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RED SHIRTS, SUCCESS AND TEAM SPORTS

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Baron von Richthofen (the Red Baron) arguably the most famous fighter pilot of all time painted his plane the vividest of red hues, making it visible and identifiable at great distance, showing an aggressive pronouncement of dominance to other pilots. Can colour affect aggression and performance and if so is it observable within team sports? This study explores the effect of red on sporting performances within a team sports arena, through empirical analysis of match results from the Australian Rugby League spanning a period of 30 years. While the descriptive analysis reports a positive relationship, the multivariate analysis provides some mixed results once you control for team effects. Thus, more evidence at the team level is required to better understand whether teams in red do enjoy greater success controlling explicitly in a multivariate analysis for many factors that simultaneously affect performance.

Keywords: impact of team colours; red; (Australian) rugby league; team sports

Introduction

Baron von Richthofen, Ferrari, Manchester United and the Chicago Bulls or Michael "Air" Jordan in particular have two common elements, a widely recognized level of skill and the colour red. In many urban myths teams wearing red are considered to be more dominant (win more) than any other colour. But why is this colour associated with this perception of greater skill and

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performance? Is it coincidence that some of the world's greatest sporting teams have worn red? Many euphemisms utilize red in context of aggression, such as *seeing red* or *the red mist* that link aggression to the colour. Are the expectations of red being more successful based upon historical evidence or just an instinct that red represents more aggression and likely more chance at winning?

Colour has a wide ranging and varied role in both nature and society. For example, red, the first visible colour in the light spectrum, it is the colour most often utilized in nature and society as a (warning) signal or indicator of danger [1] and a ruddy complexion often signifying anger which often precedes violence or displays of dominance[1]. In society, red is repeatedly used as a literary device conjuring up a range of seemingly disparate emotions, from love to hate, violence and warfare. Mars the roman god of war was associated with this colour, such that when a roman warrior received an accolade for victories in battle, they were painted from head to foot in the colour. Groups or gangs use colours to symbolize membership (e.g., notorious street gangs such as the Crips (blue) and the Bloods (red). The Bloods, e.g., have been historically identified as the most aggressive and violent street gang. [2] Red coloration has not only been associated with dominance and aggression in human societies, but also in the animal kingdom. It has been demonstrated that for male Stickleback fish, being shown a red object will always triggers an attack response. [3] The effects of aggression and dominance are not only observed among fish, but also higher order animals such as: reptiles, birds and primates. [4] Thus, one can assume that for aggressive competition colour can affect the outcome of sports contests. To some extent modern societies have ritualized identity, aggression and competition in the forms of sports. Sport is closely linked to the definition of competition in entomology, namely "the active

[1] Anger has physical effects including raising the heart rate and blood pressure, often giving the face a red or ruddy complexion.

demand by two or more of the same species or members of two or more species at the same trophic level for a common resource or requirement that is actually or potentially limiting". [5] In these ritualized competitions, team colours are used to signalize identity, membership and loyalty.

Colour also plays an important role in the organization and functioning of societies. In India, the various castes are symbolized by different colours. Red symbolizes the Kashatriyas Caste, which is second in the social hierarchy below the Brahmans (white colour). [6] The traditional wedding colours in Egypt, Russia, the Orient and the Balkans are of red and yellow hues.

Red has been fundamental in the development of human psychology. The development of human vision is progressive, such that the first colour that is recognisable by human children is red. Experiments have found that the order of colour perception as children aged was: red, green, orange, blue and violet. [7] Garbini reached the conclusion that perception and verbal expression follows a parallel path such that the progression of culture is that of colour perception. Ellis [8] neatly summed up this by saying:

> "Red, is the colour that fascinates our attention earliest, that we see and recognise most vividly; it remains the colour that attracts our attention most readily and that gives us the greatest emotional shock. It by no means necessarily follows that it is the most pleasurable colour. As a matter of fact, such evidence shows that very often it is not."

Fehrman and Fehrman indicated that the native Maori people have more than a hundred words used to describe what we call red. [9] In many of the primitive tribal groups, there exists a large vocabulary to describe red, black and white but no or limited words for blue, green and violet. [10] Not only can red change the meaning of something, it can also change the emotive context and even the behavioural patterns of individuals. Elliot and Niesta found that women

wearing red are considered more attractive and sexually desirable to men than women wearing any other colour. [11] Fast-food chains utilize red within the restaurants because of its effect on the human metabolism, which increases a customers' appetite. Alternatively, fine dining and formal restaurants utilize the colours blue and green to promote a calm and relaxed atmosphere, increasing the likelihood of customers staying longer and spending more money. [12] Providing single examples on red without discussing other colours in detail may bias the perception about the importance of red within our society. To get an idea how dominant the colour red is compared to other colours we provide three figures that report the number of hits generated via Google instant search (done December 3 2010), relating different colours with the wording "winning", "dominance" and "aggression". The Google search may provide a "window to the outside world" giving us an approximation how colours are linked with these factors within our society. *Figures 1* to *3* show that the colour red is relatively dominant in all three cases. However, looking at "aggression" and "dominance" (*Figure 1* and *2*) black has an even stronger effect. On the other hand, once we focus also on "winning" red is more dominant (see *Figure 3*). It is apparent that colour influences nearly every aspect of our daily life but do we observe a link between wearing red and improved performance? In recent years this relatively under explored concept, that is the effect of colour on performance, has undergone a research explosion. [13] Some of the earliest investigations into the effect of colour investigated the physical of perceived effect on individuals. For example, it was claimed that bright colours "weigh" more than darker ones. [14] This idea was supported by both Quantz and des Bancels who claimed that red enlarged the apparent size of an object as opposed to a blue one of identical size. [15] Pierce and Weinland's investigated if the colour of the lights in an otherwise white room affected the output of workmen hired specifically for the experiment. They found that red did not inspire greater

work output, but white, followed by yellow and green, had the highest impact on output levels. [16] Féré's experiments found that when patients were shown a red light, there was a measurable increase in pulse, breathing and an increase in muscular strength. [17] Rehm et al. performed a psychological field experiment on 5th grade German students during physical education classes. [18] The students were divided into two groups; the first group was issued a distinctive bright orange shirt, while the others wore whatever "personal shirts" they already wore. [19] The number of aggressive acts committed by each of the competing teams was counted during a sporting task (handball) by independent observers. While the study only contained 30 separate match observations, the results showed a strong variation in observed behaviour between the two teams. The results showed that individuals wearing the distinctive uniform (*orange*), committed significantly more acts of aggression than the others, however this result was only significant for the male students. This, however, was explained as being a group identification (team) effect and not associated with colour. While this study was not specifically investigating the *red* effect, the identifiable colour variation did have a significant impact on performance and behaviour. Additionally, orange and red are often associated with dominance, this may be a learned social signal that varies between cultures or biologically inherited. Pryke's findings demonstrated that in birds aggressive and dominate behaviour is not a learnt behaviour from parents, but red colouration does appear to have an effect on conflict resolution, this indicating that red dominance is innate in nature. [20]

A key study on the *red* effect or more precisely *red vs. blue* was first performed by Hill and Barton, who examined the urban myth that teams wearing red performed better in sporting contests. [21] To this end they investigated four combat sports played at the Olympics, such as boxing, tae kwon do, Greco-Roman wrestling and freestyle wrestling. Given that competitors

were randomly assigned either *red* or *blue*, the probability of either colour being successful should have been statistically equivalent. The result showed that across all four sports, red was significantly more likely to win than blue. Given the randomness of the colour allocation, this result provides strong supporting evidence for some performance enhancement effect. The authors stress that in nature, red is used as a signal of aggression or dominance and those wearing *red* could obtain some "natural" advantage. Furthermore, the results were consistent across competition rounds, where 16 of the 21 rounds were won by red and 19 of the 29 different weight classes were also won by red. The author's state that given the undoubted role of other factors such as skill and strength this advantage is only likely in relatively balanced competitions. Where skill levels are fairly equal, such as in close competitions, wearing red would tip the balance between winning and losing. One of the shortcomings of this paper is the use of simplistic analysis tools. Utilizing a multivariate analysis with an adequate number of control factors would have provided a better chance of isolate the unique contribution of the colour red, especially in the non-balanced matchups.

These findings were called into question by Rowe et al. who concluded that if wearing *red* provided some naturally occurring but unknown benefits, then by examining contests where neither combatant wear red the result should be an even distribution of results. [22] They analyzed another Olympic sport (judo) where combatants wore either *blue* or *white* and found that competitors wearing *blue* was significantly more likely to be victorious over those in *white*. Rowe et al. concluded that *blue* was not by nature a dominant or aggressive colour and therefore some other explanation was attributable for the effect. One such explanation was an artefact of visibility, such that by wearing blue the combatant may be better able to blend into the crowd background whereas those wearing white would have an increased visibility. This would lead to

the greater *number* victories for those in *blue* as opposed to any true colour inspired effect on performance. However, these results were later refuted by Dijkstra and Preenen in their follow up examination of the Rowe et al. judo paper. [23] They found the conclusions to be erroneous, due to three endogenous factors including: the seeding system; the repêchage rounds; and the differences in recovery time of athletes. The allocation of judogi in judo competitions is not random as the higher ranked opponents are systematically allocated *blue*. Additionally, the tournaments are structured such that tournament favourites, or the "seeded players', would not face off until the later rounds, this ensured that better ranked players only faced easier opponents in the earlier rounds. This caused a large bias skewed towards an apparent blue advantage and that once these factors are controlled for the *blue* dominance disappears and found no statistically significant advantage for either *blue* or *white*. Furthermore, this result held true for the other 72 judo tournaments examined which included: Olympics (2004), World Championships (2003, 2005), European Championships (2003, 2004 & 2005) and the Super World Cups (2005: Paris & Hamburg).

These investigations into the effect of wearing *red* on sports performance were limited to individual sporting events (boxing, wrestling etc.). Sutter and Kocher expanded the scope of investigation and sought to investigate a team sport for a similar *red* effect, choosing to examine a single season of Bundesliga results. [24] They concluded, through binomial analysis, that no *red* effect was evident within this team sport, such that teams wearing *red* won 23% as opposed to 21% losing matches. Additionally, they concluded that teams wearing blue performed no better than those wearing red (blue being the second most common colour amongst teams). Sutter and Kocher conclude that other factors, such as teams support effects may be reducing the impact of red on team sports. [25] However, as the examination was only performed on a single

season of data these finding are far from conclusive as could have been possible if a longer series of matches were analyzed. Attrill et al.'s paper [26] did use a much longer sample of matches, albeit utilizing a relatively simplistic analysis of win counts without controlling for a number of other factors. Examination of the last 60 years of the English football league found that teams with a primary colour of red were much more successful over this period than teams wearing any other colour.

More recently, the investigation into the impact of red on performance has been extended into not only the non-traditional sports arena. An interesting study done by Ilie et al. [27] examined the world or virtual competition for any red performance biases in the realm of online first-person-shooters (FPS). Specifically the FPS examined was an extremely popular game, Unreal Tournament 2004 (UT2004), using the "Death-Match" ranking system over a three month period (1,347 observations). Here the player avatars were visually identical except for the team colour (either *red* or *blue*. The players are anonymous, such that players can be anywhere in the world and still be on the same team. Teams colour allocation to either red or blue is prior to commencement of a death match and rankings are based upon the number of wins over the period. The results showed that over the three month window, red teams were significantly more likely to win than teams assigned to blue. Red teams won 54.9% out of 1347 matches. The strength of this study is to focus only results from contests involving the top players which may rule out or may reduce the criticism that the differences could be explained by the preferences of better players for the red teams. Observed differences may also be linked to visual interference, such that seeing red may act as a distractor. Ioan et al. [28] applied a computerized colour-word Stroop test (test for selective attention) observe that seeing red distracts men. These finding are in line with the experimental results of Elliot et al. [29] where participants were subjected to

computerized tests involving reactions, perception and colour. The 'avoidance' effect was documented across 2 nationalities, age groups and environmental settings, showing that seeing red significantly impairs performance of individuals. Elliot et al. [30] stress that it may not be that wearing *red* inspires greater performance but that the colour distracts the opponent enough to elicit an advantage.

Now, if the mechanism is a psychological one, it is unclear why one team's red uniforms would distract the members of another team, without simultaneously distracting the other members of the red team themselves. Identification and strong interactions among teammates may reduction such a distraction. One can expect learning and adaption behaviours occurring within the team that should prevent teammates to be influenced by distractions. It may even have positive externalities improving the visibility of a reference point to consider within the game.

A major criticism of some of the previously discussed studies, stem from the difficulty of ruling out alternative explanations when applying a descriptive analysis that measures only the raw effects. Only in a randomized setting (random allocation of colours) we can rule out such problems. However, it is challenging to find in the sports environment a randomized setting. The previously discussed studies on the Olympics combat sports are nice examples for it.

Specifically, by not using fixed effect models, a single highly successful individual (or team) may be driving the overall *red* effect. Additionally, the small data samples could contribute to erroneous estimations of findings, both positive and negative. It makes therefore sense to work with large datasets to better observe any *red* effect on performance, controlling for as many legitimate factors as possible. A single season or tournament may result in statistical anomalies that will be evened out over a longer time frame.

A criticism of the use of field data in a multiple regression context instead of non-random experimental data is that multiple regressions are not fully able to estimate without noise the single estimate for the effect of colour on performance as it is impossible to measure all the variables that might conceivably affect performance. Allison [31] nicely points out

> "No matter how many variables we include in a regression equation, someone can always come along and say, "Yes, but you neglected to control for variable X and I feel certain that your results would have been different if you had done so".

In an attempt to reduce the numbers of uncontrolled factors in the regressions environments are needed that closely approximate an experimental setting. Goff and Tollison [32] indicate that sporting events are such an environment, stating that:

> "Sports events take place in a controlled environment, and generate outcomes that come very close to holding "other things equal." In other words, athletic fields supply real-world laboratories for testing economic theories. The data supplied in these labs have some advantages over the data normally used in economic research (…) the economist can perform controlled experiments similar to those performed by the physical and life scientists. Sports data afford a similar opportunity. Although the laboratory is a playing field, the data generated are very "clean." Most external influences are regularly controlled by the rules of the game".

This allows for a large number of the exogenous (external) factors to be controlled when exploring the relationship between *red* and performance. Thus, sport events can be seen as quasi-natural experimental environments, where subjects, in this case athletes, are acting in the natural environment instead of an artificial laboratory environment (natural incentives to perform). It has been shown that experiments performed in an environment where the test subjects are keenly aware that their behaviour is being monitored are prone to change their normal behaviour such that it is difficult to generalize the results. [33] Selection effects are also visible when recruiting subjects for (lab) experiments (e.g., "scientific do-gooders" interested in research). In addition, real field events such as the professional sporting arena are numerous and are driven by large

financial incentives. Football players compete in an actual high stake but in a very controlled environment, where rules and regulations are consistently enforced by the referees.

Data and Methodology

This paper attempts to analyze the presence of any *red* effect within a team sport, specifically the Australian National Rugby League (NRL, 2009). The major advance of this paper is *both* the size and scope of the analysis. As previously discussed, prior papers have either had limited sample sizes and/or used simple analysis generating the raw rather than the partial effects without controlling in a multivariate analysis for additional factors (*see Table 1*). Our investigation extends over 30 years and includes 5604 matches[2] and additionally we have used a more complex multivariate analysis as opposed to a simpler comparative analysis.

The key component under investigation in our analysis is the relationship between teams wearing red and match success. The investigation consists of all NRL matches over a 30 year period, starting from the 1979 season opener until the final game of 2008. This includes all normal season matches and finals series fixtures but excludes forfeited or byes, totalling 5604 individual matches. It is well documented that sporting teams sometimes employ secondary or even tertiary strips to be utilized at away matches, especially when the normal colour is thought to be too similar to that of the home team. However, these away strips are not always used. To avoid the uncertainty of team's jersey colour at away games we have only examined the success of the home team in our analysis. The disadvantage of this analysis is the fact that we are not exploring the colour differences between the home and away team as factor of success. As a robustness test we will also run estimations where we explore the colour difference assuming

[2] Out of the 5604 matches we have 2 where official crowd numbers were not available.

that the away team plays with the home jersey[3]. The dataset, generated from NRL archives, newspaper and electronic sources, comprises a rich dataset of variables including: scores; home or away status; game venue; referees and crowd sizes. Within the investigation time frame two major structural changes have occurred: firstly points allocated for a try changed from 3 to 4 points beginning 1983 until current; and secondly a rebel breakaway competition[4], known as the 'super-league', formed for one season. To control for the possible effects these changes may have on the analysis, we have created and included a dummy variable for both events (value 0 before the event, 1 after the change). Furthermore, the period under examination spans 30 years, as such season fixed effects have been used in an attempt to allow for unobserved changes over this extended time frame.

Traditionally NRL jerseys consisted of a two part colour system, consisting of a major and minor colour (this changed as more teams joined the league, teams can now have three or more colours). To allow for the multi-coloured system every team has been assigned two colour variables, a major and minor colour, furthermore a third variable has been included to denote the volume of red. Team colours are considered to have a majority of red if it has a volume of red greater than 50%, and a minor red if it contains a volume of less than 50%. For simplicity we have adopted the most generalizable definition of red by not focusing on any one particular shade of red, all shades of red within the wavelength of 600 -700 nanometre of the visual light spectrum [34] have been considered as red regardless of hue, saturation or chromaticity[5]. In addition to these factors we have included crowd size, referee and stadiums. There is a large literature examining the effect of crowd noise on performance in sporting events, which

[3] A deeper analysis would require looking at the video footage of all the 5604 games.

[4] In 1997 a 10 team break away competition known as the Super League was formed in the on-going war for control of the sport. After one season the warring parties negotiated the reformation of a single competition.

5 For example teams such as Brisbane Broncos and the North Sydney Bears are all deemed to be red. For a full list see Appendix *Table A1*.

predominantly shows that large crowds influence referee decision in favour of the home side. [35] We have used the percentage of crowd size in lieu of the absolute value to control for both the stadium size and the crowd in attendance. Given that the auditory levels of a small crowd in a large stadium is minimal as opposed to a small sold out stadium. Thus, we have also included each individual referee in all games, to control for any possible biases of a referee towards any team. The rule change introduced in 1983 and the breakaway 'Super League' could have had some unobserved influence on the way in which teams played and approached the game. For this reason we have included both these factors to control for this possibility.

An ordered probit model has been used for the estimation of the ordinal, dependant variable (Game Outcome), where it is assumed that there is an underlying continuous latent variable $y_i^* = x_i'\beta + \varepsilon_i$, were i measures the team and x_i' is a vector of explanatory variables describing the game of team i. β is a vector of parameters to be estimated and ε_i is the error term, which is assumed to be normally distributed. Therefore y_i is determined from the model as follows:

$$y_i = \begin{cases} 0 \quad if\ y_i^* < \mu_1 & Game\,is\,Loss \\ 1 \quad if\ \mu_1 \le y_i^* < \mu_2 & Game\,is\,Draw \\ 2 \quad if\ \mu_2 \le y_i^* & Game\,is\,Win \end{cases}$$

The cut-off or boundary parameter μ_j is the delineation between game outcomes, which consists of a discrete range for each. The parameters of the model are estimated using the maximum likelihood method. [36] The complete lists of explanatory variables that are used in the model are as follows. Our key independent variable is coded in the following two ways: MAJOR_RED dummy if team has red as primary colour (0=No red, 1=Red) and VOL_RED

dummy indicating amount of red in team strip (0=none, 1=some[6], 2=All). To isolate for further factors we use dummies for MATCH ROUND, REFEREE, STADIUM, and TEAM to control for unobserved effects. We also control for the CROWD_SIZE (% of the capacity of the stadium). Moreover, the SUPER_LEAGUE dummy indicates a super league season and POINT_CHANGE (dummy) the structural change in the points system[7]. In addition, we present estimations with and without season fixed effects.

Results

First we explore in *Figure 4* whether red home teams with the primary colour perform better than home teams without the primary colour red. As can be seen, teams in red indeed perform better than other home teams. Using the Wilcoxon rank-sum test (Mann-Whitney) indicates the difference is statistically significant. However, this purely descriptive analysis gives information about the raw effects and not the partial one. *Table 2* therefore presents the regression results. As in the ordered probit estimation, the equation has a non-linear form; only the sign of the coefficient can be directly interpreted and not its size. Calculating the marginal effects is therefore a method to find the quantitative effect a variable has on the success of team. The marginal effects that we report in *Table 2* indicate the change in probability of winning the game when the independent variable changes by one unit (evaluated at the means). In specifications (1), (3), (5) and (7) we use MAJOR_RED as proxy for red and in specification (2), (4), (6), and (8) we use our three-point scale variable VOL_RED. We first start in specification (1) and (2) exploring only the relationship between red and performance. The results indicate a positive

[6] The dummy assignation for 'some' relates to teams strips that contain some red but less than the 50% required to be the Major team colour. Teams such as the St. George Dragons have major colour assigned as white but with a secondary colour red. While this amount of red does not qualify as MAJOR_RED but it is picked up in this variable.

7 In 1982 the ARL made major changes to the structure of the game including a ball handover after the 6th tackle and a change of points awarded for successfully crossing the oppositions goal line (try). The points awarded were increased from 3 points to 4 points, thus increasing the value of this form of points scoring.

correlation that is statistically significant at the 1% or 5% level. However, the low R^2 indicates the usefulness to control for further factors. Next, we control in specification (3) and (4) for further factors, namely CROWD SIZE, SUPER LEAGUE season and structural a change in the system (POINT CHANGE). The positive effect of red remains robust. In specification (5) and (6) we control for time effects (MATCH ROUND), the REFEREE and the STADIUM. The red effect is still positive, but the coefficient for VOL_RED is not statistically significant anymore. We also observe a decrease in the marginal effects. Interestingly, once you control for team effects through dummies in specification (7) and (8) the relationship becomes negative. Team dummy variables are included as it can be argued that the results are driven by unobserved team characteristics that are correlated with jersey colour and performance. Team fixed effects allow us to control for such possible omitted variable bias. Interestingly, we observe a significant increase in the R^2 compared to previous regressions. Moreover, the marginal effects are also larger. Specification (7) indicates that red as primary colour reduces ceteris paribus the probability of winning by around 21 percentage points. Moreover, an increase of redness from "some" to "full" reduces the probability of winning by around 11 percentage points (see specification 8).

So far we have just focused on the jersey colour of the home team. However, one can stress that the performance is driven by the *relative* colour differences among team. Unfortunately, we don't have data on the jersey colour of the away team. However, in most of the cases teams use also their home jersey when playing away[8]. Thus, we present in *Table 3* estimations where we explore the relative colour differences assuming that the away team does

[8] The colours of the jerseys worn by competing teams shall be easily distinguishable and, if, in the opinion of the referee similarity between the jerseys might affect the proper conduct of the game he may, at his discretion, order either team to change jerseys in accordance with the rules governing the competition in which the game is played (The Australian Rugby League Laws of the Game and Notes on the Laws, Official 2010: p. 10, section 4(e))

not change its home jersey. We therefore report in *Table 3* two new variables, namely REL_MAJOR_RED and REL_VOL_RED (calculated as red value home team –red value away team). The results provide strong support that the colour difference has an impact on performance. The coefficient is statistically significant in all eight estimations and the marginal effects, for example, indicate that an increase in major redness by one unit increases the probability of winning between 4.3 and 7.5 percentage points.

Conclusions

In this study, we investigated the validity of the urban myth that wearing of red confers performance benefits that could result in greater team success. If wearing red improves sporting performance then we would observe more wins for these teams than those wearing any other colour. Focusing on the performance of home teams we observe based on a descriptive analysis that red teams are more likely to succeed. The multivariate analysis also provides some support for a positive effect. However, once we control in the first group of estimations for team fixed effects we find a negative relationship. This could account for the longevity of the myth that those teams wearing red seem to be more successful. These results may provide some indication that a team effect is in place, where highly successful teams wearing red are driving the overall results. This could explain Attrill et al.'s [37] results in the English Premier League as Liverpool, Manchester United and Arsenal are historically some of the most successful teams and are all wearing red. However, when we explore the relative difference in the degree of redness between the home and the away team the positive relationship is quite strong, even after controlling for team effects. As previously mentioned, the disadvantage of this approach is that we must assume that the away team uses their home jersey even though in most instances they are indeed wearing home colours. This is most often true as teams are only required to change colours when the

referee decides that the two teams are not easily distinguishable. [38] The low R^2 values might be driven by the large micro dataset that we are using and it is worthwhile to mention that low R-squareds' in regression equations are not uncommon in comparable large micro dataset. Moreover, it is worth stressing that low R-squared does not mean that regression equations are useless. It shows us the importance to conduct a multivariate analysis to get a good estimate of the ceteris paribus relationship between red and performance. Still we cannot exclude that we have an omitted variable bias. We may have excluded relevant variables providing an underspecified model. However, working with such a large dataset covering a period of 30 years as done in this study is an improvement compared to previous studies on team sports that also worked with such field data, but without keeping other factors fixed. Additionally, we did not take weather into consideration such as sunshine, rain or clouds as this could change the perception or visibility of how individuals may see colours and therefore reverse the pattern of red being the dominant colour. [39] We did not control for colour specific characteristics such as saturation, brightness or chromaticity, which may have an impact on the size of the red effect. Moreover, we only investigated one sport in a single country; therefore, for a more conclusive result further countries should be investigated. Furthermore, there is a clear gender effect on the perception of wearing red and needs further investigation.

So far most of the data is related to men competition. Gender specifity may drive the results. As Ion et al. stress in many species, "red coloration is a powerful signal for quality regulating both intra-sexual (male-male competition) and inter-sexual (female choice) components of sexual competition". [40] Looking at the 2004 Olympic taekwondo competition they observe that men wearing red athletic uniform won 66.7% of the matches, while women

were only able to won 43.5% (difference between red athletic uniforms and other uniforms was not statistically significant).

In general, this literature is still in its infancy and more work is required to find a definitive answer to this research question. Based on the current findings it is difficult to provide a clear policy implication for clubs, teams or business managers who are setting up or creating a new entity or team. It makes sense to focus also on other factors such as financial performance or popularity outcomes. One only needs to look at one of the world's most recognisable brand, Coke-a-Cola to see that red can clearly have significant financial success. In general, team sports, compared to individual sports are more complex to analysis. Sutter and Kocher [41] e.g., stress that perhaps

> "the signal of a shirt's colour is much less salient in team competitions, or team members feel much less intimidated subconsciously by an aggressive colour like red when comforted at the same time by the presence and support of team-mates."

However, our main focus was if red in general has an impact on team performance and not how any particular hue may affect performance. Future research could take this into consideration and investigate how a specific hue of red impacts upon people in society, such as the widely recognisable and famous "Ferrari red". This could provide an interesting aspect of hue change on supporters and success, as the Ferrari Formula One team changed the shade of red used to fit with new sponsors. There are various questions that require a better elaboration. For example, is it that red may be more directly linked to aggressive behaviour, such that the Red Baron chose red to signify his intention to be more aggressive? Do we observe that red coloured teams are more successful at gathering sponsorships making them successful or is it because they are more attractive to fans which congregate in greater numbers and are therefore more successful because of higher revenues generated from merchandising sales? Causal relationships

or selections effects have not been explored intensively so far. For example, does wearing red promote greater performance or does greater sporting performance promote wearing red?

In general, we need more studies that explore how colour changes, within 'the same team' affect players or athletes' performance and motivation. More evidence is required to understand whether individual heterogeneity drives the results at the aggregated team level. It would also be valuable to better isolate the relative importance of single potential factors such as psychological versus perceptual effects.

Notes

[1] Humphrey, 'The Colour Currency of Nature', 95-98.
[2] see Alonso's two paper, 'Territoriality Among African-American Street Gangs in Los Angeles'; and, 'Racialized Identities and the Formation of Black Gangs in Los Angeles'.
[3] Tinbergen, '"Derived" Activities; Their Causation, Biological Significance, Origin, and Emancipation During Evolution', 1-32.
[4] for an overview see Pryke, 'Is red an innate or learned signal of aggression and intimidation?' 393–398.
[5] Miller, Patterns and process in competition, 1-74.
[6] Fehrman & Fehrman, Color: The Secret Influence, 182.
[7] see Garbini, 'A. Evoluzione del Senso cromatico nella Infanzia'.
[8] see Ellis, 'The psychology of red', 365-375.
[9] Fehrman & Fehrman, Color: The Secret Influence, 196.
[10] see Ellis, 'The psychology of red', 365-375.
[11] Elliot & Niesta, 'Romantic Red: Red Enhances Men's Attraction to Women', 1150-1164.
[12] Singh, 'Impact of Color on Marketing', 785-786.
[13] see also Pierce & Weinland, 'The Effect of Color on Workmen', Pressey, 'The Influence of Color upon Mental and Motor Efficiency' and Singer et all., 'Some aspects of deindividuation: Identification and conformity'.
[14] see Pierce, 'Aesthetics of single forms'.
[15] see Quantz , 'The Influence of the Colour of Surfaces on our Estimation of Their Magnitude' and Larguier des Bancels, 'De l'estimation des surfaces colorées'
[16] Pierce & Weinland, 'The Effect of Color on Workmen', 34-38.
[17] see Féré', Note sur les conditions physiologiques des emotions and Sensations and Movement.
[18] Rehm et al., 'Wearing uniforms and agression - A field experiment', 357-360.
[19] Singer et al., 'Some aspects of deindividuation: Identification and conformity', 356-378.
[20] see Pryke and Andersson,. 'Female preferences for long tails constrained by species recognition in short-tailed red bishops', 1116-1121.
[21] Hill & Barton, 'Red enhances human performance in contents', 293.
[22] Rowe et al., Seeing red? Putting sportswear in context.', E10.

[23] Dijkstra & Preenen, 'No effect of blue on winning contests in judo' and Rowe et al., Seeing red? Putting sportswear in context'.
[24] Sutter & Kocher, 'Shirt Color and Team Performance in Football' 125-130.
[25] Sutter & Kocher, 'Shirt Color and Team Performance in Football' 125-130.
[26] Attrill et al., 'Red shirt colour is associated with long-term team success in English football', 577-582.
[27] Ilie et al, 'Better to Be Red than Blue in Virtual Competition', 375-377.
[28] see Ioan et al., 'Red is a distractor for men in competition'.
[29] Elliot et al., 'Color and Psychological Functioning: The Effects of Red on Performance Attainment', 154-168.
[30] Elliot et al., 'Color and Psychological Functioning: The Effects of Red on Performance Attainment', 154-168.
[31] Allison, 'Multiple regression: A primer', 20.
[32] Goff & Tollison, Sportometrics, 6-7.
[33] Levitt & List, 'Field Experiments in Economics: The Past, The Present and The Future', 1-18.
[34] Fehrman & Fehrman, Color: The Secret Influence, see Figure C-8.
[35] for an overview see Greer, 'Spectator booing and the home advantage: A study of social influence in the basketball arena'; Nevill et al., 'The Influence of Crowd Noise and Experience upon Refereeing Decisions in Football', Pollard, 'Home advantage in soccer: A retrospective analysis', and Schwartz & Barsky, 'The home advantage'.
[36] Wooldridge, Econometric analysis of cross section and panel data.
[37] Attrill et al., 'Red shirt colour is associated with long-term team success in English football', 577-582.
[38] The Australian Rugby League Laws of the Game and Notes on the Laws, 2010: p. 10, section 4(e).
[39] Little & Hill, 'Attribution to Red Suggests Special Role in Dominance Signalling', 166.
[40] see Ioan et al., 'Red is a distractor for men in competition'. 290-291.
[41] Sutter & Kocher, 'Shirt Color and Team Performance in Football', 129.

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Table 1: Previous Studies

Author	Year	Team	Duration	N	Multivariate Analysis	Findings
Attrill et al.(2008)	1947 – 2003 EPL Football	Yes	56 Seasons	n	No	Home teams wearing red enjoy more long run success
Greenlees et al. (2008)	Visual Analysis of Footage	No	1 Experiment	n	No	Players in red were perceived to be of greater skill than players in other colours
Ilie et al. (2008)	UT2004 Tournaments (April-June)	Yes	3 Months	1347	No	Red teams significantly won more in a virtual environment (p>5%)
Dijkstra & Preenen (2007)	2003-2005 Judo Comps (Olympics, Worlds, Euro and Super Competitions)	No	72 Tournament	501	No	Blue not significantly more successful than white at any competition after controlling for biases.
Elliot et al.[a] (2007)	Laboratory Experiments	No	6 Experiment	71	No	Red is a distracter on participants, significantly reducing reaction and performance times.
Ioan et al. (2007)	Laboratory Experiments	No	1 Experiment	50	No	Males more distracted and affected by red (p>1%)
Sutter & Kocher (2008)	2000/2001 Bundesliga Football	Yes	1 Season	306	No	Red does not significantly win more home or away games (p>5%)
Hill & Barton (2005)	2004 Olympics (boxing, tae kwon do and wrestling)	No	1 Tournament	n	No	Wearing red win more fights, statistically significant (p>5%)
	2004 Euro Cup	Yes	1 Tournament	n	No	Teams have a significantly better result when wearing red (p>5%)
Rowe et al (2005)	2004 Olympics (Judo)	No	1 Tournament	602	No	Wearing blue significantly wins more fights (p>1%)
Rehm et al.(1987)	School handball competition	No	30 Games	30	No	Males wearing orange were more aggressive than other colours (p>1%)

Notes: n: no information available. [a]Elliot et al. (2007) find that red has a distracting effect, viewing red induces poorer performances. ** Ioan et al. (2007) findings that red is an interference colour on performance and only significant in males.

Table 2: Impact of Red Jerseys on Match Success

Ordered Probit	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MAJOR_RED	**0.119*** ** (2.86) *0.047*		**0.118*** ** (2.84) *0.047*		**0.099** ** (2.05) *0.039*		**-0.557*** (-1.84) *-0.212*	
VOL_RED		**0.047** ** (2.27) *0.019*		**0.046** ** (2.20) *0.018*		**0.030** (1.21) *0.012*		**-0.278*** (-1.84) *-0.111*
SUPER_LEAGUE			**-0.038** (-0.29) *-0.015*	**-0.027** (-0.21) *-0.011*	**0.339** (0.95) *0.134*	**0.349** (0.98) *0.138*	**0.433** (1.15) *0.170*	**0.433** (1.15) *0.170*
POINT_CHANGE			**-0.173*** ** (-3.21) *-0.069*	**-0.169*** ** (-3.15) *-0.067*	**-0.371** (-1.50) *-0.147*	**-0.359** (-1.46) *-0.142*	**-0.707*** ** (-2.76) *-0.272*	**-0.707*** ** (-2.76) *-0.272*
CROWD_SIZE (% TOTAL CAPACITY)			**0.207*** ** (3.12) *0.082*	**0.209*** ** (3.15) *0.083*	**0.187** ** (1.96) *0.074*	**0.185*** (1.94) *0.073*	**-0.027** (-0.27) *-0.011*	**-0.027** (-0.27) *-0.011*
STADIUM Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
REFEREE Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
ROUND Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
SEASON Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
TEAM Fixed Effects	No	No	No	No	No	No	Yes	Yes
N	5604	5604	5602	5602	5602	5602	5602	5602
Prob>chi2	0.004	0.023	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R2	0.001	0.001	0.003	0.003	0.041	0.041	0.072	0.072

Note: Dependant variable is GAME_OUTCOME, an ordered dummy for game outcome (Loss = 0, Draw = 1 and Win = 2). Significance levels *, **, *** are 10%, 5% and 1% respectively. Marginal effect=highest score (win). Coefficients are in bold, z-stat in parenthesis and marginal effects in italics.

Table 3: Impact of Red Differences on Match Success

Ordered Probit	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
REL_MAJOR_RED	**0.114*** ** (4.12) *0.045*		**0.115*** ** (4.16) *0.046*		**0.109*** ** (3.66) *0.043*		**0.189*** ** (3.83) *0.075*	
REL_VOL_RED		**0.047*** ** (3.42) *0.019*		**0.047*** ** (3.42) *0.019*		**0.045*** ** (3.01) *0.018*		**0.082*** ** (3.32) *0.033*
SUPER_LEAGUE			**-0.026** (-0.20) *-0.010*	**-0.023** (-0.18) *-0.009*	**0.352** (0.99) *0.139*	**0.348** (0.98) *0.138*	**0.448** (1.19) *0.176*	**0.428** (1.14) *0.169*
POINT_CHANGE			**-0.168*** ** (-3.12) *-0.067*	**-0.163*** ** (-3.03) *-0.065*	**-0.386** (-1.56) *-0.153*	**-0.367** (-1.49) *-0.145*	**-0.730*** ** (-2.85) *-0.280*	**-0.717*** ** (-2.80) *-0.276*
CROWD_SIZE (% TOTAL CAPACITY)			**0.217*** ** (3.26) *0.086*	**0.219*** ** (3.29) *0.087*	**0.201** ** (2.11) *0.080*	**0.194** ** (2.04) *0.077*	**-0.003** (-0.03) *-0.001*	**-0.006** (-0.06) *-0.002*
STADIUM Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
REFEREE Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
ROUND Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
SEASON Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
TEAM Fixed Effects	No	No	No	No	No	No	Yes	Yes
N	5604	5604	5602	5602	5602	5602	5602	5602
Prob>chi2	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R2	0.002	0.001	0.004	0.003	0.042	0.041	0.074	0.074

Note: Dependant variable is GAME_OUTCOME, an ordered dummy for game outcome (Loss = 0, Draw = 1 and Win = 2). Significance levels *, **, *** are 10%, 5% and 1% respectively. Marginal effect=highest score (win). Coefficients are in bold, z-stat in parenthesis and marginal effects in italics.

Figure 1: Colour and Aggression Using Number of Google Hits

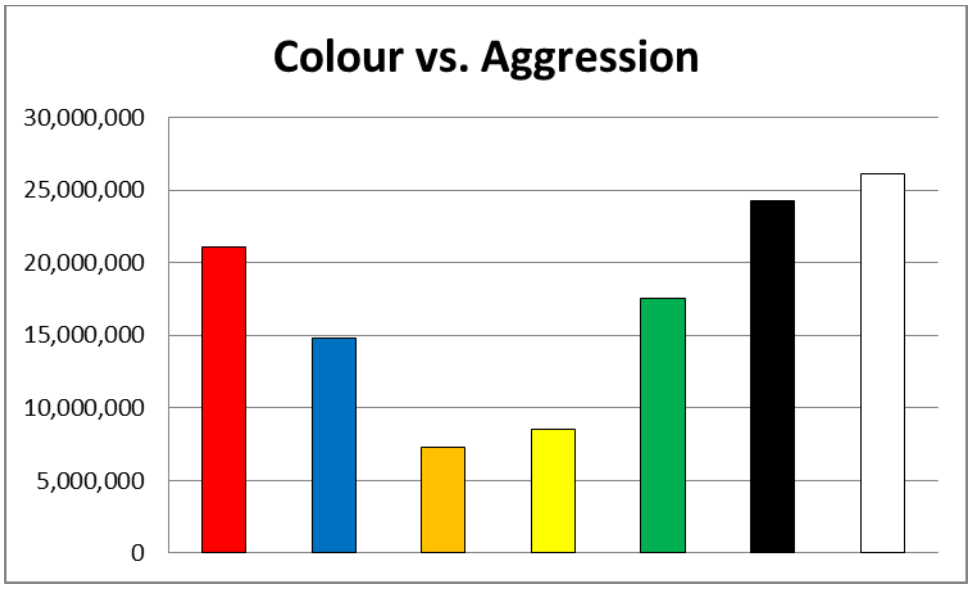


Figure 2: Colour and Dominance Using Number of Google Hits

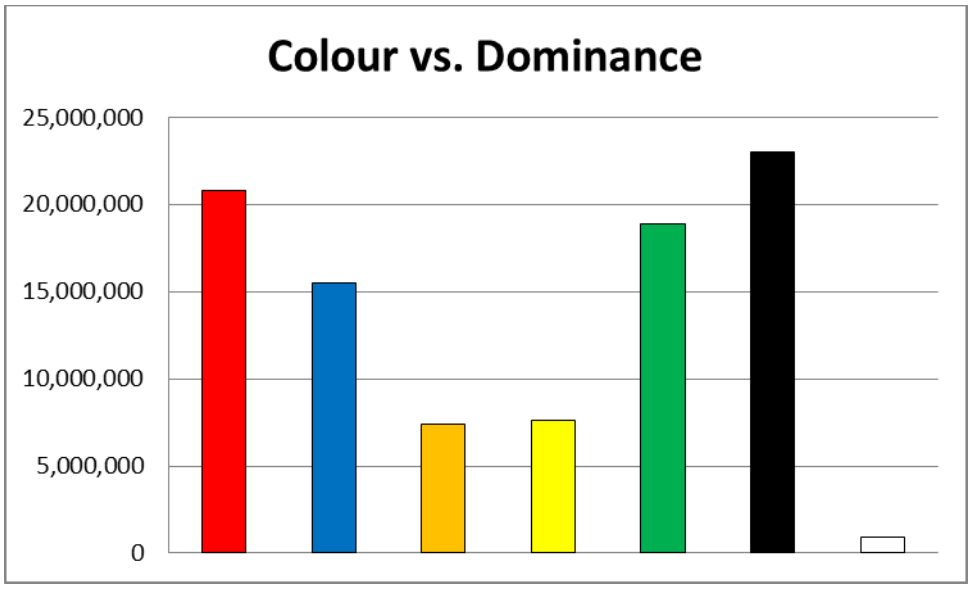


Figure 3: Colour and Winning Using Number of Google Hits

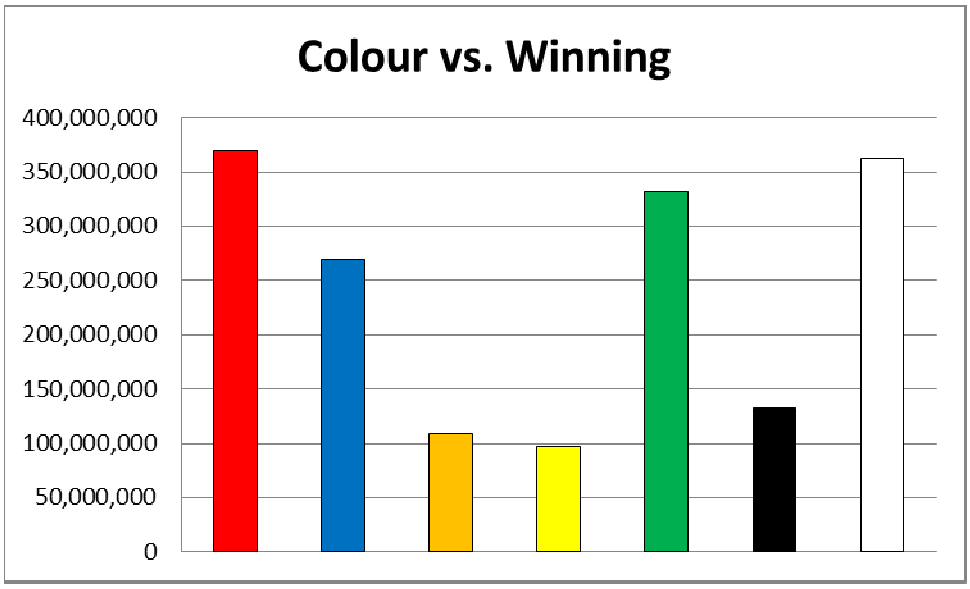
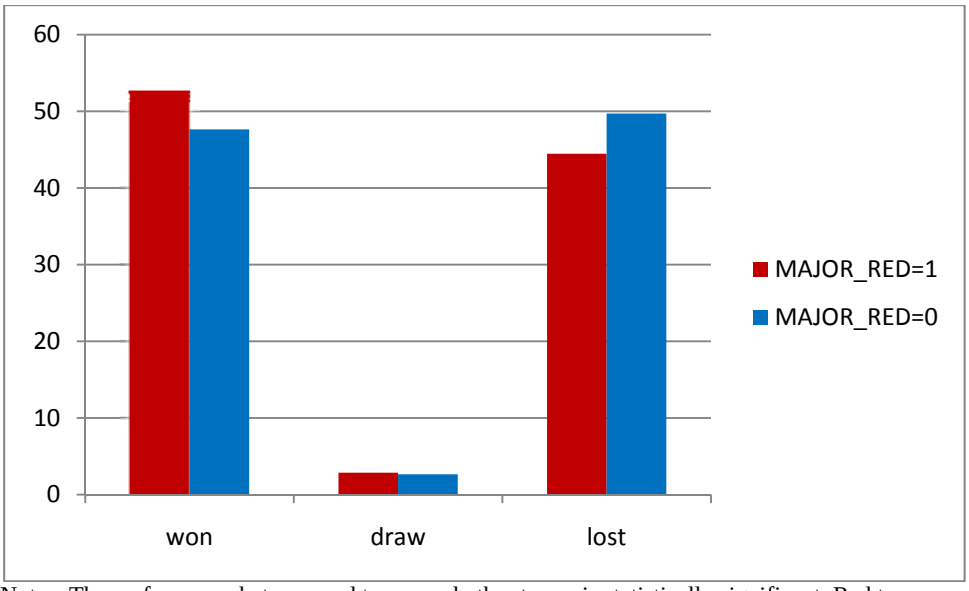


Figure 4: Home Teams' Performance (in %) With and Without the Primary Colour Red



Notes: The performance between red teams and other teams is statistically significant. Red teams perform better (z-stat.=4.557) using a two-sample Wilcoxon rank-sum (Mann-Whitney) test

Appendix:

Team	Identifier	State	Primary Colour	Secondary Colour
Adelaide	Rams	SA	Red	Blue
Auckland	Warriors	NZ	Blue	White
Balmain	Tigers	NSW	Orange	Black
Brisbane	Broncos	QLD	Red	Yellow (Gold)
Bulldogs	Bulldogs	NSW	White	Blue
Canberra	Raiders	ACT	Green	White
Canterbury	Bulldogs	NSW	White	Blue
Cronulla	Sharks	NSW	Blue	White
East(s) Sydney/Suburbs	Roosters	NSW	Blue	White
Gold Coast	Chargers/Giants/Seagulls*	QLD	Grey(Green)*	Black(Purple)*
Gold Coast	Titans	QLD	Blue	White
Hunter	Mariners	NSW	Blue	Yellow
Illawarra	Steelers	NSW	Red	White
Manly	Sea Eagles	NSW	Red (Maroon)	White
Melbourne	Storm	VIC	Purple	Blue
New Zealand	Warriors	NZ	Black	Grey
Newcastle	Knights	NSW	Blue	Red
Newtown	Jets	NSW	Blue	White
North Queensland	Cowboys	QLD	Blue	Yellow
Northern Eagles	Eagles	NSW	White	Red
North(s) Sydney	Bears	NSW	Red	Black
Parramatta	Eels	NSW	Yellow	Blue
Penrith	Panthers	NSW	Brown(Black)**	White(White)
Perth Reds	Kangaroos	WA	Red	Black
Sharks	Sharks	NSW	Blue	Black
South Queensland	Crushers	QLD	Yellow(Gold)	Blue
South(s) Sydney	Rabbitohs	NSW	Green	Red
St George	Dragons	NSW	White	Red
St George Illawarra	Dragons	NSW	White	Red
Sydney Bulldogs	Bulldogs	NSW	White	Blue
Sydney City	Roosters	NSW	Blue	White
Sydney Roosters	Roosters	NSW	Blue	White
Sydney Tigers	Tigers	NSW	Orange	Black
Western Reds	Kangaroos	WA	Red	Black
West(s) Sydney/Suburbs	Magpies	NSW	Black	White
Wests Tigers	Tigers	NSW	Orange	Black

Notes: 1 = Black; 2 = Blue; 3 = Brown; 4 = Green; 5 = Grey; 6 = Orange; 7 = Purple; 8 = Red; 9 = White; 10 = Yellow. The Gold Coast Chargers/Giants/Seagulls did not have red as a primary or secondary colour, thus we have grouped the three incantations together. Penrith has a change of colours from a predominate Brown to Black, neither of which affects the Red Variables. Volume of red has been taken into account for teams such as the Broncos on a season by season basis.