Priming to Promote Fluent Motor Skill Execution: Exploring Attentional Demands

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Abstract

The effect of priming on the speed and accuracy of skilled performance and on a probe reaction time task designed to measure residual attentional capacity, was assessed. Twenty-four skilled soccer players completed a dribbling task under three prime conditions (fluency, skill-focus and neutral) and a control condition. Results revealed changes in trial completion time and secondary task performance in line with successful priming autonomous and skill-focused attention. Retention test data for task completion time and probe reaction time indicated a linear decrease in the priming effect such that the effect was non-significant after 30 minutes. Results provide further support for the efficacy of priming and provide the first evidence of concurrent changes in attentional demands, consistent with promoting or disrupting automatic skill execution.

Keywords: conscious processing, priming, P-RT, automatic control.

Introduction

Attentional processes have been identified as significant mediators of expert motor skill execution (Beilock, Carr, McMahon, & Starkes, 2002; Beilock, Wierenga, & Carr, 2002; Beilock, Bertenthal, McCoy, & Carr, 2004; Hardy, Mullen, & Martin, 2001; Wulf, McNevin, & Shea, 2001; Zachry, Wulf, Mercer, & Bezodis, 2005). In skilled performers, the detrimental effect of focusing attention internally has been widely documented in motor and perceptual-motor tasks (e.g., Beilock & Carr, 2001; Bell & Hardy, 2009; Gray, 2004; Hardy, Mullen, & Jones, 1996; Jackson, Ashford, & Norsworthy, 2006). A widely accepted explanation is that the components of the skill performed by an expert have become proceduralized in long-term memory (Fitts & Posner, 1967) thus run under reduced levels of conscious control (i.e., more automatically). By refocusing attention on those proceduralized components, skill processes are brought back into working memory, and decomposed into smaller units (Masters & Maxwell, 2008) resulting in a decrement in performance.

Researchers have explored ways of optimizing attentional focus of expert performers in order to promote automated performance. These interventions include the use of multi-component interventions embedded in pre-performance routines (Mesagno, Marchant, & Morris, 2008; Mesagno & Mullane-Grant, 2010), the use of concurrent secondary tasks (Beilock, Carr et al., 2002; Beilock, Wierenga et al., 2002; Gray, 2004), adopting strategies that promote an external focus of attention (Wulf, 2013), and visual attention training (Vine, Moore, & Wilson, 2011). While each of these methods has shown promise, there are associated practical and theoretical limitations. For example, multi-component pre-performance interventions make it difficult to determine the source(s) of any improvements although insight can be gained from retrospective verbal reports. Concurrent secondary tasks are more targeted towards different aspects of working memory and associated attentional resources; however, there are contradictory findings in the literature. For example, dual-task conditions were found to facilitate performance in skilled golfers and experienced soccer players (Beilock, Carr et al.) and random letter generation was found to increase golf putting accuracy under high anxiety (Mullen & Hardy, 2000). Conversely, Mullen, Hardy, and Tattersall (2005) found that experienced golfers putted more poorly under high anxiety than low anxiety when performing a concurrent secondary tone counting task.

Priming

Another potential method of promoting fluent, effortless performance is through the use of priming. The term ‘priming’ is used to describe “the influence a stimulus has on subsequent performance of the processing system” (Baddeley, 1997, p. 352). Through the activation of specific contexts, traits, stereotypes, goals and related constructs, priming is hypothesized to stimulate the representations of behaviors that influence a general behavioral change in line with those representations (Bargh, Chen, & Burrows, 1996; Chen, & Bargh, 1997; Dijksterhuis & Van Knippenberg, 1998). Priming was traditionally utilised to explore the relative automaticity of certain behaviours and has since developed into the investigation of the manipulation or activation of desired behaviours unconsciously through priming methods (see Bargh & Chartrand, 2000). Specifically, once stimulated, changes in perception, evaluations, motivation or social behavior have been observed (see Dijksterhuis & Bargh, 2001; Wheeler & Petty, 2001, for reviews).

While many studies support the efficacy of priming in the afore-mentioned behavioural categories, there is a paucity of research examining the effect of priming on skilled motor behavior and the underlying processes that mediate any observed effects. This area warrants further study considering the benefits of unconscious control of expert motor skill execution and the principles of priming research. In early studies of priming (Bargh et al., 1996 - Experiment 2; Hull, Stone, Meteyer, & Matthews, 2002 – Experiments 1a & 1b) researchers found that priming participants with an elderly stereotype resulted in slower walking in both elderly and young college students. Further, Macrae et al., (1998) demonstrated that priming participants with the notion of a world champion racing driver resulted in faster walking. Similarly, Aarts and Dijksterhuis (2002) found that priming participants with words associated with fast animals (cheetah, antelope) or slow animals (snail, turtle) led to faster and slower walking speeds, respectively. In relation to skilled motor behavior, Bry, Meyer, Oberlé, and Gherson (2009) found improved relay changeover speed in beginner track athletes through priming cooperation, where cooperation was considered as the adaptation of one's behaviour to suit another's in the pursuit of a collective goal, while Stone, Lynch, Sjomeling, and Darley (1999) found decrements in golf putting performance following activation of a racial stereotype prime.

Priming to Promote Fluent Motor Skill Execution

The rationale underpinning priming research is that automatic processes can be instigated by environmental triggers (Bargh & Chartrand, 2002). Extending this idea to the sport domain, Ashford and Jackson (2010) examined the effect of priming in a group of skilled field-hockey players performing a dribbling task under low and high pressure. In two experiments, a positive prime containing target words relating to the concept of automaticity resulted in significantly faster and more accurate performance than that attained in the control condition (Experiments 1 & 2) and negative or neutral prime conditions (Experiment 2). Conversely, the negative prime resulted in significantly slower performance than the neutral prime.

Ashford and Jackson (2010) interpreted their results by appealing to attentional mediators of performance. In-line with self-focus theories (Baumeister, 1984; Masters, 1992) they suggested that the positive and negative primes may have successfully directed attention away from and towards the mechanics of movement execution, respectively. While plausible, this interpretation requires confirmation through measuring changes in the attentional demands associated with performance following priming. More fundamentally, in a careful replication of the protocol used in Ashford and Jackson's study, Winter and Collins (2013) found no difference between the control condition and a prime condition designed to promote autonomous performance. Participant performance in the PETTLEP imagery protocol condition was better than both the priming and control conditions, calling into question the robustness of the priming effect.

The Retention of Primed Behaviors

A number of studies indicate that the behavioral effects of cognitive priming are strongest immediately following exposure to the prime (Bargh, 1997; Bargh & Gollwitzer, 1994) and significantly attenuate after approximately five minutes (e.g., Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trötschel, 2001; Bargh, Lombardi, & Higgins, 1988; Higgins, Bargh, & Lombardi, 1985). The longer-term retention of behavioral effects resulting from unconsciously perceived stimuli is unconfirmed. Merikle and Daneman (1998) noted that the majority of priming studies had tested for primed effects within five minutes of exposure and had not explicitly examined subsequent retention of observed effects. Based on a meta-analysis of studies investigating memory for events during general anaesthesia (Merikle & Daneman, 1996), they proposed that unconsciously perceived stimuli can last for many hours. In addition, Srull and Wyer (1979) showed that priming hostility can impact social judgments up to one week after the priming period, when the to-be-judged stimulus had been presented right after the priming event, yet the priming effect was not retained one week later when exposure to the stimulus was also delayed. Bargh et al. (2001), proposed that effects exceeding the 4 to 5 minute timeframe result indirectly from psychological mediators stemming from the behavioural consequences of priming rather than directly from the priming intervention. For example, Nelson and Norton (2005) found that participants demonstrated an increased willingness to complete volunteer work three months after they were primed with the category ‘superhero’. It is possible that this increased willingness over an extended period was mediated by the satisfaction gained through the act of helping (Bargh et al., 2001). In the domain of skilled motor behavior the durability of any priming effect is presently unknown and is clearly an important consideration given the large range in duration of competitive sport activities.

The Present Study

The present study addressed three specific aims in investigating the efficacy of priming on motor skill behavior. The first aim was to replicate the findings of Ashford and Jackson (2010), who reported content-related changes in motor performance following fluency priming and skill-focus priming interventions. The second aim was to investigate the attentional demands associated with motor performance under the different prime conditions. In movement-related research, probe-reaction time (P-RT) tasks have been used to assess the ‘mental workload’ imposed on the performer by any particular set of task conditions (Abernethy, 1988). P-RT task performance is considered to be a reflection of residual processing capacity, with performance being proportional to the size of the remaining ‘free’ attentional space (e.g., Wulf et al., 2001). Faster responses to the secondary P-RT task are interpreted to indicate that less on-line attention was utilized for primary task performance. In the present study, inclusion of the P-RT task allowed for assessment of the relative automaticity of motor skill execution as a function of the priming conditions. Based on the premise that the priming interventions promote or disrupt automatic motor processes through reducing or increasing conscious control, we hypothesized that a fluency based prime would yield faster P-RTs than a skill-focus prime, neutral prime and a no-prime control. Accordingly, we hypothesized that a skill-focus prime would yield slower P-RTs than the neutral prime and control conditions.

In light of the equivocal evidence regarding the durability of priming effects, the absence of any data pertaining to this issue in skilled motor behavior, and considering the varying lengths of sport competitions the final aim was to explore the retention of priming effects over a one hour period.

Method

Participants

After gaining institutional ethical approval, 24 skilled male soccer players, aged between 18 and 21 years ($M = 19.2$; $SD = 0.9$), provided informed consent to participate in the study. Participants were members of a university first or second teams, currently competing in university league matches and reported a mean of 12.8 years ($SD = 2.9$ years) of involvement in organized, competitive soccer. The number of participants was selected after conducting a power analysis (G-power version 3.1) entering a medium affect size ($f = 0.25$), power set at 0.80 and a correlation of 0.5 among the repeated measures. This generated a sample size of $n = 24$ yielding power of 0.82. In addition, 24 participants allowed for complete counterbalancing of the experimental conditions.

Task and Apparatus

Soccer dribbling task

The primary task required participants to dribble a standard size soccer ball through a series of six cones spaced at 1.5 m intervals using the in-step and out-step of their dominant foot (Beilock, Carr et al., 2002; Jackson et al., 2006). Participants were instructed to complete the trials as quickly and accurately as possible and were informed that task completion time and the accuracy of their dribbling would be recorded. Newtest Power Timer 1.0 photoelectric cells were placed at the start and finish to record trial completion time to the nearest millisecond.

Lateral displacement was measured using a reference grid marked on the floor. The grid adjacent to each cone comprised five vertical lines drawn in parallel to the midline of the course, spaced 5 cm apart, with the first line drawn 10 cm from the midline. A concealed digital video camera (Panasonic NVDS65B), was positioned at the end of the course to record each trial. Subsequently, the maximum displacement of the ball in the grid adjacent to each cone was determined from the video recordings and mean values then calculated for each prime condition. In addition, 10% of trials in each condition were randomly selected and assessed by an independent rater.

Probe-reaction task (P-RT)

In the secondary task participants were instructed to respond as quickly and accurately as possible to an auditory stimulus of 80 ms duration (Gray, 2004). The randomly presented tone had a frequency of either 250 Hz or 500 Hz and participants were instructed to identify it as either 'low' or 'high'. The participant's responses were recorded by a digital voice recorder (Olympus model DS-50) affixed to the participant's waist via a small microphone clipped on to the neck-line of the participant's clothing..Subsequently, P-RT was determined from the visual representation of the amplitude and frequency of the tone and vocal response using Wavelab 6.1.1.

Conditions

Participants completed the task under three priming conditions (fluency, skill-focus, and neutral), each of which took the form of a scrambled sentence task (Bargh et al., 1996; Hull et al., 2002; Srull & Wyer, 1979). The scrambled sentence tasks were those used by Ashford and Jackson (2010). Each comprised 30 items, consisting of five words per item presented in random order, four of which could be used to form a sentence. Participants were instructed to use four of the five words to form a grammatically correct sentence and to write out the whole sentence in a space provide below the randomly presented words. Items for each of the three priming tasks had been previously assessed for face validity by two experts.

Fluency prime. Target words were based on literature relating to the concepts of automaticity, optimal performance, and flow; for example, ‘movements seemed to flow’ and ‘I am at ease’ (presented as: ‘movements very flow to seemed’ and ‘am I ease at on’).

Skill-focused prime. Target words were drawn from research on attentional focus and conscious control and directed the performer to the execution of the skill; for example, ‘I focused on technique’ and ‘hip position is important’ (presented as: ‘technique on I the focused’ and ‘important position is hip correct,' respectively).

Neutral prime. Target words bore no relation to performance; for example, ‘the grass is green’ and ‘the world is round’ (presented as: ‘green is purple grass the’ and ‘square round the is world,' respectively).

Control. In the control condition, participants were simply instructed to “complete the dribbling task as quickly and accurately as possible”.

Procedure

A repeated measures design was employed in which conditions were fully counterbalanced. Prior to the test trials, participants performed 10 familiarization trials. A total of six blocks (three priming, one control, two retention) of five test trials followed. Participants were given time between trials for their breathing rate to return to normal. A block of 5 trials took approximately 4 minutes in total. Participants responded to a single auditory stimulus in four of the five trials in each block. A single trial without the auditory stimulus occurred randomly within each block to allow for testing of the impact of the secondary task on primary task performance. Prior to each priming block, participants completed a scrambled sentence task appropriate to the particular condition. In line with Hull et al. (2002), participants were advised that this grammatical task was part of an unrelated research project and were asked if they could complete it during their rest period. With the exception of the last block of trials participants were given a short rest period of 2-3 minutes after each block, during which they were requested to count backwards in sevens from 70. This working memory intensive task was included to prevent rumination about performance in the previous block of trials and to decrease the accessibility of the previous concept.

After completing the priming and control conditions participants were given a 30-minute break. Participants then completed the first block of retention trials after which they were given an additional 30-minute break before completing the second block of retention trials. During these breaks, participants were asked not to discuss the study with anyone and to refrain from soccer dribbling. Upon completion of the experiment, each participant was shown the camera recording ball displacement and asked for their consent to use the video footage for analysis. Finally, each participant was thanked for participating, was debriefed about the purpose of the study, and was requested not to discuss the specific purpose of the study with other potential participants.

Data Analysis

Prior to analysis, all data were screened for outliers using standardized scores ($z \pm 3.29$) and the Mahalanobis distance test. Initially, to test whether the secondary task impacted primary task performance, a 2 (with/without P-RT) x 4 (prime condition) repeated measures ANOVA was conducted. Following this, one-way repeated measures ANOVAs were conducted for the performance data with prime condition entered as a within-participants factor and task completion time, lateral displacement and P-RT serving as the dependent variables.

In order to analyze the retention data while retaining statistical power, the participant sample was divided into two groups according to the last condition they completed. The control group ($n = 12$) comprised participants who had completed the neutral or control condition as their last block while the experimental group (n = 12) comprised participants who completed the fluency or skill-focus priming conditions last. As retention of a priming effect in participants exposed to the fluency and skill primes would result in opposite effects on performance, retention scores for participants who received the skill-focus prime last were reversed such that negative scores indicate the presence of a priming effect. The three difference scores (task completion time, lateral displacement, P-RT) were calculated relative to performance in the control condition and depict the presence / absence of a priming effect immediately after exposure to the last prime (baseline) and at the 30-minute and 60-minute retention tests. To analyse these data, one-sample t-test comparisons (one-tailed) were made against a value of 0 at each of the three retention points.

Results

Initial Effects of Prime

Data screening revealed no univariate or multivariate outliers. Further analyses confirmed that P-RT had no impact on primary task performance (see Footnote[1]) and that the prime effect remained constant across trial blocks (see Footnote[2]).

Task completion time. A repeated measures one-way ANOVA for task completion time revealed a significant main effect of priming condition, F (3, 21) = 30.01, $p < .001$, $\eta_p^2 = .81$. Follow-up pairwise comparisons with Bonferroni adjustment revealed task completion time to be significantly faster in the fluency prime condition than in the neutral prime, and control conditions ($p < .001$). Additionally, task completion time in the skill-focused prime condition was significantly slower than in the neutral prime and control conditions ($p < .001$) (Figure 1, top panel).

Lateral Displacement. A repeated measures one-way ANOVA for lateral displacement revealed a non-significant main effect of prime condition, F (3, 21) = 1.50, p = .24, $\eta_p^2 = .18$ (Figure 1, middle panel).

P-RT. A repeated measures one-way ANOVA for P-RT revealed a significant main effect of prime condition, F (3, 21) = 7.39, $p < .001$, $\eta_p^2 = .51$. Follow-up pairwise comparisons with Bonferroni adjustment revealed P-RT to be significantly faster in the fluency prime condition than in the skill focus prime condition ($p = .001$). Comparisons of each of these conditions with the neutral prime and control conditions revealed no significant differences (Figure 1, bottom panel).

Retention of Primed Behaviors

As can be seen in Figure 1 (right panels, experimental group), there was a linear attenuation of the priming effect for both completion time and P-RT data across the baseline, 30-minute and 60-minute retention test points. As expected, the control group's performance remained relatively stable across the retention points.

Task completion time. The one-sample *t*-tests revealed non-significant effects for the control group at baseline ($p = .22$), and in the 30-minute ($p = .23$) and 60-minute ($p = .18$) retention tests. For the experimental group the effect of the prime was significant at baseline ($p = .02$) but was non-significant at both the 30-minute ($p = .10$) and 60-minute ($p = .40$) retention tests.

Lateral displacement. For the control group the one-sample *t*-tests for lateral displacement revealed non-significant effects at baseline ($p = .17$), and at the 30-minute ($p = .12$) retention test, and, unexpectedly, a significant difference at the 60-minute ($p = .03$) retention test. For the experimental group the effect of the prime on lateral displacement was non-significant at baseline ($p = .32$) and at both the 30-minute ($p = .10$) and 60-minute ($p = .09$) retention tests.

P-RT. The one-sample *t*-tests for probe reaction time revealed non-significant effects for the control group at baseline ($p = .28$), and in the 30-minute ($p = .46$) and 60-minute ($p = .30$) retention tests. For the experimental group the effect of the prime was significant at baseline (p = .03) but was non-significant at both the 30-minute (p = .12) and 60-minute (p = .19) retention tests.

Discussion

The aim of the present study was to further investigate the efficacy of priming in skilled motor behavior, utilizing a sentence scrambling task. In particular, we aimed to assess differential use of attentional resources following different primes by assessing the speed and accuracy of a soccer skill as well as response to a P-RT task. Participants were assessed under conditions designed to optimize performance by priming words relating to fluent execution and to hinder performance by priming words associated with conscious control. Finally, we sought to explore the retention of priming effects over a one hour period.

The results provide support for the viability of priming in influencing skilled motor behavior. Following exposure to the task designed to prime autonomous, fluent execution, task completion time was significantly faster than in the control condition. By contrast, following the skill-focus prime, task completion time was significantly slower than in the control condition. Importantly, the present findings provide support for the conscious processing hypothesis and research concerning reinvestment (e.g., Baumeister, 1984; Beilock, Carr et al., 2002; Gucciardi & Dimmock, 2008; Masters, 1992; Mullen & Hardy, 2000). Specifically, predicted changes in P-RT mirrored changes in performance such that P-RT was significantly faster following the fluency prime than after the skill-focus prime.

The performance effects observed in this study replicate the findings of Ashford and Jackson (2010) but conflict with the null effects reported by Winter and Collins (2013). It is presently unclear why similar protocols, tasks, participants and measures have resulted in such different findings. One possibility is that there was greater scope for improving performance in Ashford and Jackson's study than there was in Winter and Collins' study. The participants in Winter and Collins' study were older, more experienced and competed at a higher level (from county to international level) and had faster mean trial completion times than those in Ashford and Jackson's study. By definition, the extent to which priming the concept of fluent autonomous performance will impact participants is dependent on the pre-existing level of fluency or automaticity. Cross-sectional designs examining the efficacy of priming in groups of varying experience and ability will help address this question.

The large priming effect in this study was larger than has typically been observed in other studies using the sentence completion task (REFs) and might be explained by the contextual overlap and self-relevant nature of the prime. When a prime is aligned with an individual's self-concept, a subconscious comparison process is activated resulting in behavior modification (Bruce, Carton, Burton, & Ellis, 2000; Hull et al., 2002). With respect to this contextual overlap, conscious control is the main characteristic of the beginning/cognitive stage of learning while automaticity is the main characteristic of an expert (Fitts & Posner, 1967). Consequently, the concepts used in the priming task were likely to relate to each participant in the study as well as to skill execution in the task itself. In addition, Hull et al (2002) found that people were more sensitive to self-relevant primes and that the effects of self-relevant primes are sometimes easier to obtain.

The present results are interesting to consider alongside those reported by Gucciardi and Dimmock (2008) who discussed how performance patterns can be attributed to the content of conscious processing and the influence of this on generalised motor schema. Gucciardi and Dimmock argued that global thoughts (i.e., swing thoughts or, in the case of the present study, fluency primes) promote selection of an appropriate motor program as the thoughts provide a holistic representation of the skill. This type of global processing would appear to demand few attentional resources as did performance following the fluency prime in the present study, evidenced by faster P-RTs. In contrast, explicit cues that focus on the technical components of a skill place greater demands on working memory and attentional resources as did performance following the skill-focus prime in the present study, evidenced by increased P-RTs. The extent to which priming and using verbal cues represent different means of achieving functionally equivalent outcomes is yet to be determined.

Analysis of the lateral displacement data confirmed that changes in task completion time were not at the expense of dribbling accuracy. This finding differs slightly from the results of Ashford and Jackson (2010) who found that both performance speed and lateral displacement were affected with improvements and decrements in performance observed in the positive and negative prime conditions, respectively. As lateral displacement was largely unaffected by priming in the present study, differences in task completion time are likely to have been caused by differences in sequencing and timing of motor responses, which have been shown to change as a function of attentional focus in various tasks (Beilock & Carr, 2001; Collins, Jones, Fairweather, Doolan, & Priestly, 2001, Gray, 2004). In future, kinematic analysis would enable researchers to pinpoint the precise spatiotemporal parameters underpinning changes in task completion time resulting from priming (Gray, 2004; Pijpers, Oudejans, Holsheimer, & Bakker, 2005).

With reference to the exploratory analysis examining the retention of the primed behavioural effects, a linear attenuation of the priming effect was observed with respect to completion time and P-RT, such that the effect was non-significant after 30 minutes and entirely absent after one hour. This is broadly consistent with priming research in other domains, which has shown significant attenuation of priming effects after just five minutes (e.g., Bargh et al., 1988; Bargh et al., 2001; Higgins et al., 1985). Set against this, analysis of performance across the trials within each condition in the present study revealed a non-significant effect of trial number. Each block of trials took approximately four minutes to complete suggesting the priming effect was retained for at least four minutes. Given the relatively small number of participants in each group (n = 12) for this analysis and the fact that retention of the priming effect was tested across two relatively large 30-minute time windows, a more systematic examination of the attenuation of the priming effect is warranted.

While the findings extend those of Ashford and Jackson (2010) further limitations of the present study should be acknowledged. First, owing to the nature of the experimental setting, the ecological validity of the task can be questioned. While the soccer dribbling task is representative of a skill-based drill conducted in training and a technique used within a game situation, it is important that the efficacy of techniques established in the laboratory, is assessed in field settings to confirm their effectiveness and robustness (Tipper & Weaver, 1998). Second, while the efficacy of the priming intervention was supported, the process was not necessarily implicit. The task was introduced to participants as an additional and unrelated task in line with instructions given to participants in previous studies (e.g., Srull & Wyer, 1979, Hull et al., 2002), yet expectations about a link between the priming task and the subsequent motor task may have been formed. While informal questioning of the participants after the experiment did not reveal evidence of participants making a connection between the priming task and the motor task a more sensitive formal assessment of participants' awareness of, and hypotheses about, the link between the priming task and its effect on the 'unrelated' performance task is warranted. This will also help determine whether the priming paradigm invokes use of target words in a functionally equivalent manner to the more overt or explicit use of cue words (Gucciardi & Dimmock, 2008; Mullen & Hardy, 2010).

In conclusion, the present study lends further support to the efficacy of priming skilled motor behavior. Importantly, the analysis revealed differences in the attentional demands associated with performance that were consistent with the nature of the primes and observed performance: priming fluency enhanced motor performance and was associated with faster P-RTs, while priming skill focus was detrimental to performance and was associated with slower P-RTs. With research applying priming to skilled motor behaviour in its infancy and already subject to conflicting findings, the robustness of the phenomenon needs to be established across different sporting activities. A logical extension to the present study is to determine whether the observed priming effects are moderated by either skill level or participant awareness of the link between the priming and motor tasks. In so doing, the processes through which priming impacts skilled performance will be better understood. The extent to which priming can influence psychological factors impacting sports performance, the robustness of primed effects over time, and the degree of transfer of primed effects to the field, offer additional theoretical and practical avenues for research.

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Figure 1

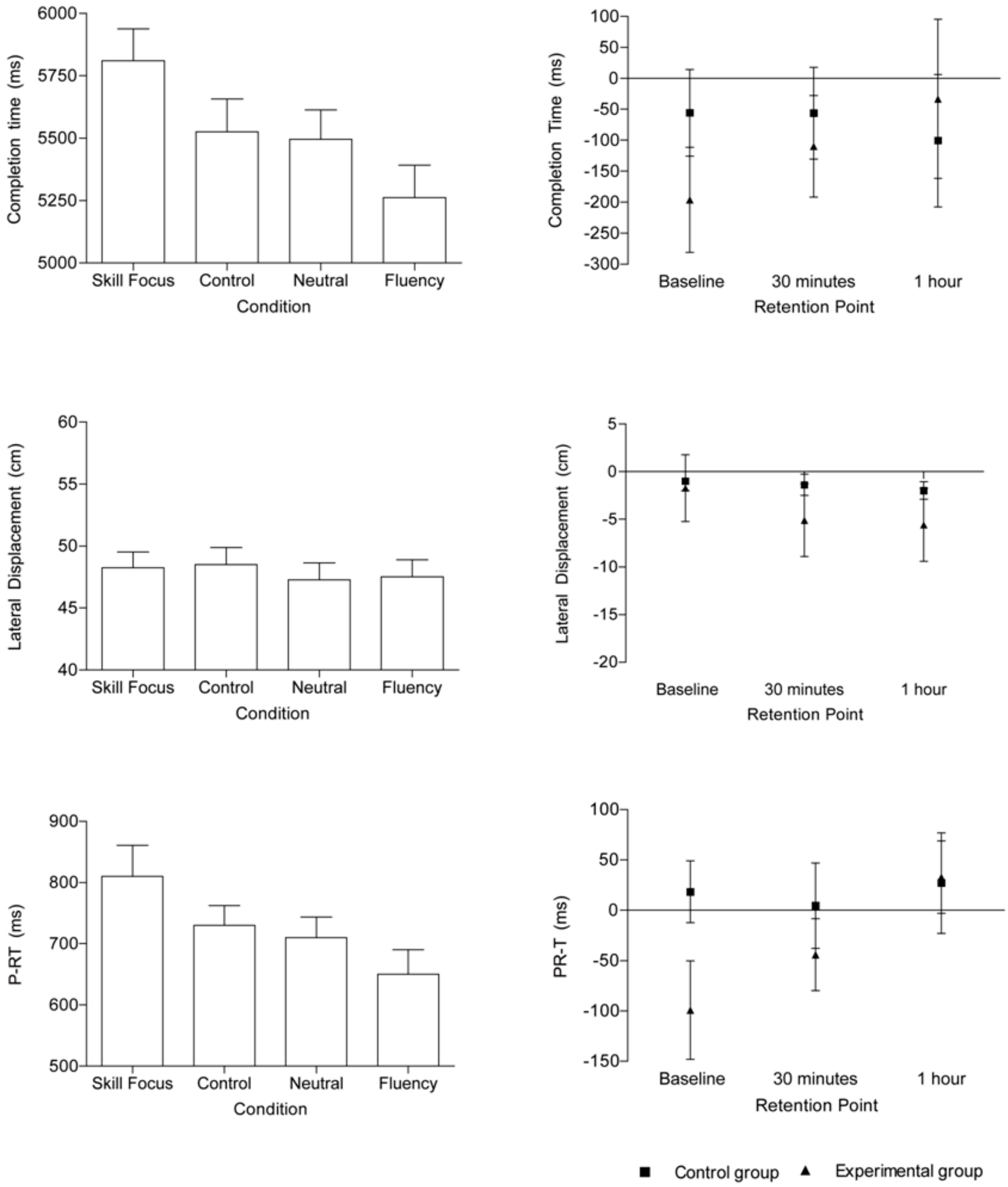

Figure 1. Mean (± SE) trial completion time, lateral displacement and probe-reaction time (P-RT) under priming and control conditions (left pane) and during the retention period (right pane).

Footnotes

[1] Separate 2 (trial type: with secondary task/without secondary task) x 4 (condition: fluency/skill-focus/neutral/control) repeated measures ANOVAs, were conducted with task completion time and lateral displacement serving as dependent variables, to confirm that the dribbling task performance was not affected by the P-RT task. For task completion time, the analysis revealed a non-significant main effect for trial type, F (1, 23) = .47, p = .50, η_p^2 = .02, and a non-significant trial type x condition interaction, F (3, 21) = 1.70, p = .20, η_p^2 = .20. Lateral displacement analysis revealed a non-significant main effect for trial type, F (1, 23) = 3.31, p = .08, η_p^2 = .13, and a non-significant trial type x condition interaction, F (3, 21) = .49, p = .69, η_p^2 = .07. These result indicate that the dependent variables were unaffected by completion of the secondary task.

[2] One-way repeated measures ANOVAs were conducted for each condition with trial number serving as the repeated measure and completion time, lateral displacement and P-RT serving as the dependent variables. For all conditions and variables, non-significant results were observed indicating the maintenance of a prime effect across trials. Time: Fluency: Wilks' Lambda = .79, F(4, 20) = 1.30, p> .05, η_p^2 = .21; Skill focus: Wilks' Lambda = .83, F(4, 20) = 1.03, p>.05, η_p^2 = .17; Neutral: Wilks' Lambda = .78, F(4, 20) = 1.41, p>.05, η_p^2 = .22; Control: Wilks' Lambda = .74, F(4, 20) = 1.75, p>.05, η_p^2 = .26. Lateral Displacement: Fluency: Wilks' Lambda = .91, F(4, 20) = .51, p> .05, η_p^2 = .09; Skill focus: Wilks' Lambda = .79, F(4, 20) = 1.35, p>.05, η_p^2 = .21; Neutral: Wilks' Lambda = .84, F(4, 20) = .97, p>.05, η_p^2 = .16; Control: Wilks' Lambda = .87 , F(4, 20) = .73, p>.05, η_p^2 = .13. P-RT: Fluency: Wilks' Lambda = .88, F(3, 18) = .85, p> .05, η_p^2 = .12 ; Skill focus: Wilks' Lambda = .97, F(3, 18) = .18, p>.05, η_p^2 = .03; Neutral: Wilks' Lambda = .81, F(3, 18) = 1.44, p>.05, η_p^2 = .19; Control: Wilks' Lambda = .94, F(3,18) = .41, p>.05, η_p^2 = .06.