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Kam, Karina KW, Uiga, Liis, Lam, Wing-Kai and Capio, Catherine M (2021) The colour we wear: Impact on self-predicted and actual motor performance. The Journal of Sport and Exercise Science, 5 (1).

DOI: https://doi.org/10.36905/jses.2021.01.05

Publisher: Sport and Exercise Science New Zealand

Version: Published Version

Downloaded from: https://e-space.mmu.ac.uk/627332/

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SESNZ
SPORT & EXERCISE SCIENCE
NEW ZEALAND

The Journal of Sport and Exercise Science, Vol. 5, Issue 1, 32-38 (2021)

www.sesnz.org.nz

JSES
ISSN: 2703-240X

The colour we wear: Impact on self-predicted and actual motor performance

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ARTICLE INFO

Received: 24.04.2020
Accepted: 12.08.2020
Online: 01.02.2021

Keywords:
Colour
Red
Apparel
Motor Performance
Perception

ABSTRACT

The effect of colour on different aspects of performance has been the subject of substantial research interest, and red had been shown to have varying effects on not only performance, but perceptions as well. This study examined the effect of apparel colour on self-predicted and actual motor performance. Thirty-six young adults (18 females, 18 males; 20.4 SD 1.32 years old), who had no experience in football, performed a task consisting of an agility ladder drill and football shooting, in each of three bib colours (red, blue, black). Self-predicted and actual performances were measured on the dimensions of shooting accuracy and kicking power. A significant effect of colour on self-predicted shooting accuracy was found. Participants expected themselves to shoot less accurately when they were wearing a red bib, compared to when wearing blue and black bibs. No effect of colour on actual performance was found and no significant interaction was found between colour and sex. The findings suggest that wearing red could reduce users' expectations of their performance in a novel motor task; there is no effect on actual performance.

1. Introduction

Colour, as an omnipresent personal experience, influences human cognition, perception and behaviour (Elliot & Maier, 2007; Feltman & Elliot, 2011). Functionally, it has been suggested that colours may attract attention, convey information, or evoke some motivations (Sorokowski et al., 2014). As such, patterns of human responses are expected as a consequence of exposure to specific colours. The majority of relevant research has examined the colour red, thereby generating substantial evidence on the effects of this hue (Jalil, Yunus, & Said, 2012). Red is associated with aggressiveness, power, dominance (Feltman & Elliot, 2011), and higher testosterone levels (Farrelly, Slater, Elliott, Walden, & Wetherell, 2013). Hill and Barton (2005) showed that athletes who wore red attires in boxing, taekwondo and wrestling, had a higher probability of winning during the 2004 Olympic Games. They further showed that the same effect of red found in male athletes was not present in female taekwondo and wrestling athletes. Hence, they argued that wearing the colour red enhances a sense of dominance and triggers superior testosterone responses in those who wear it; thereby enhancing their performance. From an evolutionary perspective, men are suggested to be more sensitive to the effects of red, as this colouration is proposed to be a testosterone-dependent signal of male quality (Ioan et al., 2007).

Attrill, Gresty, Hill, and Barton (2008) extended these findings to team sports, examining English football teams over a 55-year period. They showed that teams wearing red shirts won more games than teams wearing blue, white and yellow-orange shirts. Comparable findings were demonstrated by Piatti, Savage, and Torgler (2012) who analysed Australian Rugby League games over a 30- year period. Focusing on the performance of teams playing at home, they found that teams wearing red shirts were more likely to win compared to teams that wore other coloured shirts. On the other hand, research in European football leagues revealed that wearing red attires did not increase the likelihood of winning compared to wearing other colours (Garcia-Rubio, Picazo-Tadeo, & Gonzalez-Gomez, 2011; Kocher & Sutter, 2008). Such inconsistent findings could be explained by uncontrolled differences that might be expected of studies based on archival data. Further investigations are warranted to better understand the impact of apparel colours on sports-related motor performance.

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Viewed colour also influences attitudes and behaviours of others towards the individuals wearing them (Feltman & Elliot, 2011). For example, goalkeepers in a simulation task reported lower expectancies of saving penalties when penalty takers were wearing red than when they were wearing white (Greenlees, Leyland, Thelwell, & Filby, 2008). In addition, penalty takers scored fewer penalties when facing goalkeepers wearing red compared to those wearing blue and green (Greenlees, Eynon, & Thelwell, 2013). Even viewers appear to be affected, as referees and spectators with high understanding of football rules reportedly judged tackles from behind more harshly when players were wearing red (Hagemann, Strauss, & Leissing, 2008; Krenn, 2014). More recently, viewers perceived treadmill runners to be faster when wearing red compared to when wearing blue (Mentzel, Schücker, Hagemann, & Strauss, 2019). Nevertheless, the evidence has not been conclusive. For instance, Furley, Dicks, and Memmert (2012) found that goalkeepers' perceptions of penalty takers' performance were not affected by the colour of attire (i.e., red vs. white) they were wearing.

Some researchers have proposed that the effects of colour simply reflect culture and sport-specific associations. Greenlees and colleagues (2008) argued that the most successful football teams in England typically wear red, which may have formed associations between red and successful performances. Other researchers, have proposed that certain outfit colours (taking into consideration saturation, brightness, contrast) can affect the visibility of the opponent, thereby influencing performance (Rowe, Harris, & Roberts, 2005). Specifically, they showed a disadvantage for judo athletes wearing white compared to athletes wearing blue. Rowe et al. (2005) argued that a white judogi is likely to be perceived as brighter so moves can therefore be more easily anticipated. However, Dijkstra and Preenen (2008) argued that such an effect tends to be a result of several confounding factors associated with retrospective study designs, such as dissimilar prior experiences of participants, recovery time differences and the seeding system (i.e., the first called athlete for the fight used to wear a blue judogi). Consequently, more conclusive evidence from study designs that are not retrospective is needed.

Experimental study designs that examined uni-dimensional measures of performance have explored the mechanisms underlying the effects of colour. Most manipulations have been in terms of viewed colours (i.e., colour of environment rather than of apparel), and findings have been inconsistent. For example, grip strength was enhanced after viewing red hues but not after viewing other colours, such as blue, pink, and grey (Crane, Hensarling, Jung, Sands, & Petrella, 2008; Elliot & Aarts, 2011). However, exposure to a red environment (compared to blue and green) resulted in experienced cyclists' poorer performance as evident in shorter distances cycled, and less reported enjoyment of cycling (Briki, Rinaldi, Riera, Trong, & Hue, 2015). A further inconsistency is that Araki and Huddleston (2002) found that the colour of the target (i.e., blue, green, red, white) had no effect on dart throwing performance. Additionally, albeit with a small sample size, one study examined testosterone responses between cyclists who wore red or black apparel when cycling to exhaustion; no significant differences between groups were found (Hackney, 2006). Taken together, these inconclusive findings suggest that the effect of colour on different aspects of performance requires further examination.

Evidence on the effects of the colour that people wear on motor performance potentially adds to the range of strategies that could be employed to enhance performance in different sports contexts. Research, however, has been mostly focused on the influence of red hues on sports performance outcomes (i.e., winning). Evidence that relates to output other than likelihood to win is inconsistent, and there continues to be limited information that is specific to motor performance. To contribute towards clarifying the state of evidence, the current study sought to examine the effect of colour on two dimensions of football kicking performance – accuracy and power. Noting that the colour red is associated with perceptions of threat and dominance (Feltman & Elliot, 2011), self-predicted performance was also measured. Using a football drill task, we manipulated the colour of participants' apparel. In conditions where participants wore apparel in the chromatic colours of red and blue and the achromatic colour of black, we compared participants' self-predicted and actual performance of the football drill execution. We hypothesized that the colour of apparel would influence participants' self-predicted and actual performance. Specifically, we expected red to have a relative enhancing effect on self-predicted and actual performance.

2. Methods

2.1. Participants

A priori calculation using GPower 3.1.9 (Faul, Erdfelder, Lang, & Buchner, 2007), based on an effect size of $\eta 2 = 0.31$ (Dreiskaemper, Strauss, Hagemann, & Busch, 2013), with power set at 0.95 and alpha at 0.05, revealed a desired sample size of 30 participants. With an additional 20% increase in the target sample size, 36 undergraduate students were recruited to participate in this study (18 females, 18 males; Mean age = 20.4, s.d. = 1.32 years). All the participants were novices to the task and had no experiences with football drills or training. Participants were also screened for the following exclusion criteria: (a) lower extremity injuries within the last six months prior to the study, (b) motor and/or cognitive disorders, and (c) colour blindness (i.e., using the Ishihara Colour Blindness Test).

2.2. Procedures

All study procedures were reviewed and approved by the institutional ethics review committee. Participants signed informed consent forms prior to any procedure. In order to promote continuous motivation in task performance, participants were informed that a monetary reward was on offer for the top five performers in shooting accuracy.

Participants were asked to watch a one-minute instructional video of the task that they were to perform. The video featured a model wearing white apparel, who performed an icky shuffle agility ladder drill, followed by shooting a stationary football towards the marked centre of a goal. The agility ladder drill was included to enhance the ecological validity of the task. Participants were instructed to move through the ladder quickly, then kick the ball and hit the target as accurately as possible. All participants were able to perform the task successfully after one practice trial. Four test trials were performed while wearing each

of three colours of bibs (red, blue and black), with the colour sequence counter-balanced across participants.

With each bib colour, participants gazed at themselves in a full body size mirror for 30 seconds to call attention to the colour manipulation. They were then asked to predict their level of performance in terms of shooting accuracy and kicking power, using a Visual Analogue Scale (VAS; Cline, Herman, Shaw, & Morton, 1992). This was followed by performance of the football task according to the video instructions. Upon completing four trials, participants took a two-minute break while still wearing their bib. They were then asked to change to the next counter-balanced bib colour and the same procedure was repeated until all three colours were worn (i.e., 12 test trials).

2.3. Equipment and set-up

Lighting in the laboratory setting was controlled and curtains were used to cover the natural light, ensuring that all participants were exposed to the same gradient of colours and lighting in the background. The set-up (see Figure 1) consisted of a 10-box agility ladder (300 cm in length), a size 5 football placed on a kicking tee 250 cm from the goal, and a standardized futsal goal (200 cm x 300 cm; Fédération Internationale de Football Association, FIFA). A kicking target, represented by a 10 cm x 10 cm cross, was set at the centre of the goal and 90 cm above ground.

Self-predicted performances for shooting accuracy and kicking power were measured using VAS for each performance dimension. This is deemed a valid and reliable subjective measurement of a psychological construct using interval level data (Cline et al., 1992), and is particularly suitable when each question is along a single dimension (Rausch & Zehetleitner, 2014). The VAS used was an unmarked 10-cm line with descriptors at each end, and participants were asked to draw a vertical line on the scale to indicate how well they expected to perform. For accuracy, the descriptors were 0 cm "farthest from target possible" and 10 cm "absolutely on target"; for perceived power, 0 cm "absolutely no power" and 10 cm "strongest power possible". Marks were subsequently measured in cm and converted to percentage based on the full measure of 10 cm (100%). Marks closer to 10 cm represented better self-predicted performance.

A ceiling mounted camcorder (GoPro, Hero 4 Silver Edition, 60fps 720p) recorded the point of contact of the football relative to the target. The camera was located perpendicular to the goal, at a distance of 500 cm, and at a height of 90 cm above ground. Post-hoc video analysis using Adobe Illustrator CS4 (Adobe Inc., San Francisco, CA, USA) was performed to quantify kicking accuracy. The absolute error from target was measured in cm; smaller figures represented greater accuracy. A speed gun (Bushnell, Outdoor Technology Velocity Speed Gun 101911) was used to measure the velocity of the kicked ball (km/hr) as a measure of power; higher velocity represented greater explosive force contraction (Hermassi, Chelly, Fathloun, & Shephard, 2010).

2.4. Data analysis

The Shapiro-Wilk test showed that all perceived and actual performance scores were normally distributed (all $p > 0.05$). To examine the effect of bib colour on self-predicted performance, 3 (red, blue, black) x 2 (male, female) multivariate repeated measures analysis of variance (RM-ANOVA) was conducted on the average VAS scores (out of four trials) for accuracy and power. To examine the effect of bib colour on actual performance, 3 (red, blue, black) x 2 (male, female) RM-ANOVA was conducted separately on the average performance scores (out of four trials) for accuracy and power. Mauchly's test confirmed that the sphericity assumption was not violated across all variables (all $p > 0.05$). Significant main effects were followed up by univariate repeated measures ANOVA and paired samples t-tests with Bonferroni correction. Statistical significance was $p < 0.05$ ($p < 0.017$ for Bonferroni correction); tests were performed using SPSS 25.0.

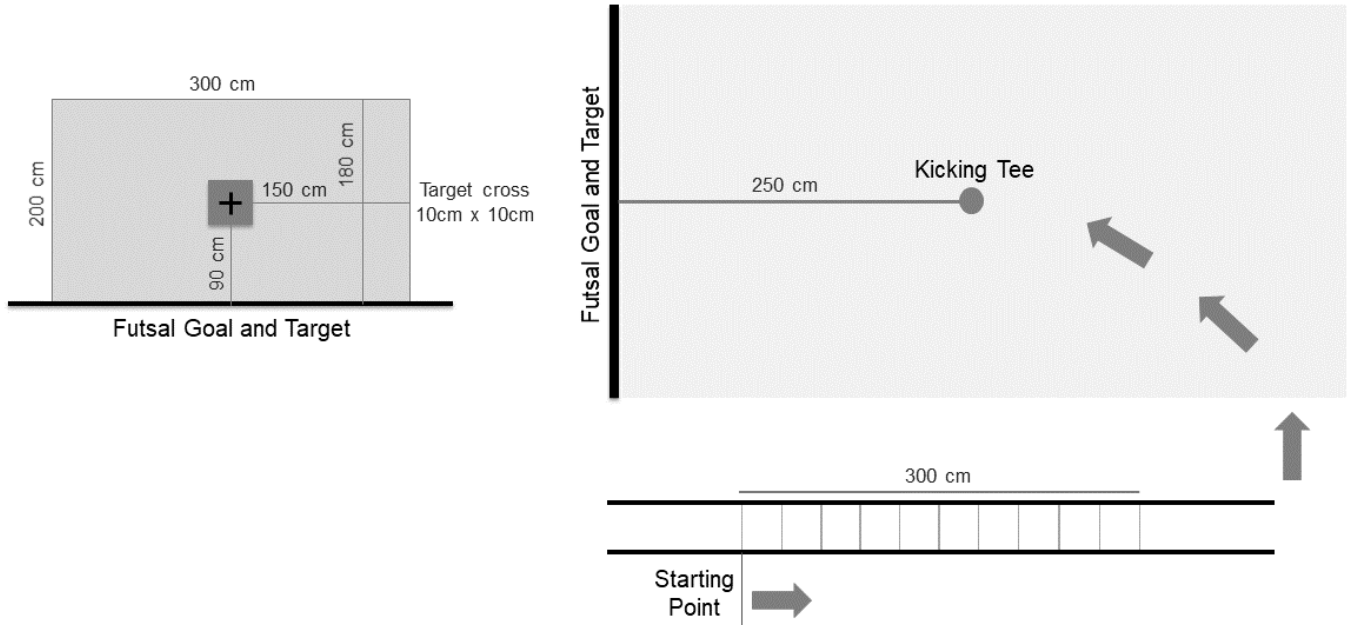

Figure 1: Schematic diagram of the motor task

3. Results

3.1. Self-predicted performance

Multivariate repeated measures ANOVA revealed a significant main effect of colour on self-predicted performance ($F(4,31) = 3.11$, $p = 0.03$ $\eta_p^2 = 0.29$). Univariate tests showed that the main effect of colour was significant only for self-predicted shooting accuracy ($F(2,68) = 5.58$, $p = 0.006$, $\eta_p^2 = 0.14$), but not for self-predicted power ($F(2,68) = 0.02$, $p = 0.98$, $\eta_p^2 = 0.001$). Pairwise comparisons (Figure 2) showed that participants expected themselves to shoot significantly less accurately when they were wearing the red bib ($M = 52.96$, $SD = 16.84$) compared to when wearing the blue bib ($M = 57.94$, $SD = 18.70$, $p = 0.004$), or the black bib ($M = 57.23$, $SD = 17.97$, $p = 0.014$). The difference between the blue and black bibs was not significant ($p = 0.67$). There was no main effect of sex ($F(2,33) = 1.83$, $p = 0.18$, $\eta_p^2 = 0.10$), and there was no interaction between colour of bib and sex ($F(4,31) = 1.13$, $p = 0.36$, $\eta_p^2 = 0.13$).

3.2. Actual performance

Multivariate repeated measures ANOVA revealed no main effect of colour on actual performance variables ($F(4,31) = 1.43$, $p = 0.25$, $\eta_p^2 = 0.16$). There was a main effect of sex ($F(2,33) = 10.28$, $p < 0.001$, $\eta_p^2 = 0.38$). Tests of between-subjects effects showed that the main effect of sex was significant only for power ($F(1,34) = 20.64$, $p < 0.001$, $\eta_p^2 = 0.38$) and not for accuracy ($F(1,34) = 1.33$, $p = 0.26$, $\eta_p^2 = 0.04$). Males displayed greater kicking power than females across all bib colours (all p's < 0.01). The interaction between colour of bib and sex was not significant ($F(4,136) = 0.54$, $p = 0.70$, $\eta_p^2 = 0.02$). Performance variables are illustrated in Figure 3.

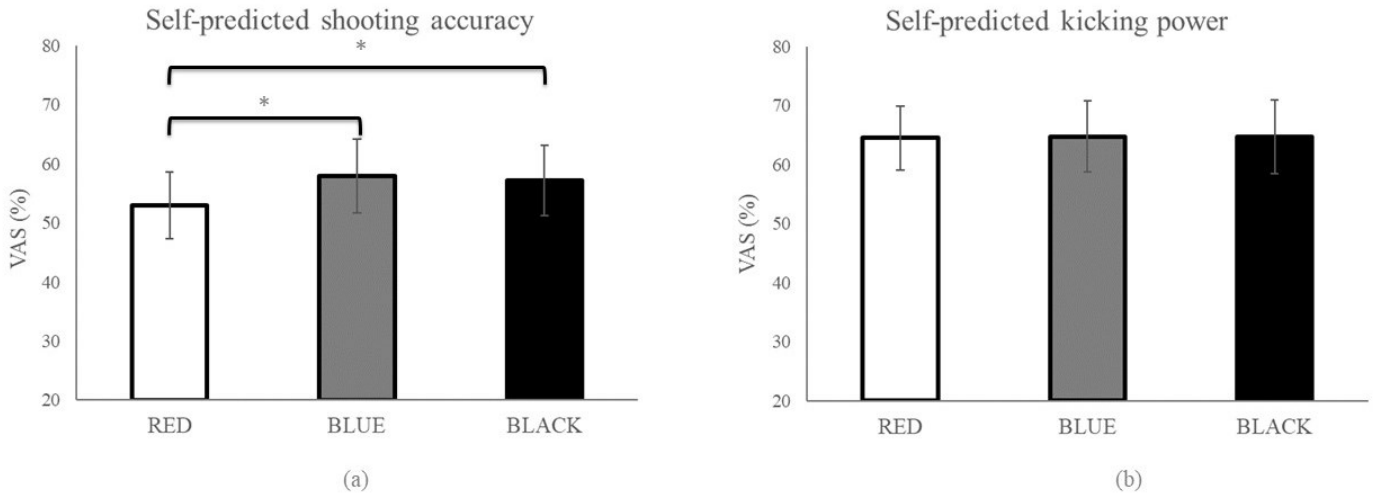

Figure 2: Mean (2SE) of participants' self-predicted performance in (a) shooting accuracy and (b) kicking power; * statistically significant difference

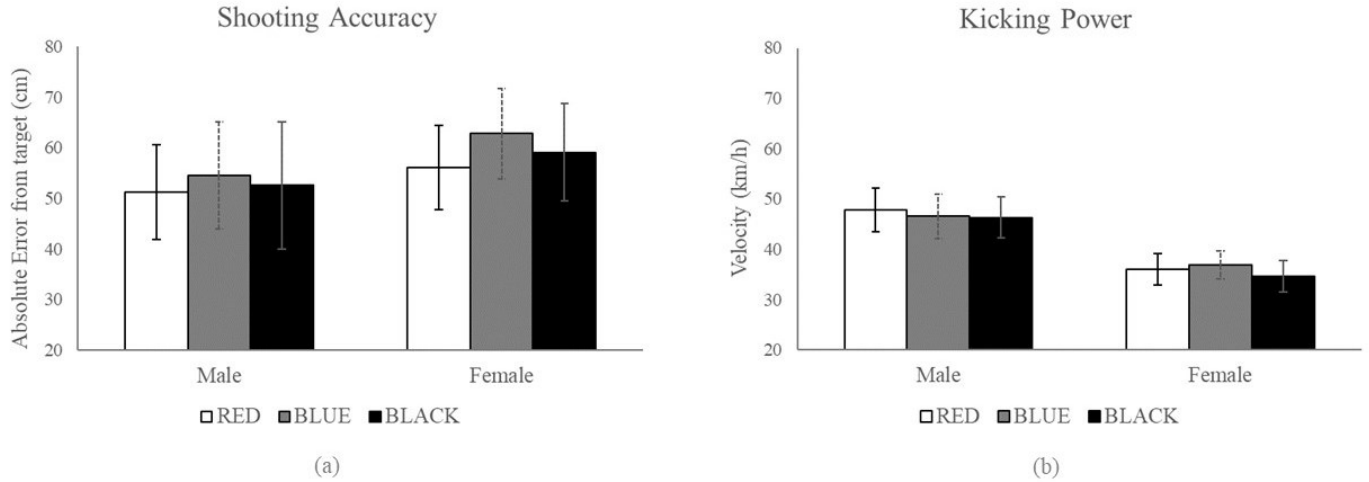

Figure 3: Mean (2SE) of male and female participants' actual performance in (a) shooting accuracy and (b) kicking power

4. Discussion

This study explored the impact of colour on performance of a relatively complex motor task with reasonably controlled context-specific constraints. Based on previous research done in other sporting contexts and colour presentations (i.e., physical environment, opponents' apparel), it was hypothesized that the colour red would have an enhancing effect on participants' self-predicted and actual performance. We found that participants predicted themselves to be less accurate with shooting when they were wearing the red bib compared to the blue and black bibs. However, colour did not have a significant effect on shooting performance.

The current findings appear to contradict the hypothesis regarding self-predicted performance, as the participants predicted themselves to have lower shooting accuracy when wearing the colour red, compared with the colours blue and black. Hill and Barton (2005) claimed that wearing red enhances one's self-perception of dominance and aggressiveness, presumably generating a heightened self-perceived performance. Elliot and Maier (2014), however, argued that factors such as task difficulty and the extent to which an individual's ability could make evaluation threatening could eliminate the positive effect of red. As our participants were novices to football, it is likely that they deemed the football drill task to be difficult and that they considered their ability to be insufficient to win the prize money for the top performers. This probably explains the negative effect of red apparel on participants' self-perceived shooting accuracy.

Our findings suggest that rather than gaining some advantage through enhanced perception of potential success in the primary task, wearing red could have a negative effect. While the findings of this study counter our hypothesis, they nevertheless contribute directional and context-specific evidence, where the effects of colour red on self-predicted performance could be moderated by the task complexity, participants' ability and experience. Whilst we acknowledge that the effect of red on self-predicted performance was found only for shooting accuracy and not for kicking power, this is arguably the more relevant dimension. Participants were instructed to complete a football drill, the goal of which was to kick a ball towards a target accurately. It is therefore likely that the shooting accuracy was the only performance dimension that mattered to the participants.

On the basis that perception and performance are intricately linked, we hypothesized that colour would have an impact on motor performance. On all dimensions, our findings revealed that colour did not influence actual performances in shooting accuracy and kicking power. Apart from archival studies, some experiments had shown that the colour red can promote enhanced performance in motor tasks such as target shooting (Sorokowski & Szmajke 2011), and pinch and hand gripping (Elliot & Aarts 2011). These studies, however, introduced colour manipulation in the form of objects that were presented to participants (i.e., balls, printed materials). In the current study, we specifically tested the effect of colour that participants had on themselves, and the results do not support our hypothesis. This suggests that wearing red apparel does not have an enhancing effect on motor performance, hence no direct advantage might be expected. The task in this study was to shoot at the target accurately; we are unable to rule out the possibility that wearing red might potentially have an effect if the task was focused on the speed of task completion.

We note that the participants were novices, and the lack of practice or training may account for their performances being relatively comparable across the bib colours (i.e., they were still learning the task). Looking at the shooting accuracy data, participants were indeed shooting quite far from the target (see Figure 3). It has been suggested that the effect of red on performance would likely manifest in situations where the task is moderately challenging and extreme situations might weaken or eliminate the effect (Elliot & Maier, 2014). For the novice participants, the football drill task is perhaps greater than a moderate challenge, hence the effect of red was eliminated. Future work could consider having participants with a range of experiences to verify the moderating role of the task challenge on the effect of red (and other colours). Additionally, a manipulation check could be introduced in which participants may rate the level of challenge or difficulty that they experienced with the task. We also consider that the number of trials might have been too few, such that we are unable to rule out a learning effect for the novice participants. Future work could consider a greater number of trials if participants are new to the task. It is also worth noting that the exposure to the colour manipulation was relatively brief (i.e., 30 seconds of focused exposure in front of the mirror), and we cannot rule out the possibility that this was simply not enough to generate an effect on performance. In the current absence of evidence-based recommendation, further work is also needed to verify the optimal time of exposure for sufficient colour manipulation.

We did not find different effects of colour between male and female participants in self-predicted or actual performance. Hill and Barton (2005) who examined the association of colour of apparel with winning in the Olympics found that the apparent advantage of red was found only in male and not in female taekwondo and wrestling athletes. In other studies, males and females have been shown to respond differently to red colour (Elliot & Niesta, 2008), but these tend to be in the contexts of attraction (e.g., Gueguen, 2012; Kayser, Elliot, & Feltman, 2010) or distraction (e.g., Ioan et al., 2007). There has been no prior experimental study that had shown such interaction of red with sex, in relation to motor performance. Whilst we found that males displayed greater kicking power than females, there was no interaction of sex with colour. The difference that we found between males and females is likely due to biological differences in lower limb strength (Miller, MacDougall, Tarnopolsky & Sale, 1993). Our findings suggest that the apparent effect of red on self-predicted motor performance is no different between males and females, and there does not seem to be any difference when it comes to actual performance as well.

The design employed in this study was intended to achieve a reasonable level of control for context-specific constraints. Consequently, there is a trade-off between controlled colour exposure and actual field conditions. It is, therefore, important to consider some design-related limitations when interpreting the evidence. We had mentioned that the wear time and exposure to the apparel colours were relatively short as they were confined to the time required to complete the task trials. In field conditions, athletes would wear the colours for much longer periods of time, and the effects could possibly be different.

To conclude, this study shows that wearing colour red is associated with lower self-predicted performance of shooting

accuracy in a football drill. Colour of attire does not directly influence actual shooting accuracy and kicking power. In a relatively complex motor task, the colour that novice performers wear could influence their expectations, but not their actual performance.

Conflict of Interest

The authors declare no conflict of interest.

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