biology
letters

Increased aggression during human group contests when competitive ability is more similar

Gert Stulp, Tobias Kordsmeyer, Abraham P. Buunk and Simon Verhulst

Biol. Lett. 2012 **8**, 921-923 first published online 15 August 2012
doi: 10.1098/rsbl.2012.0591

biology letters
Animal behaviour

Biol. Lett. (2012) 8, 921–923
doi:10.1098/rsbl.2012.0591
Published online 15 August 2012

Increased aggression during human group contests when competitive ability is more similar

Gert Stulp[1,2,*], **Tobias Kordsmeyer**[1], **Abraham P. Buunk**[1,3] **and Simon Verhulst**[2]

[1]*Department of Psychology, and* [2]*Department of Behavioural Biology, University of Groningen, Groningen, The Netherlands*
[3]*Royal Netherlands Academy of Arts and Sciences, Amsterdam, The Netherlands*
**Author for correspondence* (*gertstulp@gmail.com*).

Theoretical analyses and empirical studies have revealed that conflict escalation is more likely when individuals are more similar in resource-holding potential (RHP). Conflicts can also occur between groups, but it is unknown whether conflicts also escalate more when groups are more similar in RHP. We tested this hypothesis in humans, using data from two professional sports competitions: football (the Bundesliga, the German first division of football) and basketball (the NBA, the North American National Basketball Association). We defined RHP based on the league ranks of the teams involved in the competition (i.e. their competitive ability) and measured conflict escalation by the number of fouls committed. We found that in both sports the number of fouls committed increased when the difference in RHP was smaller. Thus, we provide what is to our best knowledge the first evidence that, as in conflicts between individuals, conflicts escalate more when groups are more similar in RHP.

Keywords: resource-holding potential; aggression; group competition; human sports

1. INTRODUCTION

When animals compete for limited resources, selection should favour accurate information gathering in animals in order to evaluate the chance of winning and reduce the risk of injury [1]. Individuals adjust their fighting strategy (e.g. fight or withdraw) based on their own resource-holding potential (RHP; [2]; the ability to win a contest, independent of motivation), and potentially on their opponent's RHP [1]. Depending on the assessment strategies of the competitors involved [1,3], theory predicts that escalation of a conflict is more likely to occur when perceived RHPs are closer matched [2]. For instance, female house finches' (*Capodarous mexicanus*) contests escalate more when the competitors are of similar size [4]. Similarly, an animal's aggression appears to be most intense when it is presented with a perfectly matched opponent, that is, a mirror image of itself ([5]; in Siamese fighting fish, *Betta splendens*).

Whereas most theoretical and empirical work has focused on conflicts between individuals in various species, conflicts also occur between groups [6]. Outcomes may be determined by group RHP in such conflicts. Group RHP comprises both group size [7] and the individual characteristics of the group members [6]. In red wood ants (*Formica rufa*), for instance, larger groups are more likely to defeat smaller groups [7]. Similarly, in contests of groups of equal size, groups with individuals of higher fighting abilities (such as body mass and body size) have higher chances of winning the fight [6].

Thus, RHP determines contest outcomes in both individual conflicts and in conflicts between groups. What is unknown, however, is whether, as in individual contests, escalation of the conflict is more likely when groups are similar in RHP. In this study, using human team sport matches, we investigated whether similarity in RHP generates increased aggression during contests between groups. We used data from two sports: professional football ('soccer') and basketball. We operationalized RHP as the teams' performance, or rank, in the competition, and aggression as the number of illegal forms of physical contact between players. Our measure of RHP is not a measure of 'absolute fighting ability' [2], but rather a measure of 'competitive ability', i.e. the ability to win a contest. In contrast with the situation in animal contests, in human sports games, competitive ability is not necessarily related to the ability to inflict aggressive strikes (i.e. low-ranking teams can be as capable of committing fouls as high-ranking teams). Nonetheless, we hypothesized that aggression is determined by the *difference* in RHP between the two competing teams. Thus, when teams are more similar in their competitive ability (their rank), this will lead to increased aggression (as measured by the number of illegal contacts during a match).

2. MATERIAL AND METHODS

Football data were purchased from Impire AG, a company specialized in collecting professional sports data (www.impire.de). Data covered 1530 matches from five seasons (2004/2005 to 2008/2009) of the Bundesliga, the highest professional German football division. For each match, the identity of the home and visiting team was known, as well as the number of fouls committed, cards shown and goals scored by each team. The foul data only include illegal physical contacts towards other players (e.g. unfair tackles), and no other illegal actions that are penalized by the referee (e.g. handball and offside). In football, cards are shown to penalize more severe fouls (two yellow cards or one red card lead to expulsion from the game). The average rank over seasons 2004/2005 to 2008/2009 (between one and 18) was available for every team and was used as an estimate of RHP. Each season there were 18 teams in the competition, but the dataset comprised 25 teams, as every season some teams are promoted to and relegated from the Bundesliga.

Basketball data were collected from www.basketball-reference.com for the 2009/2010 season of the NBA (National Basketball Association), the highest professional North American basketball league. The collected data comprised 1230 games of the regular season (30 teams, each playing 82 games). Data from the play-offs were not included because these games include only a subset of the teams. The NBA is divided into two conferences, each containing three divisions based on geography (the Eastern conference with the divisions Atlantic, central, southeast and the Western conference with the divisions northwest, Pacific, southwest). Each team plays every other team, but the number of games involved varies depending on whether the opposing team is in the same division and/or conference (e.g. three or four games against teams from a given team's own conference and two games against teams from a different conference). No overall rankings are available, and we therefore ranked the teams (from one to 30) on the basis of the percentage of games won in that season. For each game, we collected the rank of the home and visiting team and the total number of personal fouls (i.e. a breach of the rules that concerns illegal personal contact with an opponent).

Because of non-independence of the data points within teams, seasons and assigned referee, we used generalized mixed models for all analyses, including as random factors the season, the referee

Electronic supplementary material is available at http://dx.doi.org/10.1098/rsbl.2012.0591 or via http://rsbl.royalsocietypublishing.org.

Received 20 June 2012
Accepted 23 July 2012

(no referee data were available for the NBA), and which teams were competing. We tested whether rank similarity, the absolute value of the difference between the ranks of the competing teams (i.e. a value of 0 indicates no difference in rank), predicted the total number of fouls. To validate our measure of RHP, we also tested whether the rank difference correlated with the absolute value of the difference in number of goals scored, and the chance of a tie. For the basketball analyses, where ties do not occur, the absolute difference in points scored was square root-transformed to obtain a normal distribution.

Contest outcomes are not only determined by the RHP of both contestants, but also by the perceived value of the resources to be gained [8]. Thus, when an animal places a higher value on the resources, the motivation to fight is higher and this is shown by the increased cost the animal is prepared to pay to gain the resource [8]. This may also hold true for our analyses, as particularly high- and low-ranking teams may have more incentive to win a game (i.e. fighting for the championship or against relegation to a lower league, respectively). Therefore, we included the rank plus the squared term of the rank as fixed effects in our models. This did not affect our analyses regarding the difference in RHP (see the electronic supplementary material, table S1). All analyses were done in R, v. 2.13.1 [9].

3. RESULTS

Football matches between teams more similar in rank were more likely to end in a tie, and there was a smaller (absolute) difference in the number of goals scored (table 1). Similarly, for basketball, we found that the difference in rank between the teams predicted the difference in points (table 1; there are no ties in basketball). These findings support the implicit assumption in our approach that in individual matches the differences between winners and losers are smaller when the teams are closer in rank. Thus, when teams are similar in ranks the outcome of the match is not as clear-cut and a decision is either achieved later (small difference in goals or points) or never (a tie).

In line with our theoretical prediction, we found that the difference in rank significantly predicted the number of fouls committed in both football and basketball: most fouls were committed when the teams were of similar rank (figure 1 and table 1). In football, on average 38.76 (s.d. = 7.76) fouls per match were committed. When there was no difference in rank between the teams, 39.16 fouls were estimated to be committed and 4.56 fewer fouls (−12%) were estimated to be committed when the highest-ranked team played the lowest-ranked team. A similar effect was apparent when examining the number of cards shown during a match for more serious fouls (table 1). When there was no difference in rank between the teams, 4.30 cards were estimated to be shown, whereas 3.57 cards (−17%) were estimated to be shown when the highest-ranked team played the lowest-ranked team.

Results for basketball were very similar: when there was no difference in rank between the teams, 42.36 fouls were estimated to be committed, and 1.83 fewer fouls (−4%) were estimated to be committed when the highest-ranked team played the lowest-ranked team. On average, 41.71 (s.d. = 6.39) fouls were committed per game.

4. DISCUSSION

Conflicts between animals escalate more when individual competitors are more similar in RHP [2]. Here we have shown, to our best knowledge for the first time, that this effect is also apparent during conflicts between groups. More specifically, the difference in

Table 1. Match or game characteristics in relation to the (absolute) difference in rank between competing football or basketball teams. Results shown are mixed model parameter estimates for the fixed effect of the difference in rank (± s.e.; p-values in brackets) and the random effects (± s.d.) on several dependent variables.

	football				basketball	
	chance of tie[a]	difference in goals[b]	total number of fouls[c]	total number of cards[c]	difference in points[c,d]	total number of fouls[c]
intercept	−0.785 ± 0.121 (<0.0001)	0.132 ± 0.055 (0.012)	39.159 ± 1.325 (<0.0001)	4.296 ± 0.173 (<0.0001)	3.020 ± 0.071 (<0.0001)	42.365 ± 0.574 (<0.0001)
difference in rank	−0.054 ± 0.017 (0.0014)	0.027 ± 0.006 (<0.0001)	−0.268 ± 0.055 (<0.0001)	−0.042 ± 0.015 (0.005)	0.010 ± 0.005 (0.036)	−0.063 ± 0.027 (0.018)
home team	0.013 ± 0.116	0.016 ± 0.127	4.779 ± 2.186	0.038 ± 0.194	0.014 ± 0.118	3.271 ± 1.809
away team	0[e]	$2.780 \times 10^{-15} \pm 5.272 \times 10^{-8}$	3.976 ± 1.994	0.172 ± 0.415	0.031 ± 0.177	3.545 ± 1.883
season	0.013 ± 0.116	$2.128 \times 10^{-4} \pm 0.046$	5.518 ± 2.345	0.021 ± 0.144	n.a.	n.a.
referee	0.006 ± 0.075	$1.719 \times 10^{-3} \pm 0.041$	3.705 ± 1.925	0.169 ± 0.411	n.a.	n.a.
residual error variance	[f]	[d]	46.623 ± 6.828	3.744 ± 1.935	1.264 ± 1.124	34.200 ± 5.848

[a]Logistic mixed model, p-value based on Z-value.
[b]Poisson mixed model, p-value based on Z-value.
[c]Linear mixed model, p-value based on χ^2 test.
[d]Variable was square-root-transformed.
[e]Variance term so small that statistical model constrained the value to zero.
[f]Residual errors are only estimated for linear mixed models, as the residual variance is constrained to be the mean and the mean proportion in respectively the Poisson and logistic mixed model.

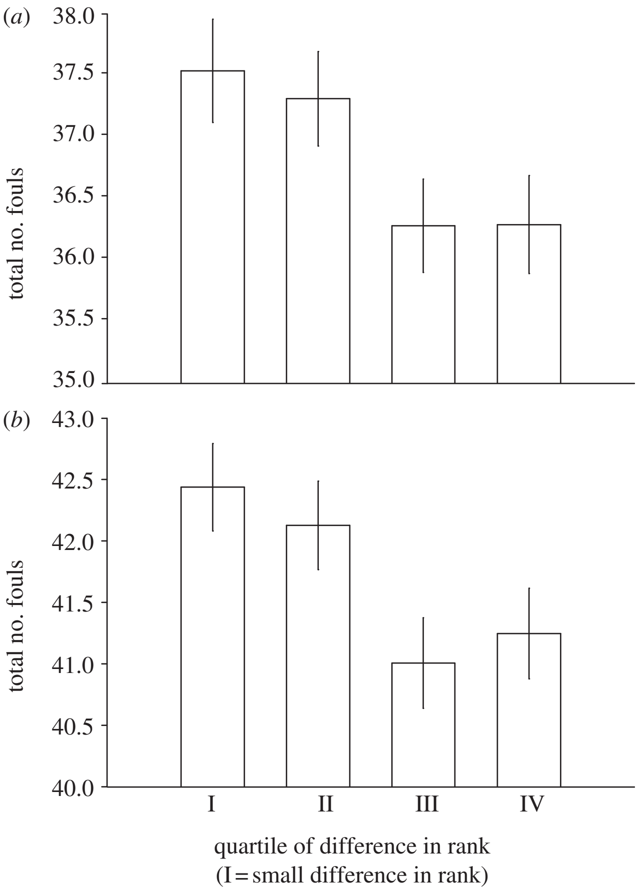

Figure 1. The effect of the difference in rank between the teams playing on the number of fouls (mean ± s.e.) for (*a*) the Bundesliga and (*b*) the NBA. We divided the difference in rank in quartiles, with 'I' being no or little difference in rank and 'IV' being large differences in ranking.

ranks (i.e. the difference in our estimate of group RHP) between teams predicts the number of fouls committed during a match in both football and basketball. Moreover, we found that in football more cards were shown by the referee when differences in rank were smaller, showing that more severe fouls were committed when the difference in RHP was smaller.

A mechanistic (proximate) explanation for these findings is provided by Neave & Wolfson [10], who showed that testosterone in football players was higher before playing against self-perceived extreme rivals compared with playing against a perceived moderate rival. Thus, playing against a well-matched team may well increase the testosterone and hence the aggressiveness of the players, which results in more fouls.

Recent studies debate whether self-assessment (i.e. decision about aggression and fight behaviour mainly based on assessment of own RHP) or rather mutual assessment (i.e. decision based on assessment of both own and opponent's RHP) prevails in animal contests [1,3]. Humans have been shown to make very accurate assessments of the physical strength of others (i.e. RHP) based on photos of faces and bodies alone [11]. Like other animals (discussed in [7]), humans may furthermore engage in numerical assessment of their own and their opponent's group size, for instance, in warfare [12]. Thus, mutual assessment mechanisms may well be quite prevalent in our species. However, because contest duration is predetermined in sports and we lack relevant information about changes in the rate of fouling as the match progresses, we are not able to distinguish between the different models of assessment [1,3].

Human sport contests may be different from animal contests, because aggression is ritualized and constrained by the rules of that sport, and the ability to be aggressive may not necessarily be determined by the competitive ability of the competing parties. Nevertheless, the origin of sport probably lies in the fact that individuals could develop skills needed in hunting and warfare [13], and the most popular modern sports require the specific skills needed for success in physical competition and hunting. The similarity between animal contests and human sport contests is also evident from our study, as we show that predictions from research on animal contests extend to sporting contests between human groups. Future studies should further address how animal contests are similar to and different from human contests.

1 Arnott, G. & Elwood, R. W. 2009 Assessment of fighting ability in animal contests. *Anim. Behav.* 77, 991–1004. (doi:10.1016/j.anbehav.2009.02.010)

2 Parker, G. A. 1974 Assessment strategy and the evolution of fighting behaviour. *J. Theor. Biol.* **47**, 223–243. (doi:10.1016/0022-5193(74)90111-8)

3 Briffa, M. & Elwood, R. W. 2009 Difficulties remain in distinguishing between mutual and self-assessment in animal contests. *Anim. Behav.* 77, 759–762. (doi:10.1016/j.anbehav.2008.11.010)

4 Jonart, L. M., Hill, G. E. & Badyaev, A. V. 2007 Fighting ability and motivation: determinants of dominance and contest strategies in females of a passerine bird. *Anim. Behav.* **74**, 1675–1681. (doi:10.1016/j.anbehav.2007.03.012)

5 Figler, M. H. 1972 The relation between eliciting stimulus strength and habituation of the threat display in male Siamese fighting fish, *Betta splendens*. *Behaviour* **42**, 63–96. (doi:10.1163/156853972X00112)

6 Batchelor, T. P., Santini, G. & Briffa, M. 2012 Size distribution and battles in wood ants: group resource-holding potential is the sum of the individual parts. *Anim. Behav.* **83**, 111–117. (doi:10.1016/j.anbehav.2011.10.014)

7 Batchelor, T. P. & Briffa, M. 2011 Fight tactics in wood ants: individuals in smaller groups fight harder but die faster. *Proc. R. Soc. B* **278**, 3243–3250. (doi:10.1098/rspb.2011.0062)

8 Arnott, G. & Elwood, R. W. 2008 Information gathering and decision making about resource value in animal contests. *Anim. Behav.* **76**, 529–542. (doi:10.1016/j.anbehav.2008.04.019)

9 R Development Core Team. 2008 *R: a language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing.

10 Neave, N. & Wolfson, S. 2003 Testosterone, territoriality, and the 'home advantage'. *Physiol. Behav.* **78**, 269–275. (doi:10.1016/S0031-9384(02)00969-1)

11 Sell, A., Cosmides, L., Tooby, J., Sznycer, D., von Rueden, C. & Gurven, M. 2009 Human adaptations for the visual assessment of strength and fighting ability from the body and face. *Proc. R. Soc. B* **276**, 575–584. (doi:10.1098/rspb.2008.1177)

12 Lanchester, F. W. 1956 Mathematics in warfare. In *The world of mathematics* (ed. J. R. Newman), pp. 2138–2157. New York: Simon and Schuster.

13 Lombardo, M. P. 2012 On the evolution of sport. *Evol. Psych.* **10**, 1–28. (doi:10.1556/JEP.10.2012.1.1)