided information about their goal orientation and encouraged to create their own ST cues. Their performance was compared to participants in the control group who were prescribed an unfamiliar ST condition (brown, tan paper) and prevented from engaging in their normal ST. The TEOSQ scores indicated that 80% of participants had a higher task orientation, and 20% had a balanced task/ego orientation. Interestingly, participants with a balanced task and ego profile completed the most sets. It was also apparent that participants tended to use primarily instructional ST early in the training session, then shifted to motivational ST as the lifts continued. This shift may also reflect a change from task-oriented focus to ego-oriented focus.

Further investigation is needed that continues to examine how various types of ST influence task performance for individuals of varying skill levels, motivation orientations, and other individual differences during and across training sessions. Future investigations could also manipulate work-to-rest ratios between sets, inter-set rest periods, and different tasks. A variety of factors may influence the effects of ST and could have limited the generalizability of the results of this study. Some of these include prior training and familiarity with ST, beliefs in the effectiveness of ST, efficiency of technique, participants' fiber type or genetic differences, and tolerance of the power clean. In future investigations, ST within a more experienced group could allow researchers to further push critical intensities at or beyond 90%. The present study adds a multifaceted evaluation of ST effects on performance (e.g., repetitions), perception (e.g. RPE), and neural factors (e.g. EMG amplitude) that may contribute to fatigue. These results suggest ST cognitive strategies increased the weight lifted by improved repetitions by about 43%, improved persistence after and "8" RPE intensity by about 63% and led to more efficient muscle firing patterns than CON or neutral ST. Replication and extension are warranted to explore this line of inquiry.

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