Influence of Red Jersey Color on Physical Parameters in Combat Sports

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Hill and Barton (2005) showed that fighters in tae kwon do, boxing, and wrestling who wore red jerseys during the 2004 Olympic Games won more often than those wearing blue jerseys. Regarding these results, this study investigated the effects of jersey color during a combat situation on fighters’ physical parameters of strength and heart rate. An artificial, experimental combat situation was created in which the color of sport attire was assigned randomly. Fourteen pairs of male athletes matched for weight, height, and age had to fight each other: once in a red jersey and once in a blue. Heart rate (before, during, and after the fight) and strength (before the fight) were tested wearing the blue and the red jerseys. Participants wearing red jerseys had significantly higher heart rates and significantly higher pre-contest values on the strength test. Results showed that participants’ body functions are influenced by wearing red equipment.

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The influence of the color red on perception and behavior has been explored in widely differing contexts. For example, Elliot and colleagues have discussed the color red as a factor in performance attainment (Elliot, Maier, Moller, Friedman, & Meinhardt, 2007), avoidance behavior (Elliot, Maier, Binser, Friedman, & Pekrun, 2009), men’s attraction to women (Elliot & Niesta, 2008), and romance in women viewing men (Elliot, Niesta Kayser, Greitemeyer, Lichtenfeld, Gramzow, Maier, & Liu, 2010). All these studies showed either a positive effect (e.g., when rating the attractiveness of women in a red-colored environment, Elliot & Niesta, 2008) or a negative effect of the color red (e.g., undermining intellectual performance, Elliot et al., 2007). Color effects on human performance have also been demonstrated in several contexts. For example, Ilie, Ioan, Zagrean, and Moldovan (2008) explored influences of colors in virtual competitions. They found that playing first-person computer games leads to more success in a red-colored team than in a blue-colored team.

In team sports, Attrill, Gresty, Hill, and Barton (2008) examined the superiority of wearing red in an archival study. They investigated the influence of the color red on long-term success in English soccer over a 55-year period and found that performance was significantly better when teams played in their home color red. However, García-Rubio, Picazo-Tadeo, and González-Gómez (2011) found that teams wearing red shirts did not perform better than others in Spanish premier league soccer after controlling for other factors such as the management success of the football team.

In their seminal study, Hill and Barton (2005) analyzed the effect of color in combat sport. They investigated the results of the 2004 Olympic Games in the disciplines wrestling (Greco-Roman wrestling and freestyle wrestling), boxing, and tae kwon do. Results showed that athletes wearing red jerseys won significantly more frequently than those wearing blue jerseys—however, only in those cases in which fighters were closely matched in terms of performance. In all four disciplines, the jersey colors red and blue are randomly assigned to opponents independently from their expertise. This discipline-specific rule enhances the internal validity of this correlational finding. Hill and Barton (2005; also Barton & Hill, 2005) explained their findings in terms of the psychological influences of the color red on athletes due to an evolutionary and cultural association of red with aggression and dominance.1

Hill and Barton’s (2005) study failed to clarify whether it is the athlete or the referee who is responsible for this phenomenon. In other words, one research question is whether it is actors and their performance that are influenced by the color of the jersey they wear, or whether it is the people who observe this color and evaluate performance who are influenced. Hagemann,
Strauss, and Leißing (2008) isolated the effect of referees in combat sports experimentally and found that referees’ judgments are influenced by the shirt color of fighters in combat. In this video-based experiment, referees were asked to watch videos of tae kwon do fights. Each video was shown twice: once with regular colors and once after the colors red and blue had been switched by manipulating the videos. Results showed that tae kwon do referees awarded more points to fighters in red even when they watched two videos depicting the same fight but with switched colors. Roberts, Owen, and Havlicek (2010) found a similar effect on the rater, but also argued that color has at least as much psychological influence on wearers as on observers (such as the referee).

If wearers are influenced by jersey color, it is important to investigate whether this is reflected in changes in measurable physiological correlates (such as testosterone) or motor abilities (such as strength). Hackney (2006) found no changes in testosterone response due to wearing red-colored apparel. However, more recent research by Elliot and colleagues (Elliot & Aarts, 2011, Payen et al., 2011) found an influence of viewing red (e.g., red-colored room) on motor output. Payen et al. (2011) designed an experiment in which participants had to perform a maximal muscle contraction while viewing either red, a chromatic control color, or an achromatic control color. Results showed increased strength development while viewing red, but no significant difference in peak amplitude of power. The authors concluded that their results support the idea of a link between seeing the color red and basic motor output. Elliot and Aarts (2011) also investigated the connection between perceiving the color red and basic motor function. In two experiments, they compared general motor output (pinch grip force and hand grip force) while looking at different colors (red, gray, and blue). They found significantly higher strength results for the red condition in contrast to gray and blue. These results included measurements of maximum force, mean force over time, and slope toward maximum force. Elliot and Aarts (2011) argued that their findings establish a link between seeing the color red and motor output.

However, these results cannot explain Hill and Barton’s (2005) findings of a link between one’s own jersey color and the outcome of fighting bouts. Furthermore, they report on only basic, isolated motor output without taking complex competitive sports situations into account. Finally, as Roberts et al. (2010) pointed out, not only the observer but also the performer may be influenced by this red effect. Feltman and Elliot (2011), for example, showed that wearing red enhances one’s own self-perception of dominance and threat, whereas viewing an opponent’s red enhances the perception of his or her dominance and threat. These findings lead to the hypothesis that persons wearing red jerseys have advantages over their opponents due to the jersey they are wearing. Our practical hypothesis is that this also influences physical parameters in persons wearing red-colored jerseys. To generate testable hypotheses, we operationalized physical parameters by measuring heart rate and strength. We expected that wearing a red jersey would lead to an increase in both parameters during a combat situation.

**Method**

The aim of this study was to examine the influence of jersey color on actors during a combat situation. Therefore, we created an artificial fighting situation in which 14 pairs of athletes (N = 28) had to fight twice against each other—one in a red jersey, once in a blue. The order within a dyad was assigned randomly.

We measured heart rate and maximum force to test the hypothesis that one’s own jersey color red would influence physiological parameters in a fighting situation.

Before the fights started, we measured heart rate and maximum strength while participants wore their normal training outfits (no red or blue included). This data served as the control condition. Participants were blind to the reasons for the experiment. They were introduced to the task with a cover story about autodidactic learning of a new type of combat sport. To conform to ethical guidelines, participants were asked to agree to take part in the experiment and were informed about the background of the study afterward. We analyzed the data by computing paired t tests, setting alpha at .05, and calculating effect sizes (Cohen’s $d$).

**Participants**

Participants were 28 randomly recruited male handball players from four German lower league handball teams (fifth to eighth league). Their average age was 27.7 years ($SD = 7.7$), their average weight was 85.6 kg ($SD = 9.1$), and their average height was 186 cm ($SD = 6.22$). They played an average of 6.76 hr ($SD = 2.3$) of sport per week. Three of them had slight prior experience in combat sports (practiced less than 2 years in a judo club). Participants matched themselves to fighting dyads on their own. Height, weight, and age were controlled for similarity. If dyad matching was difficult, because more than two players were similar in height, weight, and age, their same field position as handball players was taken into account. The participants who first wore the red outfit did not differ from those in the blue group in height ($M_{red} = 188.14, M_{blue} = 186.00$), weight ($M_{red} = 87.29, M_{blue} = 85.21$), or age ($M_{red} = 29.42, M_{blue} = 26.00$). In line with the equivalent importance of the three factors for the dyad matching, the average individual differences between the pairs were 4.86 years, 4.29 kg weight, and 5.00 cm height.

**Apparatus**

A 3 × 3 m combat field was set up in a training hall, and a camera located 2 m from the field filmed the entire procedure. We constructed so-called smash sticks with which the dyads had to fight. These were 1.80-m-long fiberglass sticks with a diameter of 2.5 cm. Each end had...
a large oblong impact surface covered with either red or blue fabric of the same color as official tae kwon do outfits (see Figure 1).

Participants had to hit each other with the long sides of the impact surfaces; sticking with the short end was not allowed. Their goal was to hit their opponent’s upper body more often than they were hit themselves. Furthermore, they had to wear red or blue tae kwon do equipment consisting of head, trunk, and two finger protectors.

Heart rate was measured with RS 100 pulse watches (Polar Electro, Germany). Pulse was measured immediately before and after the fight. The watches recorded heart rate continuously during the fight, and the average mean was computed. Participants had to wear watch and transmitter during the entire procedure. Participants’ strength was measured with a leg dynamometer before the fight (Takei A5402 back and leg dynamometer digital, Tokyo, Japan). This dynamometer measured the maximum peak of tractive force in kilograms while participants pulled up a 40-cm iron chain installed on a platform. This measuring plate provided a digital display of the strength in kilograms.

After the fight, participants completed a questionnaire tapping anthropometric data and information about their personal sport history. They also estimated their personal exertion on the Rate of Perceived Exertion Scale (RPE, Borg, 1990).

Each fight was recorded on videotape. Videos were prepared with Adobe Premiere Pro 2.0 software. After the experiment, the 30-s videos of each fight were transformed into a black-and-white format and participants’ performance (number of hits) was judged by two independent raters. Every attack with a smash stick that hit the opponent above the waistline was counted as 1 point.

Procedure
Participants attended a 120-min standard training session for their handball team. After forming matched dyads, each dyad was taken out of training twice for about 12 min. There was an interval of about 40 min of regular training between the two measurement times. The team was informed that the study was comparing autodidactic ways of learning a new type of combat sport between team athletes and individual athletes, and that the experimenters would be analyzing the video recordings. All participants were asked about their physical fitness and willingness to take part in the experiment. After a general warm-up by the handball teams, participants left the training in pairs to take part in the experiment. First, participants were equipped with a pulse watch and transmitter. For the control condition, heart rate was recorded without wearing colored combat protectors. Strength was also measured for the control condition. Then, red- or blue-colored combat protectors were assigned randomly and heart rate and strength were measured for a second time. Fighting rules were explained and the pulse watch was programmed. The fight commenced when a signal indicated that the watches had started recording. Fighters were not allowed to change their randomly chosen position in front of the camera. The fight took 30 s, and ended with a signal from the main experimenter. Pulse recording stopped after exactly 30 s, and average heart rate was recorded. After that, participants had a 2-min break in which to fill out the above-mentioned questionnaire and the RPE. Then heart rate was measured for a fourth time, and participants were allowed to take off their combat protection gear. For the next 40 min, they continued their handball training before repeating the experiment with switched protector and smash stick colors. No participant guessed the real aim of the study.

Results
Combat
No measurements taken when wearing either the red or the blue jersey revealed any differences between the three participants with and those without some prior knowledge of combat sports. An ANOVA showed no significant differences for the order of colors ($p > .05$).

Two independent raters watched each video and rated performance in terms of hits on opponents (interrater reliability: $r = .62, p < .001$). Results of the fights showed no influences of jersey color, $t(27) = .18, p = .86$. There were also no effects on subjective strain measured with the RPE scale, $t(27) = .61, p = .55$ (see Table 1).
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Heart Rate

Results showed that participants had a higher average heart rate \( M_{\text{red}} = 162.00, SD_{\text{red}} = 12.96; M_{\text{blue}} = 155.71, SD_{\text{blue}} = 15.04 \), \( t(27) = 2.55 \), \( p_{\text{one-tailed}} < .001, d = 0.48 \), when wearing a red jersey during the 30 s of combat. There was a higher heart rate during the combat situation for participants with red equipment (see Figure 2). There were no significant effects of color before and after the fight (before the fight: \( t(27) = –.09, p = .93 \), after the fight: \( t(27) = .19, p = .85 \)). There were also no differences between the control condition wearing no color protectors and wearing one of the jerseys before fighting \( t(27) = .24, p = .81 \) for the comparison control condition vs. red color and \( t(27) = .10, p = .92 \) for the comparison control condition vs. blue jersey.

Strength

Precontest values on the strength test were significantly higher in participants wearing red than blue equipment \( M_{\text{red}} = 194.38 \text{ kg}, SD_{\text{red}} = 49.15; M_{\text{blue}} = 175.84 \text{ kg}, SD_{\text{blue}} = 45.66 \), \( t(27) = 1.92, p_{\text{one-tailed}} = .026, d = 0.36 \). Whereas there were no significant differences between the blue jersey condition and the control condition, \( t(27) = .63, p = .533 \), the effect of wearing red equipment was also significant in contrast to normal clothes, \( t(27) = 2.09, p < .001, d = 0.31 \). Figure 3 shows the differences for wearing red equipment.

Discussion

This study investigated the direct effects of jersey color on athletes wearing red or blue jerseys. Before, during, and after an artificial combat situation, we measured the influences of jersey color on the participants’ physical parameters. Participants did not know why these parameters were being measured.

Results showed an influence of jersey color on physical parameters. Both heart rate during the fight and strength before the fight were significantly higher when a fighter wore a red jersey. This shows that not only observers such as referees (Hagemann et al., 2008) but also fighters themselves are influenced by their jersey color. Findings on strength showed that it was not the persons observing an opponent’s jersey color who were influenced, but the participants wearing the jerseys themselves. Because participants faced a wall with an achromatic color when performing the strength test, effects of observed colors could be ruled out. This effect could not be confirmed for heart rate, because changes could also have been due to observing an opponent wearing a blue jersey. A further possibility is that wearing blue equipment is a relaxing factor. The present results cannot rule out either possibility. Further studies will need to control for this by measuring with achromatic colored jerseys.

The findings on the strength measure are in line with findings on the influence of color on hand grip or strength (Keller & Vautin, 1998; Profusek & Rainey, 1998).
1987), although these studies explored the effects of observed light colors. We are unaware of any other study on the relations between wearing a jersey and a parameter such as strength. Whereas older studies (e.g., Profusek & Rainey, 1987) focused on the effect of light beams, the current study investigated the effect of worn color and not of observed color. It confirmed effects of jersey color on strength only before a fighting situation. Further research needs to develop methods for measuring strength while performing a sport, for example, by building dynamometers into the sticks. Experiments using computer-based simulations of combat situations may be one way of gaining more accurate measurements of strength and other linked parameters such as movement velocity. Moreover, computer-based experiments could be used to test more variables such as eye movements (e.g., distracting factor of red, Ioan et al., 2007) or color intensiveness, because we were unable to control the hue, lightness, and chroma of the colors in this study.

On the one hand, results did confirm our hypothesis that active persons are influenced by the color they wear because we showed that red jerseys activate physical parameters. Red equipment seems to enhance a fighter’s heart rate and strength, whereas no similar effect of blue jerseys could be found. Results of strength measurement before the fight show that it is not the color somebody looks at but the color you wear that is decisive.

On the other hand, the research question derived from Hill and Barton’s (2005) study addressed the outcome of fights, and our study also aimed to explore whether jersey color influences opponents in a way that is decisive for either winning or losing. However, no statements can be made on this because fighting results showed no effect of color. Nonetheless, our results are based on the observation of black-and-white video images, and this is not a completely unbiased method for evaluating performance (Little & Hill, 2007).

Furthermore, it is not clear whether greater strength and a higher heart rate lead to better fighting performance and more hits. In fact, there is no evidence that higher heart rates lead to better combat results. Another explanation for the lack of a link between the present findings and the evaluation of fight outcomes may be the layperson status of the participants. Only three of them (who did not differ from the others on any measured parameters) had some prior knowledge of combat sports. None of the test persons knew how to handle the smash sticks they were fighting with. No tactics or techniques were shown, and the outcome of the fights might have been influenced by numerous factors that we were unable to rule out or control. It may well be necessary for participants to receive tactical and technical training before they can transform higher body activation into better performance.

Results on the RPE measurements of subjective strain (Borg, 1990) showed no differences between the red and the blue jersey conditions, although heart rate was higher when wearing red. This suggests that the red effect might not be perceived explicitly by participants: It may be an implicit factor to which test persons are simply exposed.

This study investigated the influence of colors on athletes during a combat situation. As Hagemann and colleagues (2008) showed that referees are influenced by jersey colors in combat sports, these results indicate that also fighters themselves are influenced by the color of their own jersey. Red jersey color was identified as an activator of tractive force and heart rate. However, the heart rate effect seems to be restricted to the fighting situation itself. Due to the time-intensive experimental design, the sample size was small. Studies with larger samples will be needed to replicate the results with sufficient power. Moreover, further studies will need to focus on whether effects on strength and heart rate lead to better performance outcomes. This will require them to develop methods for measuring strength while performing a sport. Finally, replication studies should focus on the outcome of fights in competitions to verify the influence of the color in fighting situations. This would also call for an examination of the potentially relaxing effect of the color blue.
Note

1. Rowe, Harris, and Roberts (2005a) reported similar results for the colors blue and white in judo matches at the 2004 Olympics. They found that fighters wearing blue judogi are more successful than those wearing white ones, and argued that fighters wearing blue may have a visual advantage because it is easier for them to anticipate the movements of opponents wearing brighter white judogi. Dijkstra and Preenen (2008) pointed out that the higher ranking fighter in judo always wears the blue judogi, thereby showing that Rowe et al. (2005a) failed to consider the fighters’ expertise in their results. In a reanalysis excluding the nonrandom allocation of blue dressed judogis, Rowe, Harris, and Roberts (2005b) nonetheless still found support for their conclusion regarding a winning bias for blue jerseys in judo.

References


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