WINNER AND LOSER EFFECTS AND SOCIAL RANK IN HUMANS

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abstract
In many animals, the winners of a fight are more likely to win subsequent contests, while the losers tend to lose their following fights. Such winner and loser effects can have a large influence on individual behavior and fitness. Recent studies indicate that winner and loser effects occur in humans as well. Here we provide a narrative review of the relevant similarities and distinctions between nonhumans and humans with the goal of assessing the causes and consequences of winner and loser effects in humans. In both nonhumans and humans, winner and loser effects probably guide individuals to behave according to their apparent social rank, with winners adopting assertive postures and losers becoming submissive. Physical formidability is the dominant dimension determining social rank in nonhuman species. In adult humans, physical formidability plays a lesser role, while social conventions, physical attractiveness, competence in complex skills, and social competence are more important for social rank. Recent data indicate that human winner and loser effects may influence behavior and social rank in nonaggressive contexts. We suggest future lines of research that will help us better understand how and why winner and loser effects shape human cognition, mood, and behavior.

Introduction

AGGRESSION plays a central role in the lives of many animals and thus has been subjected to extensive research by evolutionary biologists (Tinbergen 1953; Wilson 1975; Huntingford and Turner 1987; Archer 1988). Darwin (1871) discussed the numerous observations of fighting in a wide range of species, including insects, fish, birds, and mammals, and concluded that it occurs primarily in males battling for access to females. Fighting is, however, not as widespread

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as one might expect. Eighty years ago, students of animal behavior noted the role of experience in reducing fighting: individuals that lose a fight are subsequently less eager to pursue further confrontation, while winners readily display their apparent physical formidability and often deter would-be challengers (Ginsburg and Allee 1942; Seward 1946). Subsequent studies culminating in well-controlled experiments established that winning or losing a contest influences subsequent fight outcomes. Animals randomly assigned to win a fight are more likely to win later matches against new, inexperienced opponents, while animals randomly assigned to lose a fight are more likely to lose later matches against new, inexperienced opponents. Such winner and loser effects are characterized as rules of animal aggression (Hsu et al. 2006; Rutte et al. 2006). For example, Bakker et al. (1989) randomly assigned focal male sticklebacks (*Gasterosteus aculeatus*) to receive either a winning or losing experience by either introducing a fish into the focal fish tank or introducing the focal fish into the tank of another resident male, respectively. The experimenters then placed each focal fish and an inexperienced, size-matched fish in a new tank. Although 65% of the winning fish won the second match, all losing fish lost the second contest.

The literature on winner and loser effects has focused on fighting in nonhuman animals. In the past several years, however, a few observational studies have explored winner and loser effects in humans competing in sports such as judo, tennis, and football (Cohen-Zada et al. 2017; Page and Coates 2017; Gauriot and Page 2018). Although the judo and tennis studies suggested winner and loser effects, the football analysis did not. In the first set of controlled experiments in humans, we critically tested winner and loser effects using two distinct protocols (Smith and Dukas 2024). The first experiment involved simulating aggression using the first-person shooter video game, Overwatch. We told participants that they would play two successive Overwatch rounds of one-versus-one against two different participants located in different rooms in the building. Unbeknown to the participants, we randomly assigned them to either win or lose in phase 1 by matching them with either a weak or strong computerized opponent, respectively. Then we tested their performance in phase 2, in which all participants played against a standardized, moderately difficult computerized opponent. Randomly assigned phase 1 winners performed significantly better in phase 2 than did randomly assigned phase 1 losers (Figure 1). In the reading comprehension experiment, we randomly assigned participants to either score high or low on a reading comprehension test. We did this by both manipulating the test difficulty and providing fictional scores. Then we tested all participants on a moderately difficult text. Once again, phase 1 high scorers had higher scores in phase 2 than did phase 1 low scorers (Smith and Dukas 2024). Our experimental protocol, which involved random assignment of participants to winner and loser treatments, is crucial for ruling out selection bias, whereby better performers simply win against

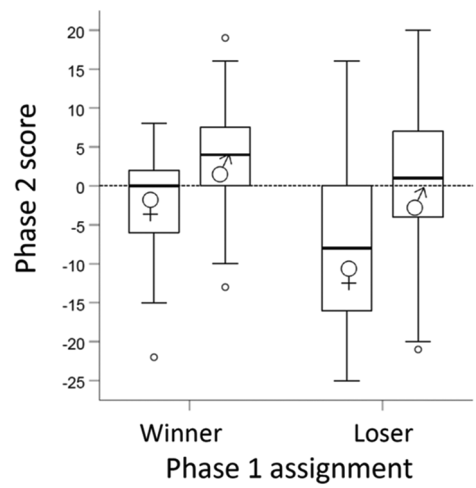

FIGURE 1. WINNER AND LOSER EFFECTS IN HUMANS

In a controlled experiment involving a first-person shooter game, female and male participants randomly assigned to win in phase 1 scored higher in phase 2 than did randomly assigned losers. The horizontal lines in the box plots show the medians, the boxes contain the middle 50% of data (interquartile range, IQR), the whiskers above and below each box represent values within ±1.5 of the IQR, and points depict outliers. Data from Smith and Dukas (2024).

weaker opponents in successive contests (Chase et al. 1994; Bégin et al. 1996). Although observational studies can attempt to control for variation in contenders' rankings, they cannot rule out pertinent factors including recent training regimes, exhaustion, diet, and mood. Such factors can readily cause initial winners to win again and early losers to lose once more.

Human winner and loser effects deserve further evaluation, as they might help explain a wide range of phenomena. There are many disciplines in which people engage in either explicit or implicit competition that may involve perceptions of wins and losses. These include: performance in academic pursuits (Ahlqvist et al. 2013; Buser et al. 2017), sports (Musch and Grondin 2001; Gauriot and Page 2019), and business (Amabile and Kramer 2011; Niederle and Vesterlund 2011); the use and abuse of power by political and other leaders (Klumpp and Polborn 2006; Bernhard and de Benedictis-Kessner 2021; Klaas 2021); stereotype threat (Spencer et al. 2016); problem gambling (Cummins et al. 2009); and investment decisions (Coates 2013; Shiller 2015; Supplemental Table 1, available at https://doi.org/10.1086/732049). Although potentially important, the current research on winner and loser effects in humans is limited in its theoretical and experimental scope because it is not based on either evolutionary or economical predictions and is predominantly observational. To address this knowledge gap, we rely on decades of research in evolutionary biology to critically assess the relevance of winner and loser effects for humans.

We start by reviewing winner and loser effects and their adaptive significance in nonhumans. These effects guide individuals to behave according to their apparent social rank—what we term rank-dependent optimal behavior. Winners may adopt assertive postures while losers may be submissive (Wilson 1975; Martin et al. 1997; Hsu et al. 2006; Robertson 2021). Compared to nonhuman species, however, physical aggression plays a lesser role in determining rank in humans (Barkow 1989; Hawley 1999; Zeng et al. 2022). Hence, we review additional factors that influence social rank in nonhumans as well as in humans. The two-way interactions between social rank and winner and loser effects can alter cognition and behavior in various domains. We thus evaluate the potential role of such winner and loser effects and their social consequences. Finally, we suggest future lines of experimental work that could elucidate how winner and loser effects influence human cognition and behavior.

Winner and Loser Effects in Nonhumans

Narrowly defined, winner and loser effects are empirical rules, which state that a contest winner is more likely to win a subsequent contest while a contest loser is more likely to lose against new opponents (Hsu et al. 2006; Rutte et al. 2006). Some researchers have adopted a less restrictive definition, referring to winner and loser effects as the propensity of previous winners to subsequently behave aggressively, and the tendency of previous losers to act submissively (Van Doorn et al. 2003; Mesterton-Gibbons et al. 2016). We take an even broader perspective and define winner and loser effects as the suite of individual traits that change after winning or losing a contest. Often, these include the tendency of winners to display their physical formidability and behave assertively toward would-be challengers and prospective mates, while losers typically keep a low profile and avoid confrontation (Wilson 1975; Martin et al. 1997; Hsu et al. 2006; Robertson 2021). We know relatively little, however, about the broader cognitive, physiological, and behavioral phenotypes of winners and losers.

Winning and losing are analogous to socially rewarding and punishing experiences, respectively. Hence, the general literature on emotions is pertinent for understanding their mechanisms and effects (Rolls 2014, 2018; Adolphs and Anderson 2018). Similarly, because winning elevates or maintains one's high social rank, while losing leads to or maintains one's low social rank, research on the mechanisms and effects of social rank is also applicable. Such effects may include levels of motivation, anxiety, and stress (Creel 2001; Sapolsky 2005; Gesquiere et al. 2011).

Adaptive Significance of Winner and Loser Effects in Nonhumans

Many animals live in some form of stratified social hierarchy in which individuals higher in rank have priority access to scarce resources and mating opportunities (Schjelderup-Ebbe 1922; Allee et al. 1949; Wilson 1975; Tibbetts et al. 2022). Often, the main feature determining rank in social hierarchies is physical formidability, which is an individual's ability to win an escalated fight if one were to occur (Parker 1974; Tibbetts et al. 2022). Features contributing to physical formidability include body size, the size or strength of weapons, residency status, motivation, and experience (Allee et al. 1949; Wilson 1975; Davies 1978; Emlen 2014; Sherratt and Mesterton-Gibbons 2015). Depending on the social circumstances, winners of a fight may assume that they are strong and thus ranked relatively highly on physical formidability. Based on the winners' probable high physical formidability ranks, assertive behaviors are optimal. By behaving assertively, winners can deter would-be challengers, avoid costly fights, and may have greater access to mates and resources. Losers, on the other hand, may gain from recognizing their probable weakness, which implies low ranks on physical formidability. Based on the losers' probable low physical formidability ranks, submissive or avoidant behaviors may be optimal. Losers should avoid further confrontations, which could be costly (Whitehouse 1997; Rutte et al. 2006; Fawcett and Johnstone 2010). Such costs include lost time, injury, and risk of death (Huntingford and Turner 1987; Archer 1988). For example, 95% of male cervids (deer, elk, and moose) older than 2.5 years inspected in Western Canada had scars from fighting injuries (Geist 1986). Furthermore, lethal aggression exists in many species (De Vita 1979; Piper et al. 2008; Gómez et al. 2016), which further disincentivizes fighting in losers. Overall, then, winner and loser effects lead individuals to express what we term rank-dependent optimal behavior.

The fitness benefits from winner effects are clear. The heightened assertiveness triggered by the winner effect allows winners to capitalize on their physical formidability. An assertive winner could win more fights than a submissive or nonassertive winner. Winning more fights tends to elevate rank (de Vries 1998; Tibbetts et al. 2022), which increases access to scarce critical fitness-improving resources, including food, shelter, social influence, and mates. The fitness benefits of the loser effects are, however, less clear. Avoiding injury and death is indeed valuable, but one must also reproduce to gain fitness. Although few studies have explicitly analyzed the fitness benefits of loser effects, what is clear is that losers are subordinate. Hence, proposed advantages of phenotypes that enhance subordinate fitness are pertinent for our understanding of the loser effects. The two most likely, nonmutually exclusive benefits of the loser effects are waiting and the deployment of alternative strategies. First, loser effects can serve as a relatively safe waiting strategy until the dominant individual weakens or dies (Wilson 1975; Sapolsky 2005). In many primates, subadult males undergo developmental arrest in the presence of dominant males (Virgin and Sapolsky 1997; Maggioncalda et al. 2002). Similarly, in cichlid fish (family Cichlidae), social rank is associated with a suite of gene expression profiles, endocrinology, cognition, and behavior. Subordinate fish can rapidly change this set of traits in their transition to dominance upon the death of the dominant fish (Maruska 2014; Milewski et al. 2022).

The second possible benefit of loser effects is that losers could adopt alternative strategies that partially disengage them from the dominance hierarchy (Sapolsky 2005). At the extreme, losers may simply emigrate or wander as floaters at the periphery of the group (Wilson 1975). More subtle strategies involve assuming subordinate position, but resorting to alternative reproductive strategies including sneaking and forced copulations (Galdikas 1985; Smuts 1985; Oliveira and Almada 1998; Kustan et al. 2011). In chimpanzees (*Pan troglodytes*), lower-ranking males often attempt consortship, in which a male leads a female away from the group for days or weeks so he can monopolize mating when she ovulates. The males initiate consortship well before females' sexual swellings

reach the peak associated with ovulation and thus depart the group before competition for the females becomes intense. Consortships lead to about 30% of conceptions and greatly increase the paternity share of subordinate males (Goodall 1986; Smuts and Smuts 1993). An even subtler strategy is for losers to increase their relative investment in postcopulatory success given their lower expected success when in the presence of winners. For example, male fruit flies (*Drosophila melanogaster*) that lost contests subsequently achieved lower precopulatory success but higher postcopulatory success than did the winners. This could be a result of the losers investing more than the winners in each mating given their expected lower number of copulations (Filice and Dukas 2019). Two other fruit fly studies reported results consistent with those of Filice and Dukas (2019). When small and large male fruit flies (*D. melanogaster*) competed for mating, the small males had lower precopulatory success but higher postcopulatory success (De Nardo et al. 2021). In another fruit fly species (*D. prolongata*), winners of a fight later had higher mating success than losers (Toyoshima and Matsuo 2023).

Although prior fight outcomes lead to winner and loser effects, we should note that animals do not need an explicit prior contest outcome to assess their rank or to exhibit rank-dependent optimal behavior. Young, small, or weak individuals typically perceive their low status and behave accordingly. Similarly, physically formidable animals possess cues and conspicuous signals of formidability, and they also assert their high status through both threats and aggressive behaviors (Wilson 1975; Tibbetts et al. 2009; Hobson et al. 2021). Nevertheless, fights are sufficiently frequent in many nonhuman species to make winner and loser effects relevant features of animal social behavior. More generally, winner and loser effects likely represent one set among the variety of mechanisms that help animals determine their rank-dependent optimal behavior. Finally, although physical formidability is the main determinant of social rank in nonhuman species, some animals rely at least in part on other features. We thus briefly discuss alternative determinants of rank in nonhuman species before elaborating on such factors in humans.

Determinants of Rank in Nonhumans

As mentioned above, physical formidability is one of the main determinants of rank in nonhuman hierarchies. More physically formidable animals tend to win a higher proportion of their fights, and this contributes to a higher rank (de Vries 1998). However, some animals rely at least in part on social conventions to determine social rank (Tibbetts et al. 2022). In such cases, though, aggressive displays from highly ranked individuals or coalitions may still reinforce the social hierarchy. Hence, rank based on social conventions is rather similar to rank maintained by physical aggression. In both cases, social rank is primarily conveyed via signals and behaviors indicating formidability or submission. Furthermore, low-ranking challengers may face threats and possible physical aggression from higher-rank, formidable individuals, which can reinforce social ranking (Hobson et al. 2021). Two well-studied types of social conventions are based on age and nepotism. First, female chimpanzees queue for social status, starting low in the hierarchy and achieving a high status by the time they die (Foerster et al. 2016). Similarly, in female African elephants (*Loxodonta africana*), social hierarchies are determined by age (Archie et al. 2006). Finally, in some paper wasps (*Polistes* spp.), rank is positively correlated with age. If the queen dies, she is most often replaced by the oldest worker (Pardi 1948; Strassmann and Meyer 1983). The second social convention, nepotism—defined as favoritism based on kinship (Bellow 2004)—occurs in some mammals. For example, among infant vervet monkeys (*Chlorocebus pygerythrus*) of both sexes, rank is acquired at least partially through alliances with family members. Often, infants of high-ranking mothers have higher rank than infants of lower-ranking mothers (Horrocks and Hunte 1983; Cheney and Seyfarth 1990).

Determinants of Rank in Humans

Human ranking systems share some similarities with nonhuman ranking systems.

First, in both humans and nonhumans, lower-ranking individuals defer to higher-ranking ones (Parker 1974; Wilson 1975; Cheng et al. 2013). Second, high rank grants similar benefits in both nonhumans and humans. In nonhumans, high rank often allows better access to scarce resources and mates, which contribute to higher fitness (Wilson 1975; Majolo et al. 2012; Tibbetts et al. 2022). In humans, high-ranking individuals have greater power, defined as the ability to control what other individuals do (Ball 1975; Robertson 2013). High-ranking individuals have greater access to resources, higher mating success (von Rueden et al. 2011; Hill et al. 2013; von Rueden and Jaeggi 2016), and better long-term health outcomes (Marmot et al. 1991; Wilkinson and Pickett 2019).

Humans and nonhumans also share some of the factors that determine rank, namely physical formidability and social conventions. In humans, however, physical formidability plays a lesser role and further factors influence rank. Based on the relevant literature detailed below, we suggest that, in addition to physical formidability and social conventions, human rank is also influenced by physical attractiveness, competence, and social competence (Figure 2). The factors that determine rank are not mutually exclusive. Moreover, they may be positively or negatively correlated and might even influence one another. As we noted above for nonhumans, dyadic contests with explicit winners and losers are only one of the means by which individuals determine their rank and subsequently change their cognition and behavior. In humans, language, behavior, and treatment by others can readily convey rank. Lower-ranking individuals might face negative feedback, verbal threats, or possibly physical aggression from higher-ranking individuals. Conversely, higher-ranking individuals might experience deference or praise

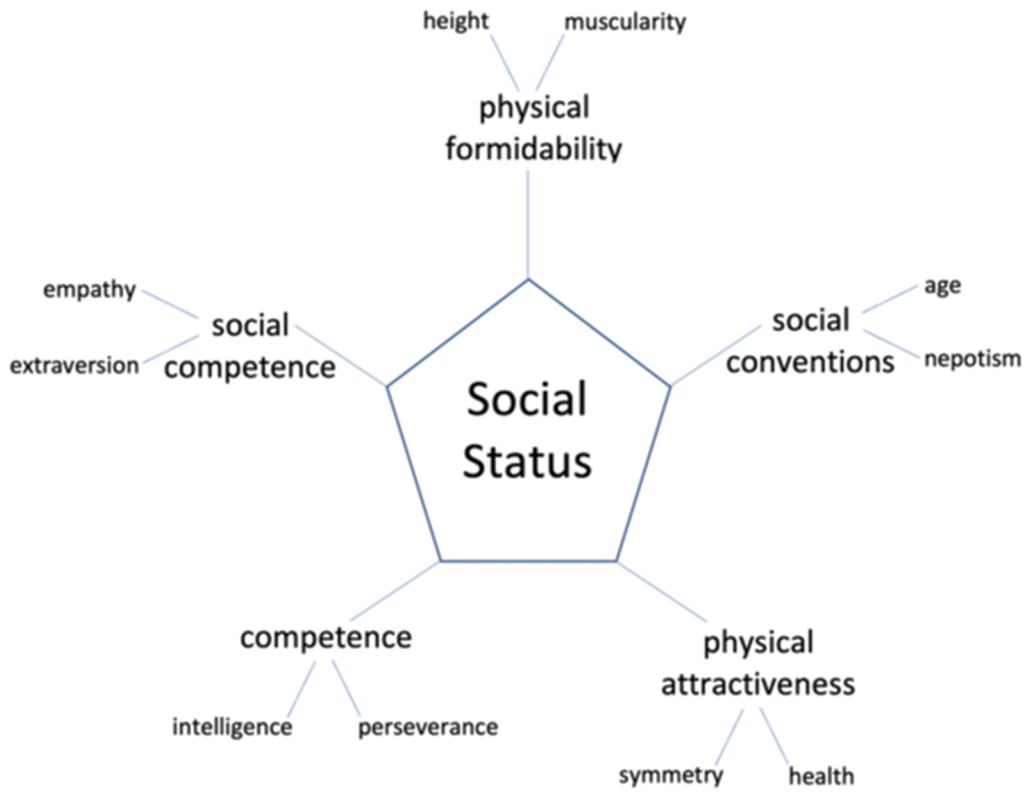

FIGURE 2. DETERMINANTS OF SOCIAL RANK IN HUMANS

The suggested major determinants of social rank in humans and two main subcategories for each dimension.

from lower-ranking individuals (Barkow 1989; Henrich and Gil-White 2001). It is likely that people often adopt phenotypes resembling winners and losers based on their perception of their rank. Hence, it is important that we thoroughly understand the determinants of rank in humans.

PHYSICAL FORMIDABILITY

Although physical formidability is less important in determining adult human rank, it still plays a significant role. Moreover, physical formidability strongly influences rank in children (Hawley 1999; Thomsen 2020; Zeng et al. 2022). Preschoolers rated more physically formidable and aggressive peers as possessing a higher status (Nelson et al. 2005). In a study of first through fourth graders, the "toughest" children were consistently rated as having higher social status (Edelman and Omark 1973). Although the relative role of physical formidability in affecting rank diminishes in older children (Savin-Williams 1979, 1980), even adults may defer to physically formidable individuals (Cheng and Tracy 2014).

Well-controlled experiments indicate that adult humans rely in part on physical formidability-based strategies to improve rank (Cheng et al. 2013; Brand and Mesoudi 2019; Redhead et al. 2019; Ketterman and Maner 2021; McClanahan et al. 2022). In a short-term experiment assessing hierarchy formation among a group of previously unacquainted individuals, both group members and outside observers rated physically formidable individuals as more dominant. Such physically formidable individuals used physically expansive postures, spoke in a way that signaled self-entitlement and intimidation, or used gestures that signaled their own importance. Along with higher group and observer ratings, physically formidable individuals often swayed group decisions to align with their own opinion, and they received more visual attention from group members and outside observers (Cheng et al. 2013). Another study found that physical formidability positively correlated with rank attainment during a four-week period (McClanahan et al. 2022). It is possible that the effect of physical formidability diminishes over extended periods. For example, Redhead et al. (2019) reported that physical formidability initially elevated social rank but failed to do so after a 16-week period. Finally, numerous observational studies have documented a positive association between height, which is a prominent cue of physical formidability, and a variety of measures of rank including education level, being in managerial or leadership roles, and socioeconomic status (Stogdill 1948; Judge and Cable 2004; Lindqvist 2012; Tyrrell et al. 2016).

SOCIAL CONVENTIONS

The two social conventions for determining rank noted above for nonhumans—age and nepotism—are pertinent for humans as well. As with nonhumans, adults rank higher than juveniles. Among adults, elderly people have had high social status in most traditional societies (Radcliffe-Brown 1933; Simmons 1945). Older people are also often well respected in modern cultures (Silverman and Maxwell 1978; Redhead and Power 2022). As with age, nepotism was prevalent throughout human history and still contributes significantly to social rank in modern times. Nepotism is well illustrated in famous political dynasties and private corporations (Bellow 2004). Material wealth, which may be considered an extended phenotype (Dawkins 1982; Odling-Smee et al. 2013), is often positively associated with social rank. If family members provide the material wealth, it is related to nepotism. Alternatively, the source of material wealth may be one or more of the categories discussed below.

PHYSICAL ATTRACTIVENESS

On average, physically attractive people make more favorable impressions on others and have a higher social rank. Attractive people are treated more positively by others, which leads them to gain better outcomes in desirable domains. These include having more friends and more desirable partners, better jobs, and higher incomes (Langlois et al. 2000; Gangestad and Scheyd 2005). Anderson et al. (2001) quantified status hierarchies

in three naturally constituted, stable social groups of university students: a fraternity, a sorority, and a mixed-sex group consisting of two floors of a university residence. Students rated their peers' social prominence within their group, and the experimenters related these ratings to students' responses to personality questionnaires and to their physical attractiveness as rated by external raters who did not know the students. Physical attractiveness was positively associated with status only in men. Note, however, that meta-analyses have documented a positive correlation between physical attractiveness and status in both men and women (Feingold 1992; Langlois et al. 2000; Frevert and Walker 2014).

COMPETENCE

The ability to perform well on a given task varies widely among individuals and depends on a variety of factors including intelligence and perseverance. People who gain extensive experience with a certain complex task become experts, and they show superior performance on that task compared to novices (Ericsson and Lehmann 1996; Duckworth 2016; Ericsson et al. 2018; Dukas 2019; Vaci et al. 2019). Competence in complex tasks including hunting, toolmaking, and spatial information about key resources has been associated with high rank in traditional societies (Hearne 1795; Simmons 1945; Henrich 2016). Similarly, expertise in numerous specializations contributes to high rank in modern cultures (Bass and Stogdill 1990; Anderson and Willer 2014). For example, a study of middle-level managers in a Fortune 500 corporation found that coworkers' perceptions of a manager correlated positively with formal company measures of manager competence (Tsui 1984).

SOCIAL COMPETENCE

Hearne (1795), who observed First Nation people in Northern Canada in the 18th century, noted perceptively that, in addition to what we term physical formidability and competence, being "well beloved" contributes to high status. As with competence in other domains, social competence is determined by a mixture of cognitive abilities, personality types, and experience (Dukas and Bailey 2024). There are many features that contribute to social competence, including the ability to recognize another person's mental state (cognitive empathy), the drive to respond to it with an appropriate emotion (affective empathy), and the ability to provide pertinent support (Baron-Cohen et al. 2005; Fiske et al. 2007). Other important traits are self-presentation, which is the ability to control the impressions that other people have of an individual, and the ability to manipulate others for personal gain (Machiavelli [1513] 1909; Christie and Geis 1970; Leary et al. 2014). Parental and other social environments influence the development of social competence. Decades of social experience can generate social expertise, defined as the characteristics, skills, and knowledge allowing individuals with extensive social experience to perform significantly better than novices on a given social task (Dukas and Bailey 2024). Indeed, there is some evidence that performance on complex social tasks improves into old age (Grossmann et al. 2010).

Of the big five personality traits, one would expect social competence to correlate positively with extraversion and negatively with neuroticism. Extraverts have positive emotions more frequently, are active, assertive, and sociable, while neurotic individuals have negative emotionality, which includes vulnerability to stress, anxiety, and depression (Digman 1990; Nettle 2006). Several studies report a positive correlation between social rank and extraversion, and a negative correlation between social rank and neuroticism (Judge et al. 2002; Anderson and Cowan 2014). For example, the study on three groups of university students detailed in the physical attractiveness section reported a positive correlation between extraversion and social rank in both men and women, and a negative correlation between neuroticism and social rank in men (Anderson et al. 2001).

SYNTHESIS

As we noted in the introduction to this section, the experience of either winning or

losing a high-stakes dyadic contest is not necessary for assessing one's rank. Such experience may even be less essential in humans, owing to our long period of parental care, language, and culture. Another prominent feature that distinguishes humans from nonhumans is our multidimensional ranking system (Barkow 1989). This leads to another human distinction, which is a person's ability to belong to multiple social groups at the same time and to attain different ranks in each. For example, a top-ranking concert pianist may rank low in their amateur hockey team and intermediate in their business skills. Although the experience of winning or losing is not required for determining rank, humans are a highly social species in which individuals frequently engage in overt and covert contests for social status across multiple domains (Guinote and Vescio 2010; Cheng et al. 2014).

Humans most likely gain their first winning and losing experiences as toddlers, perhaps physically contesting over desired toys (Hawley 1999). They keep gaining winning and losing experiences as they compete in a variety of games. Schooling adds another dimension of rank: academic performance. Similarly, athletic ability, social competence, and additional skills in various domains also contribute further determinants of rank. These skills often determine success in various implicit and explicit social contests such as grades in school, goals scored in a football (soccer) match, invitations to social events, offers to join selective groups, elections to representative bodies, and a variety of other prizes and honors. Although such contests are not usually dyadic and do not include explicit winners and losers, they provide people with positive or negative feedback about their performance and rank. This feedback may be sufficient to generate physiological, cognitive, and behavioral shifts similar to winner and loser effects.

The Potential Social Outcomes of Winner and Loser Effects in Humans

The adaptive hypothesis for winner and loser effects discussed above for nonhuman species is most likely pertinent to humans as well. That is, winner and loser effects guide individuals to behave according to their perceived social rank. For example, an individual who is highly athletic with respect to their classmates might be more eager to compete in a varsity sport than their less athletic classmates. Indeed, there are experimental and observational data indicating more positive mood and greater motivation in winners than losers (Reeve et al. 1985; Jones and Sheffield 2007; Sloman et al. 2011). We will discuss below some of the possible wide-reaching outcomes of winner and loser effects in humans.

Most schools and sporting bodies specify a single yearly cutoff date for entering into the first school-grade and sporting cohort. Children born just after the threshold date are about a year older than the ones born at the end of their cohort. This provides a powerful relative age advantage whereby the cohort's older children are physically and cognitively more developed as well as more experienced (Musch and Grondin 2001). The relative age effect may generate winner and loser effects: the older children in the cohort perform better than the younger ones and hence are more motivated to keep competing, while the younger children, who are more likely to lose, tend to drop out. Numerous studies throughout the world, primarily focusing on hockey and football, have documented the relative age effect, which in its most extreme outcome leads to a highly skewed birthdate distribution among professional players (Musch and Grondin 2001; Helsen et al. 2005; Baker and Logan 2007). Although self-perception of rank is higher in children who participate in sports than in children who do not (Roberts et al. 1981), external perception is also important. Children's peers, parents, and coaches can accentuate winner and loser effects in sports through differential motivational feedback and bias in resource provisioning (Davids and Baker 2007).

In both investment and gambling, a series of wins may reflect high competence, good luck, or other external causes such as generally favorable settings. Regardless of the true cause, a series of wins may generate a winner effect with its associated high confidence and assertiveness. Conversely, a series of losses may lead to a loser effect. A winner effect

and its associated euphoria may lead to reckless investment decisions, which could lead to substantial losses (see Coates 2013). An experiment that tested such winner and loser effects indeed documented that, compared to participants who were randomly chosen to lose in phase 1 of a rigged, computerized card tournament, participants who were randomly chosen to win reported more positive mood and bet more recklessly in phase 2 of the tournament (Cummins et al. 2009).

Exactly as a series of wins can enhance mood, either a series of losses or a single, severe loss may lead to negative mood and even depression. For example, among students who participated in competitive sports, negative mood was significantly higher after than before losing, but lower after than before winning (Sturman and Mongrain 2008; Figure 3). Similarly, in elite hockey players, losers reported higher levels of anxiety and depression four to six days after a loss (Jones and Sheffield 2007). Other studies have also explicitly or implicitly linked the loser effect to an increased likelihood of having a depressive episode (Price 1967; Price et al. 1994; Nesse 2019). The loser effect provides an intuitive, adaptive explanation for some forms of depression. As emphasized above, winner and loser effects are most likely mechanisms for determining rank, which enable rank-dependent optimal behavior.

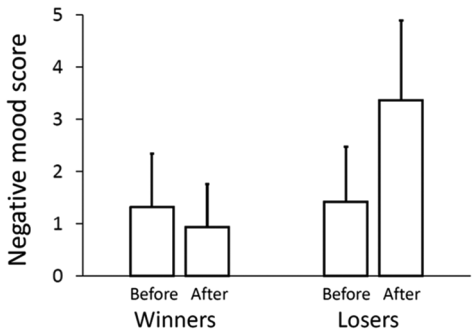

FIGURE 3. EFFECTS OF WINNING AND LOSING ON MOOD
University students participating in competitive sports reported higher negative mood after than before losing but lower negative mood after than before winning. Values are means and standard deviations (SDs). Data from Sturman and Mongrain (2008).

Often, accepting one's loss and adopting a submissive posture is better than continuing to fight. Depressive mood consists of the set of behaviors associated with the loser effect. As discussed above, however, this may only be a temporary state that allows the loser to either wait for changes or consider alternative strategies.

PROSPECTS

Although there are ample critical experimental data on winner and loser effects in many nonhuman species, the current human data are primarily observational (Supplemental Table 1). Going forward, experimental research on human winner and loser effects should strive to randomly assign human participants to either win or lose against their opponents in an initial contest, and then test participant performance against new rivals in a subsequent contest. As noted in the introduction, such a protocol eliminates selection bias (Bégin et al. 1996). Perhaps the most promising settings for controlled experiments on winner and loser effects are video games that simulate contests (Kasumovic et al. 2017). Because gamers often play against geographically remote opponents, experimenters can randomly assign participants to opponents with covertly manipulated strength to induce winning or losing. Afterwards, experimenters can quantify winner and loser effects on cognition, mood, and behavior, and match participants against standardized opponents to quantify the magnitude of winner and loser effects in relevant contexts. Experiments employing video games have been successfully used in many laboratories (e.g., Carré et al. 2013; Welling et al. 2013; Dezecache et al. 2021; Smith and Dukas 2024).

Although simulated fighting provides a clear initial step toward quantifying winner and loser effects and their consequences in humans, the studies suggesting the importance of these effects in other domains including academic performance, gambling, and investment also require further critical experimental tests. In such settings, there may not be explicit competition or clear winners and losers. Nevertheless, individuals still experience successes or failures, which may generate

winner and loser effects. Furthermore, winner and loser effects may vary in their magnitude depending on the context. In fields such as academic performance and sports, many low-stakes wins and losses such as scored shots on goal or poor performance on tests contribute to success and overall ranking. One popular example of a low-stakes winner effect is the hot hand effect in sport games, wherein both players and observers believe that consecutively scored points improve the odds of future scoring. Ultimately, the effect is low-stakes because the game continues after a player scores a point. The observational studies on the hot hand effect are inconclusive (Gilovich et al. 1985; Bar-Eli et al. 2006; Miller and Sanjurjo 2018). However, the debate could be settled by employing the experimental design often used to test winner and loser effects. For example, participants in a basketball contest would be randomly assigned to initially score either a low or high proportion of their free throws through some covert manipulation, such as a slightly smaller or greater basket diameter, respectively. Afterwards, all participants would individually complete a subsequent, standardized round using a standard basket. Experimenters would then compare the proportion of scored shots in the second round for first round high scorers and low scorers.

Unlike the hot hand effect, there is strong observational support for "hot streaks," whereby individuals working in the arts or sciences achieve sequential bursts of high-impact works (Liu et al. 2018; Wang and Barabási 2021). Associating this phenomenon with winner and loser effects requires critical assessment via experimentation. For example, participants could be invited to complete a creative task in a laboratory and their creation would be randomly assigned to receive either praise or lukewarm comments. Afterwards, all participants would complete a standardized, creative test task, which would be evaluated by scorers blind to participant treatment. Furthermore, experimenters could quantify participants' moods as well as the amount of time expended on the test task as a proxy for motivation and effort.

Another important testable parameter of human winner and loser effects is their rate of decay. A few nonhuman animal studies have examined the rate of decay of winner and loser effects (Chase et al. 1994; Bergman et al. 2003; Trannoy et al. 2016). Although this issue has not been examined in humans, a relevant observational study on hockey and football players indicated that participants felt better four to six days after wins than the same time period after losses (Jones and Sheffield 2007). The rate of decay of winner and loser effects can help explain temporal variation in mood and even depression. If winning and losing affect mood (Jones and Sheffield 2007; Sloman et al. 2011), we might also expect outcomes in one domain to affect results in another domain. Indeed, some studies reported that recent wins or losses of local sports teams influence election outcomes (Healy et al. 2010; Miller 2013), although other studies found no such association (Graham et al. 2023; Müller and Kneafsey 2023). Sports fans do not actively participate in the win or loss as in the classical winner and loser effects, but the mood of fans after a vicarious win or loss in one domain (sports) may influence their choice in another irrelevant domain (e.g., election; Healy et al. 2010). The transfer of winner and loser effects between domains requires critical experimental tests. Another related topic that requires quantification is the exact effect of context, including whether the contest location is at home or away, and the effect of observers. These factors affect fighting and likely the magnitude of winner and loser effects in nonhumans (Fuxjager et al. 2009; Cruz and Oliveira 2015). Intriguingly, the loser effect in male crickets (*Gryllus bimaculatus*) can be eliminated by subjecting them to 10 minutes of flight (Hofmann and Stevenson 2000). The most likely adaptive reason for this rapid, restored aggression in recent losers is that flight would lead them into a new social setting where they might have higher chances of winning. In a similar vein, the various contexts of human competition and sport (team-based, one-versus-one, physical, nonphysical, and so on) may also generate different magnitudes of winner and loser effects. Where possible, future experiments should quantify the effects of context.

In humans, the mechanisms underlying winner and loser effects are not well understood.

One closely examined mechanistic aspect of winning and losing in both nonhumans and humans is their link to changes in testosterone concentrations (Booth et al. 1989; Gleason et al. 2009; Fuxjager et al. 2010). Although results greatly varied in magnitudes and directions, a meta-analysis indicated a higher relative increase in testosterone after winning than losing in both men and women (Geniole et al. 2017). Winner and loser effects are, however, likely mediated by a broad range of mechanisms. Indeed, nonhuman studies have documented neurobiological changes associated with winning and losing (Zhou et al. 2017; Uy et al. 2021; Li et al. 2022; Padilla-Coreano et al. 2022). In humans, functional magnetic resonance imaging (fMRI) studies identified the brain regions activated as a function of both wins and losses and the perception of social status (Zink et al. 2008; Kätsyri et al. 2013). Therefore, future work on humans as well as model species such as mice should take a broader mechanistic approach by investigating the genetics, neurobiology, and hormonal mechanisms that orchestrate winner and loser effects.

Although proper experimental design requires us to randomly assign participants into winner and loser treatments, the reality is that there is typically large individual variation in abilities, and people assess both their own and others' ranks in many domains simultaneously. Often, people in authority, be it parents, teachers, coaches, or employers, tend to provide more resources to winners than to losers. Such reaction from the social environment can magnify the disparity between winners and losers (DiPrete and Eirich 2006). A testable prediction derived from this assertion is that, following a random assignment of subjects into winning and losing, observers who have to distribute a finite resource among these subjects would bias their allocation toward winners. Finally, although our review has focused on winner and loser effects in the context of social rank in humans, it is likely that winner and loser effects are relevant in nonsocial domains as well. Examples include success or failure in acquiring food or income, and in staying healthy (see Nesse 2019:102). The role of winner and loser effects in such nonsocial situations is unknown either in humans or nonhumans.

Conclusions

Applying a rigorous experimental approach can help us understand the potentially far-reaching effects of winning and losing in humans. In both nonhumans and humans, winner and loser effects likely help individuals determine their rank and adjust their behavior accordingly. Through critical experiments such as the ones suggested above, we can further our understanding of how and why winner and loser effects interact with social rank to shape human cognition, mood, and behavior.

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