The impact of dynamic status changes within competitive rank-ordered hierarchies

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Jockeying and competing for higher status is an inherent feature of rank-ordered hierarchies. Despite theoretically acknowledging rank changes within hierarchies, the extant literature has ignored the role of competitors' dynamic movements on a focal actor's resulting behavior. By using a dynamic lens to examine these movement in competitive situations, we examine how positive change in a competitor's rank—that is, positive status momentum—affects a focal actor's psychology and resulting performance. We consider the real-world contexts of 5.2 million observations of chess tournaments and 117,762 observations of professional tennis players and find that a focal actor's performance in both cognitive and physical competitions is negatively impacted when facing a competitor with positive momentum. Additionally, 4 experimental studies reveal that a competitor's positive momentum results in the focal actor's positive projection of the competitor's future rank, which, in turn, increases the psychological threat for the actor. Collectively, our findings advance the social hierarchy literature by helping to elucidate the manner in which rank-ordered hierarchies are negotiated and disrupted over time.

status | social rank | psychological momentum | threat | competition

From *Bloomberg Businessweek*'s "Best Business Schools" list to the *Financial Times* Global 500 to ESPN's college football rankings, hierarchies satisfy our inherent desire to organize and classify our social landscape. Implicit within these hierarchies is a status contest among those being ranked, in which small differences in rankings translate into exponential differences in rewards. Whether it is universities, sports teams, corporate boards, or other entities, the economic rewards for the elite few at the top of these status contests have jumped sharply in recent decades (1). For example, companies featured among the top 20 *Fortune* Global 500 are afforded exponentially greater monetary benefits, prestige, and admiration than those firms ranked just marginally lower (1). Given the substantial increase in benefits based on the slightest differences in rank, actors and groups within a competitive hierarchy jockey for more-favorable positions. Yet, how incumbents respond to the dynamic rise of others—a ubiquitous phenomenon in hierarchy—lacks theoretical understanding. Specifically, how do individuals react—how are their judgments, behaviors, and resulting performance affected—when facing a competitor who is successfully gaining in rank? In this research, we explore whether the positive momentum (i.e., positive gain in rank over time) of a direct competitor is viewed as more threatening and detrimental to a focal actor's performance than a competitor having the same objective rank but lacking momentum.

Rank is reflective of overall relative standing or status on a valued social dimension in a hierarchy, such that those possessing higher rank are respected, admired, and conferred with greater deference by others (2–4). Because it is associated with a number of social and psychological benefits, ranging from influence, self-esteem, health, access to resources and social attention (5–7), status is a highly desired commodity—one that individuals actively strive and compete to attain (6, 8). Further, people are willing to pay a significant price to maintain their status positions (9, 10) or to attain higher status (11). Still others are motivated to directly contest (12) and even overtly challenge the status of others (8, 13).

However, despite the central importance of status, the literatures on both competition and status lack theoretical and empirical perspective on the psychology of focal actors when competing with someone who is continually gaining in rank or overall status. For instance, competition research typically discusses the competitor's objective rank as a significant criterion in predicting success (14). The literature lacks clarity on the situation where 2 competitors might objectively occupy the same rank or status but have experienced different rank trajectories. Similarly, although there have been multiple calls to examine dynamic status or rank changes within social hierarchies, research has, so far, ignored the consequences of these changes for members within the same hierarchy who may be jockeying for better status position (4, 15). As a result, our understanding of focal actors' psychology and their competitive response to potential challengers remains patchy when it comes to rank changes within competitive status hierarchies—a phenomenon pervasive in most social contexts (15).

In this research, we integrate the literatures on status and psychological momentum (16) to demonstrate why focal actors are threatened by competitors' positive status trajectory, above and beyond their objective rank differences, leading to poor performance by the focal actor. In doing so, we offer several contributions. First, we respond to various calls in the hierarchy literature

Significance

Although extant research acknowledges status contests within hierarchies, the precise psychological process and resulting performance of a focal actor competing and jockeying for higher rank remains unexplored. We examine how competitors' positive status momentum (i.e., recent positive trajectory in the hierarchy) affects a focal actor's performance over and above their current position in the hierarchy. Across 6 studies, we find that an opponent's momentum negatively affects the focal actor's cognitive and physical performance, due to the psychological threat induced by the competitor's momentum. This research demonstrates how status momentum is a key driver that affects performance and disrupts rankings within competitive hierarchies beyond objective rank. It also offers an alternate account to the "hot hand" fallacy toward understanding success.

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(4, 15) to explore the consequences of dynamic rank changes within a status hierarchy on a focal actor's psychology and performance. Second, this study examines the consequences of rank changes on a focal actor's performance, using both cognitive and effort-based measures of performance within a field context and among professional athletes. Third, by examining these adverse effects on focal actors' performance, we advance the literature on social hierarchy, demonstrating how the dimension of successful performance (which previously enabled them to rise to the top) may be impacted by the successes of others. Finally, our work contributes to the literature on psychological momentum, which has mainly considered the focal actor's own momentum and psychology rather than the effect of others' momentum (17, 18) and has thereby failed to capture the complete dynamic nature of status hierarchies.

Social hierarchy research has advanced our understanding of members' psychology and behavior based on their current or static social standing (4, 19). However, our knowledge of members' interactions within hierarchies remains limited, as status hierarchies are inherently dynamic, that is, in a state of constant flux. Therefore, studying hierarchies as static entities hampers our understanding of the changing interactions, psychology and behaviors, and performance of members within them. Research exploring the consequences of rank changes has either taken a third-party view of status rise or fall (20) or considered individual's decision-making in light of losing or gaining rank, without considering the impact of a competitor's status change (21, 22). For example, Pettit et al. (20) examine discrepancies in status judgments when a social object had ascended (versus descended) to a certain rank. These judgments were made by a third person, outside of the concerned hierarchy, who thus had no agency to effect any changes within the hierarchy. This work did not account for a first-person perspective of a potential challenger displaying a positive shift in his or her status trajectory. Arguably, individuals who are part of a hierarchy should be more motivated to defend their social standing, given the many psychological and material benefits associated with a high-ranked position (6). Further, by performing well against rising opponents, such individuals could reap status benefits in the future.

Additionally, research on the performance consequences after losing status has not considered the effect of others' dynamic rank changes in a competitive setting. For instance, Marr and Thau (23) report that high-status actors' performance suffers after status loss, but they are agnostic about the factors that may lead to status loss and also on the actor's psychology and performance when competing for a higher status. Flynn and Amanatullah (24) note that competing with an objectively high-status actor may lead to feelings of despondency, as those with high status have superior skills and may perform better. However, none of the above studies examine the consequences for actor performance following dynamic changes in a competitor's status. Relatedly, research documenting greater risk-taking or escalation of conflict among those being challenged has focused on either challengers having similar status characteristics or a greater number of participants vying for the same position (25, 26). In summary, our understanding of a focal actor's psychology and resulting behaviors to the competitive challenges of others displaying a recent history of positive status momentum remains largely uninformed. Accordingly, this research draws on the psychological theory of momentum to explain a focal actor's reduced performance via greater perceptions of self-threat. In so doing, it offers a theoretical understanding of the ubiquitous phenomenon of actors competing and negotiating their rank within competitive hierarchies.

People hold intuitive theories and lay beliefs grounded in common sense psychology that can be misguided (27–29). For example, observers' memory recall of the final location of a moving target is often displaced in the direction of a target's motion—a phenomenon referred to as representational momentum (30). Thus, observers appear to draw causal inferences about the pattern of physical movement, even when no such physical forces are in action. The cognitive findings pertaining to representational momentum transcend to motivational systems as well, such that expectations for future outcomes are perceived to be influenced by past outcomes (18). This tendency to project future outcomes based on past results is termed psychological momentum (16).

Psychological momentum influences individuals' cognition and behavior by forming future expectations for an actor having momentum. Specifically, those who have attained recent success are expected to continue doing well into the future and thus associated with positive momentum, whereas those who have faced recent setbacks are expected to experience further failures in the future and hence associated with negative momentum. For instance, athletes who experienced success (failure) reported greater positive (negative) momentum with greater expectation of future success (failure) (31–33). Similarly, those observing others with positive momentum expected greater success for them in the future, in both sports and nonsports contexts (18). The effects of psychological momentum extend to financial investments, whereby mutual funds with greater positive momentum register significant gains (34), and investors projecting a fund's continued momentum increase their own investments into these funds (35). In short, there is sufficient empirical evidence of psychological momentum across a variety of social and nonsocial contexts.

Consistent with the tenets of psychological momentum, research on social status from a third-party perspective suggests that 2 actors at the same rank are conferred different status depending on whether they have risen or fallen to arrive at that rank (20). As outlined above, individuals tend to project an actor's future rank based on the direction of momentum, thus granting higher status to those with positive (versus negative) momentum. We contend that this process should be amplified for focal actors within the hierarchy who witness other competitors associated with positive or negative momentum, for 2 related reasons. First, status is a fundamental motive and one that individuals actively monitor; therefore, any appreciable movement in others' rank is highly salient and noticeable (6). Second, in a competitive status hierarchy, a competitor's success has consequences for one's own future position, which further motivates and occupies an actor's attention. As a result, focal actors incorporate various social cues such as rank, references, similarity, appearance, and clothing to estimate their opponents' overall future standing (4, 36–39). In line with these factors, we argue that focal actors would utilize opponents' momentum to extrapolate their future position in the direction of their momentum.

Further, work on psychological momentum has suggested that competitors with momentum are perceived as threatening (32). In support of this finding, Hsee et al. (40) suggest that any kind of approaching stimulus, whether positive or negative, is perceived as threatening to the self in comparison to a receding one. Integrating these findings from both the momentum and status literature within rank-ordered competitive hierarchies, we contend that, when focal actors observe competitors' positive movement, they expect them to continue their ascent within the hierarchy. This projected future momentum of others will be perceived as self-threatening by focal members, as rank order is often zero-sum [i.e., one typically gains rank at the expense of others (41, 42)]. Hence, the projected future rank of a competitor with momentum will raise the focal actor's concern about his or her own future position, resulting in an increased feeling of self-threat. Additionally, there is considerable evidence that self-threat causes individuals to experience self-doubt or rigidity, which harms their performance (43–45). Therefore we hypothesize, facing a competitor with positive momentum will result in focal actors to project a better future rank for the competitor, which will be psychologically threatening to the focal actor resulting in poor performance against such a competitor.

Therefore, and ironically, the very thing that the focal actor is motivated to guard against (rank loss) results in poorer performance from the psychological threat that comes from recognizing this possibility. In contrast to the studies examining the effect of psychological momentum on the performance of the actors with momentum [i.e., the hot hand fallacy (17)], our research shows that, when competitors have positive momentum, it negatively impacts the focal actor's own performance. Thus, momentum may not only help the actors possessing it to perform well but may also impair their competitors' performance. We test our hypothesis across 6 studies that include 2 large real-world datasets and 4 experimental studies.

Results

Study 1. This study demonstrates the influence of a competitor's status momentum on a focal actor's performance, in a real-world context. We analyzed players' performance on the Free Internet Chess Server (FICS), one of the oldest and largest global Internet servers devoted to the game of chess. FICS assigns a rating to each chess player that is updated based on their performance. Moreover, these ratings, and their rise and fall based on past performances, are highly visible to other users on the server (46), making this an ideal setting to test our hypothesis. We created our dataset by obtaining all standard completed games played on FICS during 2015 and 2016. Since our hypothesis is at the player level, our unit of analysis is the "player-game," consisting of 2 players per game, one playing white pieces and the other playing black. We used a minimum of 3 data points per player to calculate momentum, as 2 data points are not enough to ascertain a trend. Hence, players who appeared in the database less than 3 times were excluded from the analysis. We also excluded games where move count was zero and the outcome of the game was based on time-out. Our final sample consisted of 5,220,293 player-game observations from 2,754,708 unique games.

Each player's rank or rating was based on the Elo rating system, the most accepted system used to rank professional chess players worldwide. A rating of 1,200 and below belongs to a novice category, whereas scores greater than 2,700 are at the level of professional experts. In our data, players' ratings ranged from 672 to 3,230 points, with a mean of 1,653.04. Next, we estimated a focal player's momentum and an opponent's momentum, in 2 steps. First, we calculated the average rating of each player at the time of starting a new game using a moving average window of that player's current and previous 2 ratings. We then subtracted the average rating of the player from the current rating and divided by the average rating of the player at a given time to normalize momentum across players. Thus, momentum was calculated using the following equation:

$$\text{Momentum} = \frac{P_{it} - \text{Avg.}\left(\sum_{t}^{t-2} P_{it}\right)}{\text{Avg.}\left(\sum_{t}^{t-2} P_{it}\right)},$$

where P_{it} is ith player's rank at a given point in time (t). Our main dependent variable was the overall probability of winning the match, coded as 1 for a win, 0 for a draw, and −1 for a loss. We included a number of covariates that could potentially impact a player's performance, such as 1) the focal player's own momentum, which can have a psychological impact on his or her performance (17); 2) the difference between the focal player's and opponent's current ranks as an indicator of their differences in ability or skill; 3) the total number of moves in the game; 4) whether the player was playing with white or black pieces; 5) whether the game was rated (i.e., played on FICS servers under its aegis or independently on a player's server via FICS); and 6) year fixed effects.

We performed a multilevel multinomial logistic regression with players nested within each game to account for any game-level variance. Additionally, multinomial logistic regression accounted for the categorical dependent variable having more than 2 outcomes. We used probability of losing as a baseline comparison. In line with our prediction, regression analysis revealed that the opponent momentum had a significant negative effect on the number of games won by the focal player. This effect was significant with (b = −2.25, P < 0.001; Table 1, model 4) and without control variables (b = −7.51, P < 0.001; Table 1, model 1). We also performed multinomial logistic regression without considering the effect of nesting within each game, as each game had only 2 underlying observations which could result in unreliable estimates. This additional analysis produced identical results with similar effect sizes (*SI Appendix*, Table S1). *SI Appendix*, Fig. S1 demonstrates the predicted probability of the focal actor's chances of winning the game as a function of opponent momentum in our data after accounting for the focal actor's momentum, rank difference, and year fixed effects. The focal actor's probability of winning drops from 65% to 30% as opponent momentum increases. We find no meaningful effect of the opponent's momentum on the probability of drawing the game.

As a robustness check, we not only calculated a player's momentum based on the moving averages for the last 3 games but also expanded that window to 4, 5, 6, and up to the last 10 games (i.e., we only analyzed players who played a minimum of 4, 5, 6, and up to 10 games). Multinomial logit regression results were significant and consistent with our hypothesis even after utilizing longer temporal windows of the opponent's momentum. We find similar results if momentum is calculated based only on the last 2 instances, but one should be cautious in interpreting these results, as 2 data points do not signify a trend. An alternative explanation for our findings could be that players with momentum are the ones who are constantly improving, and that could be driving this effect, rather than momentum. We ruled out this possible explanation in 2 ways. First, we looked at the correlation between the opponent momentum at 3 different time points: t, $t-1$, and $t-2$. The correlation was low and ranged from 0.32 to 0.006, suggesting that the same players did not have momentum throughout, and hence were not constantly improving. Second, if learning was driving the effect, then those with a greater momentum shift should cause focal players to lose more games than those with less momentum. However, if momentum were driving the effect, we would not expect an interaction. Accordingly, we categorized an opponent's momentum based on whether the jump in rank was less than 1 SD or greater than or equal to 1 SD of average movement in rank and interacted that with the opponent's momentum to observe its impact on a focal player's chances of winning. We observed a significant interaction (b = 5.48, P < 0.001), but, in contrast to the learning explanation, we find that focal players' likelihood of losing is greater against an opponent within 1 SD jump (b = −1.47, P < 0.001) than against those with greater than 1 SD (b = −0.30, P < 0.001; see *SI Appendix*, Fig. S2). This test rules out learning as an alternative explanation. Moreover, significant negative slopes for both high and low values further supports momentum as the underlying cause. As an exploratory analysis, we examined whether a focal actor's and opponent's momentum interacted to predict game outcome; the interaction was insignificant (P > 0.05).

Overall, analysis of more than 5.2 million player-game observations revealed that focal actors had a lower chance of winning if their opponent had positive momentum, even after controlling for several variables and ruling out alternative explanations such as the improvement/learning of the competitor. However, this field study fails to capture the psychological processes behind this effect, which we elucidate in the following studies.

Table 1. Results of multinomial logit regression analysis for study 1 on game outcome

		Game drawn			Game won			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Opponent's momentum	0.436 (0.246)	2.867*** (0.263)		0.354 (0.347)	−7.511*** (0.123)	−2.256*** (0.129)		−2.253*** (0.128)
Player's own momentum		4.674*** (0.260)	2.173*** (0.322)	2.273*** (0.34)		1.919*** (0.133)	1.998*** (0.138)	1.972*** (0.132)
Rank difference		3.672***(0.009)	3.609***(0.011)	3.61***(0.011)		7.618***(0.015)	7.553***(0.014)	7.544***(0.015)
Total number of moves			0.026*** (0.000)	0.026*** (0.000)			−0.000*** (0.000)	−0.000*** (0.000)
Chess piece color			0.043*** (0.005)	0.043*** (0.002)			0.150*** (0.003)	0.151*** (0.003)
Event rated†			1.711*** (0.009)	1.711*** (0.009)			−0.005 (0.001)	−0.005 (0.001)
Year‡			0.027*** (0.005)	0.026*** (0.006)			−0.001 (0.000)	−0.001 (0.000)
Constant	−2.368*** (0.003)	−2.256*** (0.003)	−4.632*** (0.009)	−4.632*** (0.009)	−0.009*** (0.000)	0.024*** (0.000)	−0.038*** (0.001)	−0.039*** (0.001)
Level 2 variance	2.24e-09	5.85e-10	0.00000034	6.80e-09	2.24e-09	5.85e-10	0.00000034	6.80e-09
N	5220293	5220293	5220293	5220293	5220293	5220293	5220293	5220293
AIC	8820344.8	8003154.9	7679824.0	7679412.8	8820344.8	8003154.9	7679824.0	7679412.8
BIC	8820398.7	8003262.7	7680012.6	7679628.3	8820398.7	8003262.7	7680012.6	7679628.3
Log likelihood	−4410168.4	−4001569.5	−3839898.0	−3839690.4	−4410168.4	−4001569.5	−3839898.0	−3839690.4

***$P < 0.001$.

†Game was rated by FICS, 1; game was unrated by FICS, 2.

‡Year 2015, 1; year 2016, 2; SEs in parentheses.

Study 2. Study 2 examined whether competitors' positive status momentum led the focal actor to project their continued ascent into the future, thereby resulting in increased perceptions of threat compared to when competitors held the same objective rank but lacked momentum. Participants were randomly assigned to either a status momentum condition or a control condition. We recruited 350 participants from Amazon Mechanical Turk (MTurk), 171 in the control condition and 179 in the momentum condition (M_{age} = 35.36 y, 48.86% female).

Participants read a hypothetical scenario where they assumed the role of an assistant manager in the sales department of a well-known multinational conglomerate, ABC Company. The scenario described how ABC Company runs a problem-solving competition every year. For example, last year's competition was about how to reduce procrastination among desk clerks. Managers from across the company (e.g., finance, operations, accounting, human resources) compete for a bonus prize awarded to the top 3 managers who come up with the best proposals. Apart from earning extra cash, equivalent to 10% of their yearly salary, the winners also receive a great reputational boost within the company, as winners are announced publicly and prizes are awarded at the annual company dinner. Thus, having one's proposal ranked in the top 3 would bring both tangible and intangible benefits. In both conditions, participants read that they have been ranked third for the past 3 y. In the momentum condition, they read that one of the competitors has consistently improved his or her ranking from 8→6→4 over the last 3 y, whereas, in the control condition, the same person was ranked 4→4→4. In this way, the objective and most proximal final rank leading into the competition remained the same across the 2 conditions. We structured the study such that male/female participants were always assigned to the same gender competitor (Josh/Jenny) to ensure that our results were not influenced by intergender dynamics (see *SI Appendix* for scenarios and measures).

We then asked participants to respond to 2 separate measures of threat and a single item measuring projection of future rank. The first measure of threat consisted of 12 negative emotional items, a measure commonly used in the competition literature (47) (α = 0.96). We also used 3 additional items to measure participants subjective sense of threat (α = 0.67). We measured the mediator—expectation of future rank—by asking participants to indicate the rank they expected the competitor to achieve in the next round of competition. In line with convention, the smaller numerical value of rank implied higher objective rank. We also included an 8-item competitiveness scale (α = 0.93) (48) to ensure that the within-gender competition condition did not differentially influence competitive motivation across gender.

A 2 × 2 ANOVA with momentum and gender as 2 independent variables revealed a main effect of momentum condition on emotional threat items, $F(1, 346) = 4.07$, $P = 0.044$, $d = 0.23$, such that participants reported greater threat ($M = 2.80$, SD = 1.28) in the status momentum condition than in the control condition ($M = 2.51$, SD = 1.26). In line with the existing research on competition (49–51), we find a main effect of gender, $F(1, 346) = 7.58$, $P = 0.006$, $d = 0.31$, such that women reported greater negative feelings ($M = 2.86$, SD = 1.35) than men ($M = 2.47$, SD = 1.18). However, we observed no interaction between momentum and gender, $F(1, 346) = 0.37$, $P = 0.54$, suggesting that the momentum manipulation influenced all genders equally. Similar analysis for subjective threat again revealed a main effect of momentum on threat perceptions, $F(1, 346) = 22.80$, $P < 0.001$, $d = 0.51$, such that participants in the momentum condition perceived greater threat ($M = 0.34$, SD = 1.41) than those in the control condition ($M = -0.36$, SD = 1.32). There was a marginal difference in threat perceptions across gender, $F(1, 346) = 3.11$, $P = 0.078$, $d = 0.23$, such that women reported greater self-threat ($M = 0.17$, SD = 1.50) than men ($M = -0.16$, SD = 1.30). Yet, there was no interaction between momentum and gender, $F(1, 346) = 1.20$, $P = 0.28$.

We next inspected whether status momentum also influenced future rank expectation. There was a significant main effect of momentum, $F(1, 346) = 28.74$, $P < 0.001$, $d = 0.58$, such that participants expected their competitor to do much better in the momentum condition ($M = 3.33$, SD = 1.06) than in the control condition ($M = 3.83$, SD = 0.60). We find no main effect of gender, $F(1, 346) = 0.16$, $P = 0.69$, or it's interaction with momentum, $F(1, 346) = 0.00$, $P = 0.99$, on future rank expectation of the competitor. We also performed the same analysis on participants' competitiveness ratings. Consistent with past research, only a main effect of gender was observed, $F(1, 346) = 7.44$, $P = 0.007$, $d = 0.30$, such that women reported lower competitiveness ($M = 4.52$, SD = 1.35) than men ($M = 4.90$, SD = 1.26). Neither the main effect of momentum, $F(1, 346) = 0.65$, $P = 0.42$, nor it's interaction with gender was significant, $F(1, 346) = 0.67$, $P = 0.41$.

We then examined whether a projected better future rank of the competitor mediated the positive relationship between status momentum and threat. Since results for both threat measures were the same, we standardized and combined the 2 measures ($\alpha = 0.95$). For all of the studies, we performed a bootstrap mediation procedure with 5,000 iterations and report bias-corrected 95% CI. We coded the independent variable as 1 for momentum and 0 for control conditions. Bootstrap analysis resulted in a marginally significant indirect effect on threat via positive rank expectations ($b = 0.08$, $P = 0.066$, 95% CI [0.006, 0.187]) after controlling for participants' gender and age. The direct effect of the independent variable after accounting for the indirect effect was significant ($b = 0.26$, $P = 0.045$, 95% CI [0.01, 0.53]), suggesting partial mediation. Overall, this study demonstrated the role of future rank projection as a probable cause of self-threat when facing a competitor with positive momentum versus a similar competitor with the same objective rank but no momentum.

Study 3. In this study, we wanted to replicate our findings using a more conservative scenario where the final rank of a competitor with status momentum was objectively lower than that of another competitor without momentum. We randomly assigned 123 MTurk participants to either a control ($n = 63$) or momentum ($n = 60$) condition ($M_{age} = 34.45$ y, 44.72% female). Participants read a hypothetical scenario where they assumed a brand manager role in a luxury watch company, OMEGA, and learned how various luxury watch brands were ranked by a famous brand magazine over the past 3 y. In the control condition, their watch company (OMEGA) was ranked fifth over the past 3 y, whereas their closest competitor (TAG Heuer) was consistently ranked sixth during this period. In the momentum condition, OMEGA was also consistently ranked fifth over last 3 y, but another competitor (TAG Heuer) had steadily increased its ranking from 19→13→7 during this period. Thus, the final rank in the momentum condition of the competitor was objectively lower than in the control condition (7 versus 6), offering a stricter test of our hypothesis. Since both measures of threat in study 2 showed similar results, we only measured subjective threat perceptions in this study ($\alpha = 0.66$). Similar to study 2, expectations were measured by asking participants to indicate the rank they expected Tag Heuer to achieve in the next year's rankings by selecting an option between 1 and 10.

A one-way ANOVA revealed a significant effect of momentum on threat, $F(1,121) = 36.25$, $P < 0.001$, $d = 1.08$, such that participants reported greater threat ($M = 0.89$, SD = 1.73) in the momentum condition than in control ($M = -0.85$, SD = 1.48). Likewise, we find a significant difference in future rank expectations across the 2 conditions, $F(1,121) = 25.79$, $P < 0.001$, $d = 0.92$. Participants in the momentum condition predicted a higher future rank for Tag Heuer ($M = 4.78$, SD = 1.09) compared to those in the control condition ($M = 5.65$, SD = 0.79). We further examined whether positive future expectations of a competitor's rank mediated the relationship between status momentum and threat. We coded the control condition as 0 and momentum as 1. A bootstrap mediation analysis with 5,000 iterations revealed a significant indirect effect of momentum on threat via expectations ($b = 0.35$, $P = 0.025$, 95% CI [0.09, 0.71]). The direct effect of momentum on threat after accounting for the indirect effect was also significant ($b = 1.39$, $P < 0.001$, 95% CI [0.79, 1.99]), indicating partial mediation. This study not only replicated findings from study 2 but also demonstrated that an objectively lower-ranked competitor's momentum elicits greater self-threat than a competitor with an objectively higher rank but void of momentum. These findings run counter to the widespread notion of attributed skills and expertise being associated with a higher position in a hierarchy.

Study 4. To further demonstrate threat as the psychological mechanism underlying our findings, we used a process of moderation (52) approach by giving participants reasons to discount momentum as the source of the threat—an established way of attenuating self-threat (28). We preregistered the study, discussing sample size, study design, and expected results (https://aspredicted.org/3f4wq.pdf). The final sample consisted of 278 MTurk participants ($M_{age} = 37.37$ y, 57.19% female). Participants were randomly assigned to either a momentum, control, or doubtful momentum condition. The scenario for this study was identical to study 2 for both the momentum and control conditions. In the doubtful momentum condition, participants additionally read that there might be a clerical error in accurately measuring the competitor's past performance (see *SI Appendix* for verbatim wording), thus raising suspicion of the veracity of the momentum. Unlike in study 2, we relaxed the within-gender assignment, as there was no evidence of gender effects based on momentum. We expected that participants in the doubtful momentum condition would discount the validity of the competitor's momentum and therefore feel less threatened than those in the momentum condition, who did not have any basis to discount the legitimacy of the competitor's rank. The 2 main dependent variables were threat and expectation of competitor's future rank.

A one-way ANOVA with threat as the dependent variable revealed a significant difference across the 3 conditions, $F(2, 275) = 7.26$, $P < 0.001$, $\eta^2 = 0.05$, such that participants were more threatened in the momentum condition ($M = 0.51$, SD = 1.67) than in the control ($M = -0.42$, SD = 1.52) or doubtful momentum condition ($M = -0.03$, SD = 1.85). Consistent with the prior studies, the momentum and control conditions differed significantly, $F(1, 275) = 14.47$, $P < 0.001$. Importantly, however, threat perception also differed significantly in the momentum condition versus the doubtful momentum condition, $F(1,275) = 4.60$, $P = 0.033$. No significant difference was observed between the control and doubtful momentum conditions, $F(1,275) = 2.56$, $P = 0.11$, confirming that the doubtful momentum condition was successful in attenuating self-threat by allowing participants to discount the legitimacy of their competitor's momentum. (*SI Appendix*, Fig. S3). Similarly, we also find a significant difference when measuring competitor's future rank expectation across the 3 conditions, $F(2, 275) = 20.52$, $P < 0.001$, $\eta^2 = 0.13$, such that participants expected higher rank for the competitor in the momentum condition ($M = 3.01$, SD = 0.92) than in the control ($M = 3.76$, SD = 0.52) or doubtful momentum condition ($M = 3.31$, SD = 0.95). Post hoc analysis showed a significant difference between the momentum and the control condition, $F(1,275) = 40.24$, $P < 0.001$, and also between the momentum and doubtful momentum condition, $F(1,275) = 6.24$, $P = 0.013$. Additionally, the control and doubtful momentum condition differed significantly, $F(1,275) = 14.24$, $P < 0.001$.

We next examined whether rank expectations mediated the effect of momentum on threat perceptions. Since the control and doubtful momentum conditions did not differ in terms of threat perceptions, we collapsed the 2 into a baseline condition for the mediation analysis. A bootstrap procedure with 5,000 replications confirmed the presence of an indirect effect of momentum condition in comparison to the baseline condition on threat via expectations ($b = 0.56$, $P < 0.001$) with 95% CIs not containing 0 [0.32, 0.86]. Further, when we accounted for the indirect effect, the direct effect of momentum on threat became insignificant ($b = 0.18$, $P = 0.35$, 95% CI [−0.19, 0.57]), suggesting that positive rank expectation fully mediated the effect of momentum on threat. Thus, via the process of moderation, this study provided

PSYCHOLOGICAL AND COGNITIVE SCIENCES

additional evidence that self-threat among focal actors is elicited by opponents' momentum.

Study 5. This study again moderated self-threat as a consequence of an opponent momentum by affording individuals an opportunity to self-affirm. Individuals can buffer themselves from threatening situations by drawing on additional resources valued by the self (53, 54). We constructed a simulated competition as per the preregistration that discussed our hypothesis, manipulation, measures, sample size, exclusion criteria, and analysis strategy (https://aspredicted.org/4pq57.pdf). The final sample consisted of 1,072 participants (M_{age} = 35.65 y, 53.87% female), randomly assigned to a 2 (momentum: yes, no) × 2 (self-affirmation: yes, no) between-subjects design. Participants took part in a competition designed to assess their general intelligence against 9 other people. The test consisted of 4 rounds, and, after each round, participants were informed about their standing in the group. In reality, every participant's rank was kept constant at 3 across the 3 rounds. In the momentum condition, they were shown a graphic wherein one of the participants (participant 107) made consistent progress after each round from rank 10→7→3. To make the competition more realistic, we oscillated the rank in the control condition, whereby the participant (participant 107) ranked at 4 after round 1 then moved to a rank of 5 after round 2, and finally back to a rank of 4 after round 3.

In line with real-world hierarchies, participants learned that finishing among the top 3 competitors would result in additional rewards. Participants further learned that, after the third round, they would be paired up with their nearest competitor and would have to perform better than this competitor in the final round to finish among the top 4th. All participants were paired up with the competitor ranked 4 after round 3. After learning about their competitor, half of the participants were given an opportunity to self-affirm by briefly writing about their core strengths that helped them perform well in the past. This affirmation manipulation was intended to boost the global self-worth of an individual by increasing a pool of psychological resources that serve to assuage threats to the self (53). In the no-affirmation condition, participants wrote about their last shopping trip to the grocery store. Participants then reported their perception of threat and future rank expectation of the competitor. Consistent with previous studies, threat was measured using 3 items (α = 0.83) and expectation with a single item capturing the participant's anticipation of the competitor's rank in the next round. We predicted a main effect of momentum across the 2 conditions, but, more importantly, we also predicted an interaction of self-affirmation with momentum, such that those in the affirmation condition would feel less threatened facing a competitor with positive momentum than those in the no-affirmation condition. We preregistered differences in means based on a one-tailed t test but report below using a more conservative 2-tailed test (see *SI Appendix* for analysis with one-tailed test).

A 2-way ANOVA revealed a main effect of momentum $F(1, 1{,}068) = 108.99$, $P < 0.001$, $\eta^2 = 0.03$, as well as a main effect of affirmation $F(1, 1{,}068) = 29.15$, $P = 0.005$, $\eta^2 = 0.007$. Participants reported more threat in both the momentum and no-affirmation conditions. Notably, we observed a significant interaction effect of momentum and affirmation conditions on threat, $F(1, 1{,}068) = 18.20$, $P = 0.026$, $\eta^2 = 0.005$. Post hoc analysis revealed that participants experienced maximum threat in the momentum and no-affirmation conditions ($M = 0.61$, SD = 1.95). This value differed significantly from the other 3 conditions (i.e., when participants were either in the momentum condition but affirmed, $F(1, 1068) = 12.59$, $P < 0.001$, ($M = 0.02$, SD = 1.98), or in the no-momentum condition with affirmation, $F(1, 1068) = 34.22$, $P < 0.001$, ($M = -0.35$, SD = 1.70) or in the no-momentum condition without affirmation, $F(1, 1068) = 29.88$, $P < 0.001$, ($M = -0.28$, SD = 2.02)). Additionally, participants in the momentum condition who were allowed to affirm reported greater self-threat than those in the no-momentum condition and without self-affirmation, $F(1, 1068) = 5.11$, $P = 0.024$, but this difference was only marginally significant compared to those in the no-momentum and affirmation condition, $F(1, 1068) = 3.45$, $P = 0.064$. We saw no significant difference among participants in the no-momentum condition. Overall, the pattern of results indicates that self-affirmation helped reduce the impact of a competitor's positive momentum (*SI Appendix*, Fig. S4). In short, self-affirmation buffered against the self-threat caused by a competitor's momentum.

A 2-way ANOVA on competitor's future rank expectations revealed a main effect of both the momentum, $F(1, 1{,}068) = 26.98$, $P < 0.001$, $\eta^2 = 0.03$, and affirmation conditions, $F(1, 1{,}068) = 7.61$, $P = 0.006$, $\eta^2 = 0.007$, and a significant interaction of the 2, $F(1, 1{,}068) = 5.70$, $P = 0.017$, $\eta^2 = 0.005$. Post hoc analysis of means showed a pattern similar to self-threat, wherein nonaffirming participants within the momentum condition expected the competitor to do much better in the next round ($M = 2.54$, SD = 1.40) than the affirmed participants ($M = 2.96$, SD = 1.53), $F(1, 1{,}068) = 13.12$, $P < 0.001$. In addition, future rank expectations of nonaffirming participants in the momentum condition were significantly higher than those in the no-momentum condition with ($M = 3.19$, SD = 1.13), $F(1, 1{,}068) = 31.69$, $P < 0.001$, or without ($M = 3.16$, SD = 1.27), $F(1, 1{,}068) = 29.18$, $P < 0.001$, affirmation. Participants in the affirmed momentum condition reported marginally better rank compared to those in the no-momentum condition with, $F(1, 1{,}068) = 3.88$, $P = 0.05$, or without, $F(1, 1{,}068) = 2.96$, $P = 0.09$, affirmation (*SI Appendix*, Fig. S5). Taken together, these results highlight the role of self-affirmation in attenuating the effect of a competitor's momentum on future rank expectations.

Consistent with our hypothesis, we also tested for a conditional indirect effect of momentum on threat via future rank expectations, such that the effect was expected to be positive and significant when participants were not afforded the ability to affirm versus when they were affirmed. Hence, we analyzed a first-stage moderated mediation model, such that affirmation moderated the link between the momentum condition and rank expectations (55). A bootstrap procedure with 5,000 iterations revealed a significant positive indirect effect of momentum on threat via expectations under no affirmation ($b = 0.55$, $P < 0.001$, 95% CI [0.34, 0.75]). A marginal positive indirect effect of momentum on threat via expectations was also observed in the affirmation condition ($b = 0.20$, $P = 0.057$, 95% CI [−0.004, 0.41]). However, more importantly, the difference in the 2 conditional indirect effects was positive and significant, such that participants felt more threatened in the absence than in the presence of affirmation ($b = 0.34$, $P = 0.018$, 95% CI [0.05, 0.62]). In short, our findings suggest that self-affirmation helps attenuate self-threat caused by a competitor's momentum. By utilizing a simulated competition and the experimental process of moderation, this study supports greater self-threat caused by positive rank expectations as an underlying mechanism of our findings.

Study 6. Having elucidated the psychological process underlying our effect in the previous 4 studies, in this study, we sought to examine the role of opponent momentum and self-threat in a real-world high-stakes context where individuals compete at the most elite professional level. Accordingly, we developed a large dataset of 27 y of male and female tennis players, representing the Association of Tennis Professionals (ATP) and the Women's Tennis Association (WTA), respectively. This field represented a fitting context to test our hypothesis, as ATP/WTA rankings provide a rank-ordered hierarchy where being on top results in significant financial and social benefits. Further, there is a scope for upward and downward movement within the hierarchy contingent upon one's performance, and any change in ranking is observable to everyone. First-round draws for any ATP/WTA tournament are determined through a random distribution, except for the top 32 players in major tournaments, who are strategically placed in the top or bottom half to ensure that the top 4 players do not play each other prior to the semifinals. Such random distribution of draws also affords players who are far apart within the hierarchy an opportunity to compete with each other. Moreover, to analyze the impact of an opponent's momentum on a player's performance, tennis data provide excellent objective markers of performance, simultaneously allowing us to rule out a number of potential confounds. Finally, tennis tournaments are based on a knockout format with a discreet payoff function, which offers a high-stakes context to test our hypothesis.

We collected match data of all men's and women's tennis matches from 1990 to 2016. The data were obtained from the ATP and WTA websites. Our unit of analysis was at the match-player level, resulting in 2 observations per game. We focused on only the first-round games of each tournament for the following 2 reasons: First, players' rankings are updated only upon the conclusion of a tournament and not during the tournament, and, second, a host of other within-tournament factors (e.g., when a lower-ranked player defeats a top-seeded player, injuries, positive or negative press) may influence players' intratournament momentum without any visible adjustment in their ATP/WTA ranking. Thus, we only examined first-round matches for which ranking data accurately mirrored a player's position in the hierarchy. We also eliminated those players who appeared less than 3 times in our dataset (n = 1,552), as we needed a minimum of 3 time points to calculate momentum. Our final sample consisted of 117,762 observations, with 59,200 unique matches and participation from 2,451 distinct players at an average of 48.04 matches per player (range 3 to 402).

Status momentum for each focal player and opponent was calculated based on moving averages, as in study 1. We used the overall probability of winning the match as the first dependent variable (1 = win, 0 = loss). We also employed an additional continuous dependent variable to capture match closeness. A tennis match is typically won by the player who wins a greater number of games compared to the opponent. Therefore, we measured the difference in total number of games won by the focal player versus the opponent, divided by the total number of games in the match. The variable ranged from –1 to 0.9 with values close to 0 (on either side of the decimal) suggesting the match was very close, values close to 1 indicating it was a one-sided match in favor of the focal player, and values close to –1 indicating that the opponent dominated the match. We operationalized threat to the focal player, using their count of double faults. A double fault (unlike a winner, or a break point saved/converted) is an unforced error for which the focal player is solely responsible, and the opponent exerts no active role, compared to other unforced errors, which could be a result of opponent's quality return. Hence, we chose double faults as a behavioral manifestation of a focal player's internal state of psychological threat. We divided the double fault count of the focal player by the double fault count of the opponent to ensure that we considered the match context and avoided overdispersion in our measure. The opponent's double fault count was increased by 1 to avoid the problem of division by 0 in cases where the opponent's double fault was 0.

We included a number of covariates that could potentially impact a player's performance. We controlled for 1) the focal player's own momentum (17); 2) the difference between the focal player's and opponent's current ranks, as this is a good indicator of differences in the players' ability or skill; and 3) the focal player's and opponent's height, age, and serving hand. We also accounted for other external factors, such as 1) the size of the tournament based on draw size (e.g., Grand Slams have a draw size of 128 and attract a larger number of players than smaller tournaments with draw sizes of 64, 32, ...); 2) the type of surface (clay, grass, or hard), as some surfaces favor certain players and their style of play; 3) the number of sets required to win the match (2 or 3); and 4) the type of series (e.g., ATP, Grand Slam, Masters), as each series has different requirements for a player participation.

We ran a multilevel regression with players nested within each game-opponent dyad to partial out any variance based on game-level factors. In line with our prediction, regression analysis revealed the negative effect of opponent momentum on the number of games won by the focal player. The effect of an opponent's momentum was negative and significant with (b = –0.034, P < 0.001, Table 2, model 4) or without (b = –0.038, P < 0.001, Table 2, model 1) the control variables. For the categorical win variable, we performed a multilevel logistic regression, again accounting for the variance based on game-level factors. Opponent momentum had a significant negative effect on a player's chances of winning the match, both with (b = –0.15, P < 0.001; *SI Appendix*, Table S2, model 4) and without (b = –0.20, P < 0.001; *SI Appendix*, Table S2, model 1) the control variables. *SI Appendix*, Fig. S6 demonstrates how a focal actor's probability of winning varies as a function of the opponent's momentum in our data while adjusting for the focal actor's momentum, rank differences, and year fixed effects. We find that a player's chances of winning drop from 52% to 38% as the opponent's momentum increases. In sum, the above results were consistent with our prediction. We performed the same analysis on threat-based unforced errors. In line with our prediction, a significant positive effect of opponent momentum was observed with (b = 0.084, P = 0.001; Table 2, model 8) or without (b = 0.083, P = 0.001; Table 2, model 5) the control variables, suggesting that an opponent's momentum increases focal player's threat perceptions, resulting in unwanted errors. We also performed a panel regression analysis with year as the panel variable as an alternative analysis for the 2 continuous variables—net games won and threat—and a logistic regression for the categorical win outcome. These alternative analyses produced similar results and effect sizes (*SI Appendix*, Tables S3 and S4).

We next examined whether threat mediated the effect of opponent momentum on a focal player's performance. A bootstrap procedure with 5,000 iterations revealed that opponent momentum had a significant negative indirect effect via threat on a player's ability to win more games than his or her opponent (b = –0.003, P = 0.047, 95% CI [–0.006, –0.0004]) and overall chances of winning the match (b = –0.002, P = 0.047, 95% CI [–0.004, –0.0003]).

As a robustness check, we calculated each player's momentum based on the moving average for not only the last 3 instances but also the last 2, 4, 5, 6, and up to 10 instances (i.e., we examined data for players who were present at least 2, 4, 5, 6, and up to 10 times). The regression results remained significant and consistent across these horizons of momentum. Further analysis using the nominal count of a player's double fault and controlling for the opponent's nominal count resulted in significant results that were consistent with our hypothesis. Similar to study 1, we also examined whether learning could provide an alternative explanation for these results. The within-momentum correlation for a player at time t, t – 1, and t – 2 was low and ranged from 0.39 to 0.04, suggesting that momentum was not consistent among the same players. As in study 1, interacting momentum with a jump in opponent momentum based on less than 1 SD or greater than or equal to 1 SD on net games and double faults revealed the same pattern. The interaction for net games won was significant (b = 0.18, P < 0.001); however, the slope for an opponent momentum with less than 1 SD jump in momentum was more negative (b = –0.20, P < 0.001) than the same for an opponent momentum greater than or equal to 1 SD jump (b = –0.02, P = 0.001; see *SI Appendix*, Fig. S7), suggesting that learning alone was not driving the effect. Similarly, the interaction for threat was significant (b = –0.27, P = 0.007), revealing that the focal player committed a greater number of double faults when facing an opponent with a lower (b = 0.34, P = 0.001) versus higher (b = 0.08, P = 0.022, see *SI Appendix*, Fig. S8) jump in momentum. Overall, the above analysis suggests that learning cannot be the only

PSYCHOLOGICAL AND COGNITIVE SCIENCES

Table 2. Results of multilevel regression analysis for study 6 on net games won and threat

	Net games won				Threat			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Opponent's momentum	−0.038***	−0.041***		−0.034***	0.081***	0.083***		0.084***
	(0.006)	(0.006)		(0.006)	(0.026)	(0.026)		(0.026)
Player's own momentum		0.024***	0.016**	0.019***		−0.063*	−0.075**	−0.077**
		(0.006)	(0.006)	(0.006)		(0.026)	(0.026)	(0.026)
Rank difference		0.002***	0.002***	0.002***		−0.001*	−0.001*	−0.001*
		(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)
Gender†			−0.047	−0.047			−0.15	−0.152
			(0.047)	(0.047)			(0.47)	(0.47)
Player's age			−0.002***	−0.002***			−0.003*	−0.003*
			(0.000)	(0.000)			(0.001)	(0.001)
Opponent's age			0.002***	0.002***			0.002	0.002
			(0.000)	(0.000)			(0.001)	(0.001)
Player's service hand			−0.032***	−0.032***			−0.031**	−0.031**
			(0.003)	(0.003)			(0.011)	(0.011)
Opponent's service hand			0.031***	0.031***			0.026*	0.026*
			(0.003)	(0.003)			(0.011)	(0.011)
Surface type								
Clay			−0.000	−0.000			−0.018	−0.017
			(0.004)	(0.004)			(0.019)	(0.019)
Grass			0.001	0.001			0.011	0.011
			(0.005)	(0.005)			(0.022)	(0.022)
Hard			−0.000	0.000			0.004	0.003
			(0.004)	(0.004)			(0.018)	(0.018)
Best of‡			−0.046	−0.046			−0.149	−0.152
			(0.046)	(0.046)			(0.47)	(0.47)
Series type FE			Included	Included			Included	Included
Draw size FE			Included	Included			Included	Included
Year FE	Included	Included	Included	Included	Included	Included	Included	Included
Constant	−0.003	−0.002	−0.009	−0.004	1.03***	1.030***	1.084***	1.071***
	(0.006)	(0.006)	(0.026)	(0.026)	(0.023)	(0.023)	(0.097)	(0.097)
Level 1 variance	6.18e-27	1.89e-25	3.54e-26***	1.92e-29***	2.40e-24***	1.13e-22***	3.51e-25	5.03e-16***
	(2.66e-24)	(5.19e-23)	(1.80e-27)	(9.70e-31)	(1.40e-25)	(7.09e-24)	(1.31e-22)	(2.13e-17)
Level 2 variance	0.11***	0.11***	0.109***	0.109***	1.324***	1.324***	1.322***	1.322***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.003)	(0.003)	(0.003)
N	117762	117746	117750	117746	82477	82477	82477	82477
AIC	74681.0	74070.3	74034.5	73997.7	257406.2	257417.1	257488.0	257484.9
BIC	74971.3	74380.0	74634.5	74607.4	257676.5	257706.0	258010.0	258016.2
ICC	5.61e-26	1.72e-24	3.24e-25	1.76e-28	1.81e-24	8.52e-23	2.66e-25	3.80e-16
Log likelihood	−37310.5	−37003.2	−36955.3	−36935.9	−128674.1	−128677.6	−128688.0	−128685.5
Degrees of freedom	27	29	59	60	26	28	53	54

$^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

†Male (ATP), 1; female (WTP), 2.

‡Best of 3 sets, 1; best of 5 sets, 2; SEs in parentheses.

explanation for these results, as we continued to observe the main effect of opponent momentum at both higher and lower jumps in momentum. We did not find the interaction between the focal actor's and the opponent's momentum to be significant ($P > 0.05$).

Another explanation for the above results could be player fatigue, but it is difficult to imagine why it would affect only 1 out of the 2 players, as both players played for a similar duration. Nonetheless, we empirically ruled out this alternative account by controlling for match length, in total number of minutes, and find that our effects remain consistent and significant. The data for total minutes played were only available for men; hence, we provide this analysis in *SI Appendix*, Table S5. In short, the performance drop among professional ATP players when facing a competitor with positive status momentum was robust across several temporal windows of status momentum and multiple analyses aimed at ruling out alternative explanations. Further, using a behavioral measure, this study also demonstrated that threat mediates the negative relationship between opponent momentum and an elite focal player's performance.

Discussion

We set out to explore how a competitor's rise in a competitive hierarchy over time—that is, positive status momentum—affects a focal actor's psychology and performance. After conducting 6 studies that included 2 large longitudinal archival analyses, experiments employing various competitive contexts, and more than 5.3 million observations, we find that opponent momentum negatively affects a focal actor's cognitive and physical performance. Focal actors' tendency to project a competitor's momentum into the future increases their likelihood of experiencing self-threat, which harms their performance. Thus, the very element that a focal actor intends to guard against (i.e., their own status loss) becomes more likely when they notice a competitor's momentum.

Our findings advance the social hierarchy literature in several important ways. First, we offer insights on how competitors' rank changes impact a focal actor's psychology and resulting performance. In doing so, we respond to repeated calls in the social hierarchy literature to investigate interactions in hierarchies through a dynamic lens, contrary to the extant work that treats status as a largely static measure (4, 15). Moreover, our study examines rank changes from a first-person (rather than third-person) perspective using a field sample and preregistered experiments to replicate the focal actor's psychology. These findings suggest that a focal actor assigns weight not only to a competitor's current rank but also to the competitor's past trajectory in attaining that rank.

The second and perhaps the most important contribution of our work lies in demonstrating the adverse effect of opponent momentum on a focal actor's performance. When rank is contingent on a sustained level of performance, a drop in performance will increase the likelihood of a decrease in future rank. Hence, our findings have crucial implications for how hierarchies are dynamically negotiated and changed over time. Additionally, our results are not limited to one type of task or performance. We find impairment in performance for both cognitive and effort-based domains, underlining the generalizability of our findings across different performance areas. Further, these effects manifested among both amateur chess players and elite tennis professionals. In the latter group, the focal actor who lost in the first round of the tournament incurred heavy costs, both financially and professionally.

Third, by examining the impact of opponents' momentum directly, this research contributes to the psychological momentum literature, which has mostly explored the benefits of psychological momentum for the focal actor embodying this momentum (17, 56). In addition to the hot hand phenomenon or self-beliefs associated with positive momentum, our research indicates that those with momentum might also perform well because they increase the salience of self-threat among their competitors. Although proponents of the hot hand fallacy have suggested that a focal actor having momentum can negatively impact the opponent, there is lack of systematic evidence to support this claim. Additionally, it has been suggested that one gains momentum at the expense of one's competitor(s), since rank-ordered hierarchies are essentially zero-sum (32); this might be true for some player-opponent dyads but is not always the case. One can, in fact, gain rank without affecting the incumbent's rank or momentum. For instance, both members of the dyad can have upward momentum at the expense of others in the hierarchy, or an opponent can gain rank without affecting the focal actor's position.

Additionally, in our field studies, we demonstrated the effect of opponent momentum over and above the focal actor's momentum. We also probed for a possible interaction between a focal actor and opponent momentum but did not find any support for it. Similarly, in our experiments, we held the rank of the focal actor constant and higher than that of the competitor to further demonstrate that opponent momentum independently increases the salience of self-threat beyond the competitor's objective rank. Thus, our research contributes to the literature on psychological momentum in 2 critical ways: by focusing on the opponent's momentum instead of the dominant hot hand explanation and by highlighting that momentum need not be zero-sum within a player-opponent dyad to exert its effect. Having said that, we do note that, in certain settings, momentum could be zero-sum and could exaggerate these effects.

Fourth, although we utilize the threat rigidity framework to explain performance impairment, our findings also advance the literature on "choking" under pressure (57–59), which documents how heightened self-awareness or internal monitoring interferes with an automatic response on a learned task, resulting in performance impairment. However, our research emphasizes a mechanism that is outward-focused—that is, anticipating a competitor's future rank—can increase the salience of self-threat and handicap one's performance. Further, in contrast to the literature on choking under pressure, where performance is compared across pressure and no-pressure situations, we held the objective form of pressure constant across experimental conditions in our studies (e.g., same monetary rewards, competitor with the same rank). Under all of these conditions, we find that focal actors experience psychological pressure because of their opponent's momentum and perform inadequately. By employing a mixed-method approach, using field and experimental studies that measure and manipulate the mediator via the process of moderation and preregistering the studies in advance, our work follows the recommendation of several scholars to use a full-cycle approach when investigating a real-world phenomenon of interest (60).

In light of these findings, there are several fruitful directions for future research. Since our goal was to examine the impact of an opponent's upward momentum, we intentionally restricted our focus to others' positive momentum in experimental studies. Hence, future research could explore how an opponent's negative momentum may affect the focal actor's performance in a hierarchy. There is also an opportunity to examine how the velocity of change in status momentum (i.e., a jump of 3 ranks versus 9) across time might affect the focal actor's threat perception differently. Another possible limitation of our work is the lack of consideration given to individual dispositional or situational factors that could amplify or attenuate the impact of others' momentum. For example, having a history of highly competitive interactions (61) can make a competitor with positive momentum appear more threatening than a competitor with no such history; this is an interesting proposition and could provide a useful direction for future work. Finally, the psychological momentum literature treats decision-making based on momentum as irrational (18). Likewise, research on competition would proffer a rational view of using current rank rather than momentum as the most objective criterion to assess a competitor. However, evolutionary psychology underscores the importance of avoiding conflict by gauging others' status in advance using any relevant information, thereby increasing one's adaptiveness to the environment (62–64). Thus, future research may examine the contexts where focusing on opponent momentum as a heuristic can be irrational versus adaptive. Nonetheless, our findings offer important insights into how competitive hierarchies are negotiated over time.

Christian Doppler's observation that motion of a source affects the experience of a stationary observer appears to extend well beyond sound and light waves. As this research has demonstrated, the motion of a social competitor toward a higher-status actor similarly amplifies that actor's experience of psychological threat, and, in turn, impairs performance.

Ethics Approval. The ethics approval for this project was provided by the London Business School per the school's guidelines. All participants provided informed consent prior to participation.

Data Availability. All experimental data reported in the paper including the study protocol and stimulus materials are available at https://osf.io/jv5aw/.

PSYCHOLOGICAL AND COGNITIVE SCIENCES

1. R. H. Frank, P. J. Cook, *The Winner-Take-All Society: Why the Few at the Top Get So Much More Than the Rest of Us* (Penguin Books, reprint ed., 1996).
2. C. Anderson, O. P. John, D. Keltner, A. M. Kring, Who attains social status? Effects of personality and physical attractiveness in social groups. *J. Pers. Soc. Psychol.* **81**, 116–132 (2001).
3. R. F. Báles, F. L. Strodtbeck, T. M. Mills, M. E. Roseborough, Channels of communication in small groups. *Am. Sociol. Rev.* **16**, 461–468 (1951).
4. J. C. Magee, A. D. Galinsky, Social hierarchy: The self-reinforcing nature of power and status. *Acad. Manage. Ann.* **2**, 351–398 (2008).
5. N. E. Adler, E. S. Epel, G. Castellazzo, J. R. Ickovics, Relationship of subjective and objective social status with psychological and physiological functioning: Preliminary data in healthy white women. *Health Psychol.* **19**, 586–592 (2000).
6. C. Anderson, J. A. D. Hildreth, L. Howland, Is the desire for status a fundamental human motive? A review of the empirical literature. *Psychol. Bull.* **141**, 574–601 (2015).

7. J. Berger, B. P. Cohen, M. Zelditch, Status characteristics and social interaction. *Am. Sociol. Rev.* **37**, 241 (1972).
8. C. Bendersky, N. A. Hays, Status conflict in groups. *Organ. Sci.* **23**, 323–340 (2012).
9. J. M. Brett *et al*., Sticks and stones: Language, face, and online dispute resolution. *Acad. Manage. J.* **50**, 85–99 (2007).
10. D. C. Hambrick, A. A. Cannella, Relative standing: A framework for understanding departures of acquired executives. *Acad. Manage. J.* **36**, 733–762 (1993).
11. F. J. Flynn, How much should I give and how often? The effects of generosity and frequency of favor exchange on social status and productivity. *Acad. Manage. J.* **46**, 539–553 (2003).
12. P. M. Blau, *Exchange and Power in Social Life* (Transaction Publishers, 2017).
13. N. A. Hays, C. Bendersky, Not all inequality is created equal: Effects of status versus power hierarchies on competition for upward mobility. *J. Pers. Soc. Psychol.* **108**, 867–882 (2015).
14. M. Washington, E. J. Zajac, Status evolution and competition: Theory and evidence. *Acad. Manage. J.* **48**, 282–296 (2005).
15. C. Bendersky, J. Pai, Status dynamics. *Annu. Rev. Organ. Psychol. Organ. Behav.* **5**, 183–199 (2018).
16. T. L. Hubbard, The varieties of momentum-like experience. *Psychol. Bull.* **141**, 1081–1119 (2015).
17. T. Gilovich, R. Vallone, A. Tversky, The hot hand in basketball: On the misperception of random sequences. *Cognit. Psychol.* **17**, 295–314 (1985).
18. K. D. Markman, C. L. Guenther, Psychological momentum: Intuitive physics and naive beliefs. *Pers. Soc. Psychol. Bull.* **33**, 800–812 (2007).
19. S. T. Fiske, "Interpersonal stratification: Status, power, and subordination" in *Handbook of Social Psychology*, S. T. Fiske, D. T. Gilbert, G. Lindzey, Eds. (Wiley, ed. 5, 2010), vol. 2, pp. 941–982.
20. N. C. Pettit, N. Sivanathan, E. Gladstone, J. C. Marr, Rising stars and sinking ships: Consequences of status momentum. *Psychol. Sci.* **24**, 1579–1584 (2013).
21. N. C. Pettit, K. Yong, S. E. Spataro, Holding your place: Reactions to the prospect of status gains and losses. *J. Exp. Soc. Psychol.* **46**, 396–401 (2010).
22. N. C. Pettit, S. P. Doyle, R. B. Lount, C. To, Cheating to get ahead or to avoid falling behind? The effect of potential negative versus positive status change on unethical behavior. *Organ. Behav. Hum. Decis. Process.* **137**, 172–183 (2016).
23. J. C. Marr, S. Thau, Falling from great (and not-so-great) heights: How initial status position influences performance after status loss. *Acad. Manage. J.* **57**, 223–248 (2014).
24. F. J. Flynn, E. T. Amanatullah, Psyched up or psyched out? The influence of coactor status on individual performance. *Organ. Sci.* **23**, 402–415 (2010).
25. M. S. Bothner, J. Kang, T. E. Stuart, Competitive crowding and risk taking in a tournament: Evidence from NASCAR racing. *Adm. Sci. Q.* **52**, 208–247 (2007).
26. H. Piezunka, W. Lee, R. Haynes, M. S. Bothner, Escalation of competition into conflict in competitive networks of Formula One drivers. *Proc. Natl. Acad. Sci. U.S.A.* **115**, E3361–E3367 (2018).
27. C. Y. Chiu, Y. Y. Hong, C. S. Dweck, Lay dispositionism and implicit theories of personality. *J. Pers. Soc. Psychol.* **73**, 19–30 (1997).
28. Z. Kunda, Motivated inference: Self-serving generation and evaluation of causal theories. *J. Pers. Soc. Psychol.* **53**, 636–647 (1987).
29. D. T. Wegener, R. E. Petty, "The flexible correction model: The role of naive theories of bias in bias correction" in *Advances in Experimental Social Psychology*, P. Zanna, Ed. (Academic, 1997), vol. 29, pp. 141–208.
30. J. J. Freyd, R. A. Finke, Representational momentum. *J. Exp. Psychol. Learn. Mem. Cogn.* **10**, 126–132 (1984).
31. D. Cohen-Zada, A. Krumer, Z. Shtudiner, Psychological momentum and gender. *J. Econ. Behav. Organ.* **135**, 66–81 (2017).
32. S. E. Iso-Ahola, K. Mobily, "Psychological momentum": A phenomenon and an empirical (unobtrusive) validation of its influence in a competitive sport tournament. *Psychol. Rep.* **46**, 391–401 (1980).
33. J. M. Silva, C. J. Hardy, R. K. Crace, Analysis of psychological momentum in intercollegiate tennis. *J. Sport Exerc. Psychol.* **10**, 346–354 (1988).
34. D. Hendricks, J. Patel, R. Zeckhauser, Hot hands in mutual funds: Short-run persistence of relative performance, 1974–1988. *J. Finance* **48**, 93–130 (1993).
35. J. Chevalier, G. Ellison, Risk taking by mutual funds as a response to incentives. *J. Polit. Econ.* **105**, 1167–1200 (1997).
36. G. Charness, D. Masclet, M. C. Villeval, The dark side of competition for status. *Manage. Sci.* **60**, 38–55 (2013).
37. D. Stewart, Social status in an open-source community. *Am. Sociol. Rev.* **70**, 823–842 (2005).
38. K. Corcoran, J. Crusius, T. Mussweiler, "Social comparison: Motives, standards, and mechanisms" in *Theories in Social Psychology*, D. Chadee, Ed. (Wiley-Blackwell, 2011), pp. 119–139.
39. I. Greenlees, A. Bradley, T. Holder, R. Thelwell, The impact of opponents' non-verbal behaviour on the first impressions and outcome expectations of table-tennis players. *Psychol. Sport Exerc.* **6**, 103–115 (2005).
40. C. K. Hsee, Y. Tu, Z. Y. Lu, B. Ruan, Approach aversion: Negative hedonic reactions toward approaching stimuli. *J. Pers. Soc. Psychol.* **106**, 699–712 (2014).
41. J. Berger *et al*., "Formation of reward expectations in status situations" in *Status Power Legitimacy*, J. Berger, M. Zelditch Jr., Eds. (Routledge, 1998), pp. 121–154.
42. R. V. Gould, The origins of status hierarchies: A formal theory and empirical test. *Am. J. Sociol.* **107**, 1143–1178 (2002).
43. P. B. Carr, C. M. Steele, Stereotype threat affects financial decision making. *Psychol. Sci.* **21**, 1411–1416 (2010).
44. B. M. Staw, L. E. Sandelands, J. E. Dutton, Threat rigidity effects in organizational behavior: A multilevel analysis. *Adm. Sci. Q.* **26**, 501–524 (1981).
45. C. M. Steele, J. Aronson, Stereotype threat and the intellectual test performance of African Americans. *J. Pers. Soc. Psychol.* **69**, 797–811 (1995).
46. A. Anderson, E. A. Green, Personal bests as reference points. *Proc. Natl. Acad. Sci. U.S.A.* **115**, 1772–1776 (2018).
47. S. Y. Lee, S. Kesebir, M. M. Pillutla, Gender differences in response to competition with same-gender coworkers: A relational perspective. *J. Pers. Soc. Psychol.* **110**, 869–886 (2016).
48. D. W. Johnson, A. A. Norem-Hebeisen, A measure of cooperative, competitive, and individualistic attitudes. *J. Soc. Psychol.* **109**, 253–261 (1979).
49. T. Buser, N. Peter, S. C. Wolter, Gender, competitiveness, and study choices in high school: Evidence from Switzerland. *Am. Econ. Rev.* **107**, 125–130 (2017).
50. T. Buser, M. Niederle, H. Oosterbeek, Gender, competitiveness, and career choices. *Q. J. Econ.* **129**, 1409–1447 (2014).
51. M. Niederle, L. Vesterlund, Gender and competition. *Annu. Rev. Econ.* **3**, 601–630 (2011).
52. S. J. Spencer, M. P. Zanna, G. T. Fong, Establishing a causal chain: Why experiments are often more effective than mediational analyses in examining psychological processes. *J. Pers. Soc. Psychol.* **89**, 845–851 (2005).
53. C. M. Steele, Stereotyping and its threat are real. *Am. Psychol.* **53**, 680–681 (1998).
54. N. Sivanathan, D. C. Molden, A. D. Galinsky, G. Ku, The promise and peril of self-affirmation in de-escalation of commitment. *Organ. Behav. Hum. Decis. Process.* **107**, 1–14 (2008).
55. J. R. Edwards, L. S. Lambert, Methods for integrating moderation and mediation: A general analytical framework using moderated path analysis. *Psychol. Methods* **12**, 1–22 (2007).
56. B. Green, J. Zwiebel, The hot-hand fallacy: Cognitive mistakes or equilibrium adjustments? Evidence from major league baseball. *Manage. Sci.* **64**, 5315–5348 (2017).
57. S. L. Beilock, R. Gray, "Why do athletes choke under pressure?" in *Handbook of Sport Psychology*, R. C. Eklund, Ed. (Wiley, ed. 3, 2007), pp. 425–444.
58. S. L. Beilock, C. A. Kulp, L. E. Holt, T. H. Carr, More on the fragility of performance: Choking under pressure in mathematical problem solving. *J. Exp. Psychol. Gen.* **133**, 584–600 (2004).
59. B. P. Lewis, D. E. Linder, Thinking about choking? Attentional processes and paradoxical performance. *Pers. Soc. Psychol. Bull.* **23**, 937–944 (1997).
60. C. R. Mortensen, R. B. Cialdini, Full-cycle social psychology for theory and application. *Soc. Personal. Psychol. Compass* **4**, 53–63 (2010).
61. G. J. Kilduff, H. A. Elfenbein, B. M. Staw, The psychology of rivalry: A relationally dependent analysis of competition. *Acad. Manage. J.* **53**, 943–969 (2010).
62. R. M. Sapolsky, *A Primate's Memoir: Love, Death and Baboons in East Africa* (Vintage Digital, 2011).
63. G. E. Schaller, *The Mountain Gorilla: Ecology and Behavior* (University of Chicago Press, 1963).
64. C. Boehm, J. C. Flack, "The emergence of simple and complex power structures through social niche construction" in *The Social Psychology of Power*, A. Guinote, T. K. Vescio, Eds. (Guilford, 2010), pp. 46–86.