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Original Article

Winner and loser effects in human competitions. Evidence from equally matched tennis players

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ABSTRACT

Animals winning an agonistic encounter are more likely to win their next encounter while losers are less likely, even when controlling for motivation and physical size. Do these winner and loser effects exist in human competitions? Drawing on a large database of professional tennis matches, we were able to control for players' ability and thereby test for winner and loser effects. We narrowed the database to matches between players who on average did not differ significantly in rank, and further to matches in which the first set was fought to a long tie-break. These closely fought matches present a natural experiment because players are assigned to treatment conditions – winning or losing a set – despite similar ability and performance. We found that among men, the winner of a closely fought tie-break had an approximate 60% chance of winning the second set, the loser a 40% chance. These effects did not exist among women, a finding consistent with the hypothesis that androgens mediate winner and loser effects. Our results may help in the design of competitions in sport as well as in work environments, where it may prove useful to either encourage winner effects or to attenuate their occasional adverse consequences.

1. Introduction

A phenomenon known as the 'winner effect' has been documented in a large number of animal species, from insects (Whitehouse, 1997; Kasumovic, Elias, Sivalinghem, Mason, & Andrade, 2010), fish (Hsu & Wolf, 2001, Oliveira, Silva and Canario, 2009a, b, Dijkstra, Schaafsma, Hofmann, & Groothuis, 2012), reptiles (Garcia, Murphree, Wilson, & Earley, 2014) to mammals (Oyegbile & Marler, 2005; Jennings, Carlin, & Gammell, 2009) and non-human primates (Bernstein, Gordon, & Rose, 1989; Franz, McLean, Tung, Altmann, & Alberts, 2015). In behaviour displaying the winner effect, an animal that has won a fight or a competition for territory is more likely to win its next agonistic encounter (Rutte, Taborsky, & Brinkhof, 2006; Dugatkin, 2013).

Animal behaviour studies documenting the winner effect have controlled for a number of factors that could help an animal sustain a winning streak, such as its resource holding potential, in other words, the resources, like size and metabolic reserves, it can draw on in an all-out fight; its motivation, because a hungry animal will fight harder over a carcass than a sated one; and its aggression, a more aggressive animal being able to fight off a larger but less aggressive one (Smith, 1982; Neat, Huntingford, & Beveridge, 1998; Hurd, 2006; Fawcett & Johnstone, 2010). Even when controlling for these physiological advantages, pure winner and loser effects emerge, suggesting that winning and losing in themselves contribute to future performance (Rutte et al., 2006; Lehner, Rutte, & Taborsky, 2011). It is thought that these effects help establish a social hierarchy in round-robin animal competitions. Importantly, though, with winner and loser effects, this hierarchy cannot be predicted from the pre-existing physiological advantages of the animals - it emerges from the competition itself. In other words, the result of the competition is path-dependent (Dugatkin & Druen, 2004; Hock & Huber, 2009).

How does a prior victory help an animal win again? Answers to this question have been proposed by animal behaviourists on both theoretical and empirical grounds. Game theoretic models have suggested several mechanisms (Mesterton-Gibbons, Dai, & Goubault, 2016). First, the outcome of a fight can provide information to both winners and losers about their relative chances of winning future fights or about their resource holding potential (Mesterton-Gibbons, 1999; Fawcett & Johnstone, 2010; Dugatkin & Reeve, 2014). Winners revise upwards their beliefs about their strength and become more likely to engage in fights and win them. Second, it has been suggested that a winning experience can increase the animal's resource holding potential (Hsu, Earley, & Wolf, 2006; Kura, Broom, & Kandler, 2016). Third, when a series of fights decides the overall winner, the winner of a first fight has a greater incentive than the loser to invest resources in later fights simply because the former is now closer to an overall victory; while the loser can suffer a "discouragement effect" (Konrad, 2009; Konrad & Kovenock, 2009).

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These game theoretic models predict a winner effect between contests taking place across dyads. But several also predict a winner effect within a dyad. This is the case with the family of models unpacking a contest as a series of smaller fights (Konrad, 2009). This is also the case with models where a first win increases the animal's resource holding potential (Kura et al., 2016) or increases merely its perception of this potential (Dugatkin & Reeve, 2014). Whenever the animal's resource potential or its self-perception increases after an early victory within a dyad, a winner effect can be expected. This effect of winning can therefore be one of the mechanisms creating an asymmetry between otherwise equally matched contestants (Van Doorn, Hengeveld, & Weissing, 2003; Hsu et al., 2006; Dugatkin & Reeve, 2014).

Empirical research has led to the suggestion that winning leaves physical traces, such as odour, which broadcast an animal's recent victory and these can deter a new opponent from escalating an encounter (Rutte et al., 2006). Still other research, investigating the physiological mechanisms of winner effects (Chase, Bartolomeo, & Dugatkin, 1994; Chang, Li, Earley, & Hsu, 2012; Earley, Lu, Lee, Wong, & Hsu, 2013), have focused on the role of androgens in mediating the winner effect. Several research groups have found that competition raises testosterone levels (Wingfield, Hegner, Dufty, & Ball, 1990) and that victory raises them still further (Hsu & Wolf, 2001, Trainor, Bird, & Marler, 2004, Oyegbile & Marler, 2005, Oliveira, Silva and Canario, 2009a, b, Fuxjager, Oyegbile, & Marler, 2011). Victory may also up-regulate the androgen receptor, leaving an animal more sensitive to a given level of circulating testosterone (Fuxjager et al., 2010). Rising levels of testosterone can increase, with varying time lags, the animal's lean muscle mass, its haemoglobin and hence its blood's capacity to carry oxygen, as well as its confidence (Boissy & Bouissou, 1994) and persistence (Andrew & Rogers, 1972; Archer, 1977). The winner effect may thus be mediated by a physiological feedback loop in which winning leads to higher levels of, or increased sensitivity to, testosterone, which in turn raises the likelihood of further victories.

There have been relatively few studies of the winner effect in human competitions. Some studies have used avatars in video games to rig a winning situation and observe its real effects afterwards on the players (Yee, Bailenson, & Ducheneaut, 2009). Other studies have tested for the existence of a related phenomenon known as the 'hot hand'. Athletes are said to have a hot hand when they or their supporters believe that a streak of scoring increases the likelihood of further scoring. Early studies dismissed this phenomenon as an illusion stemming from a bias in subjective judgements regarding random sequences (Gilovich, Vallone, & Tversky, 1985): people tend to believe that random sequences of independent events should display only short strings of repetition, so when presented with longer strings, even in a purely random game, people tend to reject the hypothesis of independence. After >20 years of research into the hot hand, the evidence is mixed, with some studies finding a hot hand (Malueg & Yates, 2010), others not (Bar-Eli, Avugos, & Raab, 2006).

A notable feature of the hot hand debate, however, is that it has not been linked to the biological research conducted by animal behaviourists on the winner effect, surveyed above. Nor has it been linked to research in physiology showing that testosterone levels in athletes are elevated after a win (Gladue, Boechler, & McCaul, 1989; Zilioli & Watson, 2014), a phenomenon observed in for, example, tennis (Booth, Shelley, Mazur, Tharp, & Kittok, 1989) and ice hockey (Carre & Putnam, 2010), as well as non-sporting competitions such as chess (Mazur, Booth, & Jr, 1992) and even trading in the financial markets (Coates & Herbert, 2008; Coates & Page, 2009). The hormonal mechanism that is thought to drive the winner effect in animals has thus been identified in humans. If the mechanism exists, does the winner effect itself? This paper proposes an answer to that question by attempting to bridge the research on animal winner effects with the research on athletes' hot hand.

Testing for a winner effect in humans, however, faces a difficulty: How can we know that a winning streak is not due to a player's greater ability? If an athlete's ability and fitness were constant over time, it could be controlled for by using fixed effects/within subject regression estimation (Jones, 2007). However, the ability and fitness of an athlete can vary, even during a single match, due to factors such as fatigue, injury, confidence, and learning. If ability varies across time with positive autocorrelation then standard fixed effect/within subject regression will produce a spurious winner effect: a win will be followed by further wins (Bar-Eli et al., 2006). As individual ability is not fully observable, and can vary over time, it is difficult to solve this problem with standard regression techniques.

Here, we propose a protocol that we argue can control for ability. Drawing on a large database of professional tennis matches, we construct a quasi-experimental situation in which to test for within-match momentum. Tennis provides a unique competition in which to do so, for in it we can control for long term ability by focusing on matches fought between players who on average do not differ significantly in rank, and for playing form on the day of competition by focusing on matches which are fought to long tie-breaks in the first set. Here players differ on average only in their assignment to treatment condition – i.e., winning or losing the first set – but not in ability. We can then look at the causal effects of a first set win on the probability of winning the second set. Situations such as these are termed 'natural' or 'quasi-experimental' because the experimenters do not control the assignment of players to treatment and control groups; this randomization is found ready-made in the study population (Shadish, Cook, & Campbell, 2002).

A quasi-experimental protocol looks at treatment and control groups closely clustered either side of a threshold or discontinuity, where the local differences are small; the protocol then involves testing for substantial effects caused by assignment to these groups (Thistlethwaite & Campbell, 1960). For example, the awarding to students of a letter of merit creates a discontinuity: a student either receives it or not. To assess the effects of this letter on future academic performance we cannot compare average grades of everyone who did receive the letter with those who did not. These averages will include at one end students who failed and at the other end students of the highest distinction. Looking at these averages will merely show that past academic achievement predicts future. To isolate the effect of the letter itself, we should look rather at students just above the merit cut-off line, say an average grade of 75.5%, and those just below, say 74.5%. Here differences in students' ability are trivial, yet if we find that after receipt of the letter the winners perform substantially better then we can conclude that the letter contributed to that performance. In our study, long tie-breaks between equally ranked tennis players create a similar discontinuity – the winning of the first set.

Our study design focuses only on a winner effect within a given dyad of opponents, and not between dyads. While most of the literature on the winner effect is on the effect of winning on future encounters against new opponents here we look at the effect of winning in the early stage of a contest on the chances of a later match victory. As discussed above, many game theoretic models predict a winner effect in a series of fights within a dyad (Van Doorn et al., 2003; Konrad, 2009; Dugatkin & Reeve, 2014; Kura et al., 2016).

Our study does not permit us to test for the physiological substrate of winner and loser effects, but the database is deep enough to allow us to run separate analyses for men and women. A smaller winner effect in women would lend support to the hypothesis that the winner effect is mediated by androgens, because women have lower levels of circulating testosterone than men (Davis & Marler, 2003; Huhman et al., 2003; Oliveira, Gouveia and Oliveira, 2009; Jiménez, Manuel, & Alvero-Cruz, 2012).

2. Data and method

In tennis a set is won if a player wins 6 games provided they have won a minimum of 2 games more than their opponent. If a set reaches