Fighting Alone versus Fighting for a Team: An Experiment on Multiple Pairwise Contests*

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Abstract

People who compete alone may entertain different psychological motivations from those who compete for a team. We examine how psychological motivations influence individual competitive behavior in response to a head start or a handicap when competing alone or competing for a team. We find that contestants' behavior in both individual and team contests exhibits a psychological momentum effect, whereby leaders fight harder than trailers. However, the momentum effect is significantly larger in individual contests than in team contests and further disappears in team contests that are enriched with pre-play communication. The standard economic model, which predicts neither momentum effects nor treatment differences, fails to explain our findings. The findings can be better explained by a combination of two behavioral models: disappointment aversion and team spirit.

Keywords: individual versus team behavior, multiple pairwise contest, head start, psychological momentum effect, disappointment aversion, team spirit

JEL Classification: C72, C91, C92, D79

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1 Introduction

Competitions between teams or groups are pervasive in economic and political activities. Sports teams compete for trophies; political parties compete to ensure a majority of seats in a parliament; universities compete in rankings to attract more students and grants; and private firms compete to boost revenues. In many cases, a team competition unfolds over multiple stages and the winning team is determined by some aggregated measures (Konrad, 2009). Like many other types of team competitions, a multiple-stage team competition presents a fundamental tension between individual and team incentives. Individuals on a team receive feedback about their teammates' and an opposing team's performance in previous stages and know that their teams are either leading or trailing. They must weight their fighting costs against the increased probability of their team's winning and then decide whether and how hard to fight.

In past studies, such a tension within a team has often been modeled as a public goods game (Nalbantian and Schotter, 1997; Gunnthorsdottir and Rapoport, 2006; Tan and Bolle, 2007; Sutter and Strassmair, 2009; Leibbrandt and Sääksvuori, 2012; Chen and Lim, 2013; Markussen, Reuben, and Tyran, 2014) or as a coordination game (Bornstein, Gneezy, and Nagel, 2002; Cason, Sheremeta, and Zhang, 2012). Every team member will decide simultaneously on their own input; the winning team is determined by comparing the joint production of each competing team (Abbink, Brandts, Herrmann, and Orzen, 2010; Ahn, Isaac, and Salmon, 2011). These studies have provided important insights into how individuals compete in a team compared to when they are alone (see comprehensive reviews of experimental studies on group contests by Dechenaux, Kovenock, and Sheremeta (2015) and Sheremeta (2018)). While strategic interdependence in these games captures important features of intra-group dynamics, such frameworks do not allow for a clear-cut test of the *pure psychological* influences of a team situation on individual competitive behavior. This is an important shortcoming to address because simply being in a team situation could affect intrinsic motivations, which might or might not interact with strategic incentives to influence behavior.

The aim of this paper is to compare individual behavior when competing alone and when competing on a team, absent any confounding factors due to strategic interdependence and uncertainty about other players' behavior. With this purpose, we study a stylized team competition, known as a multiple pairwise contest (Fu, Lu, and Pan, 2015b), in which the fundamental tension between team and individual takes place dynamically. Using a real-effort experiment, we examine how being ahead or behind influences individual competitive behavior. In particular, we ask how individuals' efforts in a team differ from those in a situation where they have to work alone and thus respond to a *given* head start or a handicap.[1]

Consider the following sequential best-of-three team contest, which is a special case of multiple pairwise contests. Six symmetric players compete in three-member teams for a prize, which will be awarded to each member of the winning team. The contest comprises three pairwise battles, which are played out sequentially, and each battle is between two players, one from each team. Henceforth, we refer to the paired players in the first battle as "first movers," pairs in the second battle as "second movers," and pairs in the third battle as "third movers." In each battle, the two players exert effort independently after they learn about the outcomes of previous battles. The first team to win two out of three battles wins the contest. In this team contest, a rational second mover's effort does not depend on being ahead or behind after the first battle.[2] Notably, this neutrality result is largely driven by the contest structure. Hence, once we remove all movers except for second movers, we are able to construct a structurally-equivalent individual contest while holding constant the underlying strategic incentives for second movers. Theoretically, in this individual contest, a given head start or handicap will continue to have no bearing on second movers' efforts. We can thus cleanly compare individual behavior when competing alone to when competing on a team, absent any strategic confounds usually present between these two situations.

Our experimental results strongly reject the standard theory predictions. Second movers' behavior in both individual and team contests exhibits a "psychological momentum effect," in which second movers who were ahead worked harder than those who were behind. The momentum effect was significantly smaller in team contests than in individual contests. Importantly, the psychological influence of a team situation worked mainly on trailers who exerted greater efforts in teams than when alone, whereas the effect on leaders' efforts was null.

[1] Head starts have been theoretically studied in single-stage contests by, for example, Siegel (2014). In an early experiment, Schotter and Weigelt (1992) studied how individual effort responds to a head start in a simultaneous two-person tournament, named as the unfair tournament. In practice, head starts or handicaps could arise due to, for instance, unduly favoring some competitors in sales contests or firms' earlier entry into market competitions.

[2] The sequential best-of-three team contest was first theoretically introduced by Fu et al. (2015b) and then tested experimentally using a real-effort task by Fu, Ke, and Tan (2015a) and empirically using data from squash tournaments by Dong and Huang (2018). Both tests found that individual behavior closely followed the theory prediction. This contest structure resembles some real-world competitive situations. One example is some large-scale projects in private enterprises. Development of new technologies, for example, is usually split and outsourced to members of R&D alliances: the famous Intel-Sony-Toshiba alliance sequentially took on development, customization and manufacturing of a new cell microprocessor (Fosu, 2013). Other examples of such team contests are political races for a majority of seats in a parliament. Political candidates from opposing parties battle against each other and their successes depend on their campaigning effort, which is only minimally coordinated and funded by the political party they belong to (Ansolabehere, de Figueiredo, and Snyder, 2003). Victories, however marginal, in two constituencies can always count more than a huge success in only one.

To model the individual behavior observed in our experiment, we turn to behavioral models by introducing non-standard preferences to the standard benchmark as ex-post rationalization. An important research program in behavioral economics has been the development of theories of reference-dependent preferences, and in particular disappointment aversion (e.g., Bell, 1985; Loomes and Sugden, 1986; Kőszegi and Rabin, 2006). These theories have obvious relevance to team and individual contests, which naturally result in winners and losers, gains and losses (Gill and Prowse, 2012; Gächter, Huang, and Sefton, 2018). It is typically posited that disappointment from losing is a stronger emotion than elation from winning. In our context, we assume that disappointment-averse second movers dislike losing the *whole* match to a greater extent than they enjoy winning it. Thus, they will incur a negative utility (from being disappointment averse) when the match has to move on to the third battle to determine the match outcome. The negative utility, however, creates opposite incentives for leaders and trailers: while leaders work harder to avoid the negative utility that is only incurred when the match moves on to the third battle, trailers have no choice but to incur this negative utility and thus have weaker motivation to work than if they are not affected by disappointment aversion. Consequently, in contrast to the standard theory, a model based on disappointment aversion predicts a psychological momentum effect in which individuals who are ahead will compete harder than those who are behind, consistent with our experimental data.

How might a team situation influence the strength of the psychological momentum effect? Previous studies on team versus individual differences have frequently used "team spirit" as a general mechanism which may encompass various sub-mechanisms specific to different team situations (Tajfel, Billig, Bundy, and Flament, 1971; Sutter and Strassmair, 2009; Babcock, Bedard, Charness, Hartman, and Royer, 2015). In our context, we suggest that guilt or responsibility aversion might be a plausible mechanism. Specifically, guilt-averse trailers fight harder to avoid losing their battles (which will cause their team's defeat in the whole contest) than leaders (Chen and Lim, 2013; Babcock et al., 2015). From a slightly different perspective, a notion of responsibility aversion suggests that trailers do not want to be the one responsible for their team's defeat and this creates a stronger incentive for them to fight harder than trailers fighting individually (Leonhardt, Keller, and Pechmann, 2011). We use the term "responsibility-alleviation effect," coined by Charness (2000), to capture the common idea underlying these concepts that players in the trailing position feel increasingly responsible, charging internal impulses toward loyalty, honesty, generosity and, in our case, greater effort to win the battle. Combined with disappointment aversion, the responsibility-alleviation effect predicts that the effort gap between leaders and trailers in team contests is narrower than that in individual contests because trailers increase their efforts in teams.

To better understand whether the treatment difference could be attributed to team spirit or specifically the responsibility-alleviation effect, we conduct an additional team contest treatment in which teammates can briefly communicate before the contest starts. Communication within a team will help decrease the social distance among teammates (Sutter and Strassmair, 2009). We thus expect that, with team communication, trailers are more likely to be influenced by team spirit than without communication. Consistent with this hypothesis, the momentum effect was eliminated as trailers caught up by exerting the same level of effort as leaders.

Finally, to test disappointment aversion as the plausible explanation for the psychological momentum effect, we conduct another individual contest treatment that has a best-of-five structure but with all movers except for the second movers replaced by a computer. Again, we focus on second movers' behavior and observe a similar psychological momentum effect, as predicted by disappointment aversion. This helps us to rule out some other explanations of our results, such as goal-based reference-dependent preferences, trailers' choking under pressure or leaders' uncertainty aversion.

The present study primarily contributes to the literature on how social or team situations shape individual competitive behavior. The economics and psychology literatures have explored the effect of a team situation on individual competitive behavior in a myriad of ways. Studies on social categorization and group identity have mainly looked at influences on individuals' other-regarding preferences, biases and behaviors toward their own teammates and opposing players (Sherif, Harvey, White, Hood, and Sherif, 1961; Tajfel and Turner, 1979; Charness, Rigotti, and Rustichini, 2007; Chen and Li, 2009). Sherif et al. (1961)'s seminal contribution shows that simply grouping people into different teams on a random basis could give rise to animosity and hostility against other team members, even when there are no material consequences of conflicts. This line of research was continued in the social psychology literature by Amnon Rapoport, Gary Bornstein and their colleagues, who studied the effects of inter-group competition on intra-group cooperation in controlled lab experiments (Rapoport and Bornstein, 1987; Bornstein, 1992, 2003). More recently, economists have applied game-theoretic analyses to study the effect of team incentives on individuals' strategic behavior in competitions (e.g., Nalbantian and Schotter, 1997; Abbink et al., 2010; Chen and Lim, 2013).

We have now gained a deep understanding of individual motivations in teams, such as when they choose to free-ride on other team members, when they try to second-guess each other by picking up the slack left by others, and when they choose to cooperate in anticipation of reciprocity from team members. Yet, we know little about the pure psychological influences of a team situation on individual motivations, which might interact with strategic incentives in unexpected ways. Our study takes the first step to identify pure psychological influences by investigating the difference between fighting alone versus fighting on a team in a dynamic team competition (which, although specific, presents the same fundamental tension between team and individual as do many other types of team competitions).

This paper also contributes to a growing literature on individual motivations in dynamic contests, especially team contests (Fu et al., 2015a,b; Häfner, 2017; Feng and Lu, 2018). In all of the different variants of multiple pairwise team contests, a central theoretical observation is the neutral response to previous battle outcomes, as is true in the standard theory of this paper. However, we find evidence for momentum effects in team contests without communication. Only in teams with communication do we finally observe neutral responses to previous battle outcomes. Together, our findings highlight the importance of team spirit in elevating trailers' efforts in team settings. The two most closely related papers are Fu et al. (2015a) and Dong and Huang (2018), who use a real-effort experiment and naturally-occurring data from squash tournaments, respectively, to test the neutral response prediction in the same sequential best-of-three team contest. Data in neither of the two studies reject this prediction. We conjecture that the previously observed neutral behavior could be due to either the absence of explicit effort costs or the presence of a rich context of team play. Both in Fu et al. (2015a) and Dong and Huang (2018), players have no direct costs of effort that could deter them from exerting the maximum amount of effort to win the contest. Furthermore, in Dong and Huang (2018), sports teams naturally operate under a much richer context than a typical experiment can achieve in the lab. With this in mind, we implemented a team contest in a more sterile team environment and compared it to a case where the team environment was enriched with pre-play communication. Moreover, we used a novel real-effort task that bears explicit monetary costs of effort. By doing so, our treatments allowed us to isolate the underlying economic incentives from the team situation altogether. This explicit control of strategic incentives is absent in previous studies.

Despite our main interest in the difference between fighting alone and fighting for a team, we also investigate the reasons behind the observed strong psychological momentum effects that contradict the standard economic theory prediction. Our findings in individual contests thus add to the debate on the existence of psychological momentum effects. So far, the literature shows mixed evidence on psychological momentum effects and they often work in opposite directions. For example, the experiments reported in Berger and Pope (2011) and Fu et al. (2015a) suggest a different form of psychological momentum effect from ours: leaders slack off while trailers work harder. The disparate findings may partly arise from the fact that our individual contests only consist of a single effort-exerting battle and that leading and trailing positions are created by exogenous manipulations, whereas in Berger and

Pope (2011) and Fu et al. (2015a) the strategic positions are determined by efforts in earlier battles. Thus, one possible explanation is that leaders may think they can afford to slack off with their earlier advantage but only if the advantage is earned by hard work rather than endowed by chance. The difference might also be attributed to a sunk-cost effect: successful investment in a prior battle triggers higher future investment (Mago and Sheremeta, 2019).

2 Experimental Design

All treatments in our experiment had the same two-part structure. The first part, which was the same across all treatments, consisted of four rounds with the last three rounds incentivized by a piece rate. The first part was primarily meant to familiarize subjects with the real-effort work task, which was also used in the second part.

We used the ball-catching task as our real-effort task (Gächter, Huang, and Sefton, 2016). Subjects had a fixed amount of time to catch balls that fell randomly from the top of the screen by using mouse clicks to move a tray at the bottom of the screen. The *number of clicks* is interpreted as the *effort* in a round. Given that most previous real-effort experiments use task performance as a noisy measure of effort, in Section 3.2 we used the number of catches as an alternative measure of effort for robustness check. The ball-catching task permits a level of control over the effort-cost function by attaching financial costs to mouse clicks and thus to effort levels. Therefore, subjects who worked on the ball-catching task had to engage in an explicit trade-off between the benefits of a higher probability of winning and the costs of higher effort. Previous experiments using the ball-catching task have shown that the effort (the number of clicks) does respond both qualitatively and quantitatively to various incentives such as piece rates, team incentives, and tournaments (Gächter et al., 2016; Büyükboyacı and Robbett, 2017). Our version of the task lasts only one minute and thus allows us to repeatedly measure the behavior of each subject. The task thus combines the advantages of induced-effort tasks, giving us control over monetary effort costs, and of real-effort tasks, providing arguably stronger realism.[3]

[3]Gächter et al. (2016) showed in various experiments that the point predictions are indeed borne out and are consistent with the corresponding induced-value experiments. This suggests that while some subjects may click more carefully than others, it is no more than the fact that some subjects in induced-value experiments may make more accurate calculations than others. Heterogeneous ability (physical or cognitive) or non-monetary costs and benefits always exist to some degree. The key point is that clicks as effort are costly and it is the fact that the ball-catching task satisfies the precepts of non-satiation, salience and especially dominance (Smith, 1982) that provide the necessary control of the experimental environment.

2.1 Pairwise Team Contest

We varied the second part of the experiment across treatments. The TEAM treatment parallels a theoretical best-of-three team contest with symmetric players. In the best-of-three contest, three battles occur sequentially. In each battle, one player from each team plays against an opponent from the rival team and the side performing better (catching more balls) wins the battle. The team that wins two out of three battles wins the contest. We denote a player's effort, $e_i(t)$, $i = A, B$; $t = 1, 2, 3$, where i is the team to which the player belongs and t the order of her battle. The marginal cost of effort is normalized to 1. The winning team receives a prize of V for each member while the losing team gets v; $V > v > 0$.

In each of the 12 paid rounds of TEAM, subjects competed in three-member teams by working sequentially on the ball-catching task. To minimize the possibility of reputation and other peer effects due to identification of other subjects' past behavior, both the team composition and the matching of two competing teams in a contest were randomized every round at the session level. After the matching was completed, each subject in a team was assigned to the role of either First, Second or Third Mover. Subjects did not know others' identities or performance histories at any point during the session.

With the session-level randomization, we created ex-ante symmetric team competition, since ex-ante each third mover had the same probability of winning the third battle. By keeping the valuation of winning for all second movers constant, we ensured that each second mover, whether ahead or behind, faced the same level of economic incentives. By doing so, we also ensured that risk attitudes could not systematically explain any treatment differences in second movers' behavior conditional on being ahead and behind.

Within a contest, the feedback structure was kept as simple as possible insofar as the theory permitted: each of the six subjects in a team competition received feedback on previous battle outcomes, but not on the actual number of balls caught by previous movers. We chose such minimal feedback because, if team members could observe each other's actual performance, it might give rise to additional strategies such as dropping out of their own battles after being disappointed by other team members' poor performance or other reputational concerns given the observability of effort choices. Lastly, a third battle would not occur if one team had already won the first two battles. Along with the randomization, this last feature was designed to minimize second movers' uncertainty about third movers' actions because, unlike the first battle (which is indecisive) and the second battle (which is ex-post unfair), the third battle, if necessary, is both decisive and fair for both third movers, and therefore not likely to cause uncertainty about its expected outcome.[4]

[4]Note that in equilibrium there is no strategic uncertainty about the expected outcome of the third battle. Even if subjects may have some psychological uncertainties, given the session-level randomization, perceiving

2.2 Individual Contest

In IND_Bo3, we deprived second movers of the team situation while retaining the basic economic incentives. Specifically, the individual contest mimicked the second battle in a best-of-three contest of TEAM. Recall that in each second battle, one player was on the leading team and the other was on the trailing team. The player on the leading team was in a position where, if she won the battle, her team won the contest, whereas if she lost, the contest outcome was essentially determined by a fair coin toss. This is because, from the perspective of the second movers, the two third movers were ex-ante symmetric. Conversely, the opposing player on the trailing team was in a position where, if she lost the battle, her team lost the contest, whereas if she won, the contest outcome was equivalent to a fair coin toss.

Therefore, in IND_Bo3 we removed the team situation by using two separate fair coin tosses to determine first and third battle outcomes, respectively. Specifically, subjects received feedback after the first fair coin toss telling them whether they won or lost in the first battle, and then they only competed in the second battle; the third battle, the result of which was determined by another fair coin toss, only followed in the case of a tie after the first two battles. As a result, second movers would respond to the situation of being ahead or behind, which was exogenously given by a random device as opposed to a similar situation which was endogenously determined by the first battle fought by other players in team contests. As in TEAM, the contest in IND_Bo3 was repeated for 12 rounds. Matching was randomized every round at the session level.[5]

2.3 Standard Economic Theory Prediction

Here, we show that the standard economic theory predicts a neutral response in effort to previous battle outcomes. Let $P_i(e_i, e_j)$, $i, j = A, B$; $i \neq j$ denote the probability that

the third battle as a 50-50 chance is the most natural and focal assumption. Supporting this view, ex-post analysis of the data shows that third movers' effort levels (as well as probability of winning) do not depend on second movers' strategic positions, implying that second movers (who themselves sometimes play as third movers) should at least learn to realize the third battle outcome does not depend on previous battle histories.

[5]As a robustness check, we also did another individual contest treatment which aims to further remove the best-of-three structure while still holding the underlying economic incentives constant. Specifically, we assigned one player the Red Type, which corresponded to a second mover on a leading team, and the other player the Blue Type, which corresponded to a second mover on a trailing team. Accordingly, the rule of winning became as follows: if the Red Type caught more balls than the Blue Type, she would win the contest; if the Blue Type caught more balls than the Red Type, the contest outcome would be determined by a fair coin toss; and if there was a tie, the contest outcome would again be determined by a fair coin toss. Therefore, we retained the basic economic incentives in the second battle of a best-of-three team contest, while converting the second battle into a strategically equivalent (asymmetric and unfair) individual contest. The experimental results in this treatment are very similar to IND_Bo3. Reports are available upon request.

player i wins in a battle; $P_A(e_A, e_B) + P_B(e_A, e_B) = 1$. Similar to Fu et al. (2015a), we assume that the winning rule only has to follow four regularity conditions, which are satisfied by the most popular contests in the literature, e.g., lottery contests and all-pay auctions. First, $P_i(e_i, e_j)$ increases in one's own effort, e_i, and decreases in the opponent's effort, e_j. Second, independence: if a pair equally values winning the battle, there is a unique stochastic equilibrium battle outcome that is independent of the common valuation of winning. Third, monotonicity: higher valuations of winning encourage players to exert greater effort. Fourth, fairness: if one player exerts zero effort, the other player wins the battle with any positive effort level; if both players exert zero effort, each wins with equal probability.

A key observation of the best-of-three structure is that, in each battle, the two players always face the same level of incentive to win. This is the case for the second movers, irrespective of their being on the leading or trailing team after the first battle. To see this, first note that if the third battle were to occur, from both second players' perspectives, each side would win with an ex-ante probability of 50%. The second mover on the leading team reasons that, if she wins, she receives the prize V immediately; if she loses, the third battle occurs and her expected payoff is $V/2 + v/2$. Thus, the prize incentive for her to win the battle is $V - (V/2 + v/2) = V/2 - v/2$. On the other hand, the opposing second mover on the trailing team reasons that, if she wins, the third battle occurs and the expected payoff is $V/2 + v/2$; if she loses, she receives v with certainty. Thus, the prize incentive for her to win the battle is also $V/2 + v/2 - v = V/2 - v/2$.

Since both second movers face the same prize incentive, in the (stochastic) equilibrium battle outcome, each player's probability of winning the battle is independent of the common valuation of winning thanks to the independence condition (Fu et al., 2015a). Therefore, the standard economic theory predicts that

Hypothesis 1. *Second movers' efforts are independent of their (team) being ahead or behind.*

Hypothesis 2. *Second movers' efforts are the same in TEAM and IND_Bo3.*

In section 4, we present behavioral models and alternative hypotheses as they are formulated after observing the (unexpected) results discussed in section 3. We will then implement additional treatments to further test predictions from these models.

2.4 Parametrization and Experimental Procedure

The parameters of the experiment were as follows. In the first part, the first round was not paid and the next three rounds were paid by a piece rate, in which each caught ball was worth 20 tokens while each click cost 10 tokens. In the second part, a winner in IND_Bo3 or each member of a winning team in TEAM was awarded a winner prize of 1200 tokens; a loser or each member of a losing team received a loser prize of 400 tokens. In both parts, the cost of each mouse click that moved the tray, that is the marginal cost of effort, was 10 tokens and this was kept constant across all treatments. Under this condition, we emphasize that a subject's optimal strategy is never to click as much as possible.[6] Subjects' earnings were the sum of their payoffs in both parts.

We ran both treatments in two different labs to collect more data. The first set of sessions, consisting of 6 sessions of TEAM and 2 sessions of IND_Bo3 with 30 subjects each, were conducted at the University of Surrey (UK) in May 2016. The second set of sessions, consisting of 2 sessions of TEAM and 6 sessions of IND_Bo3 with 18 subjects each, were conducted at the Nanjing Audit University (China) in September 2020. Each session lasted around 1.5 hours with an average payment of £11.4 (UK sessions) or 55 Renminbi (China sessions). We followed the same procedure in both labs: upon arriving at the lab, each participant was randomly allotted a computer booth by the experimenter. The instructions for the second part were distributed after subjects completed the first part. The software was programmed in z-Tree (Fischbacher, 2007). Full experimental instructions are reproduced in Online Appendix A.1.

3 Results

Throughout the paper, we pooled the data from UK and China sessions since the results from different labs were very similar. Separate results from each lab are reported in Online Appendix A.2 (including Figure A1, Table A1, Table A2 and Table A3). Before presenting our main results, Table 1 shows the clicks-catches data for all types of movers. As expected, third movers in teams clicked more than all other types of movers since their strategic incentive to fight is strongest. Second movers' efforts did not seem to differ between TEAM and IND_Bo3, but later we show that this disguises important differences between leaders and trailers.

Throughout the rest of the results section, we focus on second movers' behavior conditional on being ahead or being behind. To simplify the exposition of the results, we also refer to the players in IND_Bo3 as second movers. Our full sample consists of 864 observations of second movers' behavior for TEAM and 2016 observations for IND_Bo3. No observation is

[6]Figure A2 in Online Appendix A.2 shows the relation between clicks and catches and a fitted production function using the last three rounds data from the first part of TEAM and IND_Bo3. It shows that catches increase by clicks, but plateau at around 50 clicks, suggesting that more clicks may actually lead to fewer catches. However, clicking more than 50 times represent only 5% of all data. Thus, the number of clicks is predominantly within the range where the production function is concave and increasing.

Table 1: Descriptive Statistics for All Movers

Treatment		Clicks				Catches			
	Obs.	Mean	SD	Min	Max	Mean	SD	Min	Max
IND_Bo3									
All	2016	24.48	16.46	0	91	30.81	9.24	4	52
TEAM									
1st Mover	864	25.83	16.67	0	73	30.60	8.24	5	50
2nd Mover	864	25.97	16.97	0	79	30.99	8.78	4	49
3rd Mover	414	32.23	17.14	0	83	34.43	7.34	8	48

excluded from the analysis.

3.1 Second Mover's Effort

We calculated each second mover's average clicks and catches across rounds where they played as second movers, when they were both ahead and behind (note that in individual contests a subject always played as a second mover). Figure 1 displays the average clicks by second movers' leading and trailing positions for both treatments (the error bars in the figure should not be used to make statistical inferences as observations within a session might be correlated). Table A1 in Online Appendix A.2 presents detailed summary statistics on clicks and catches by leading and trailing positions.

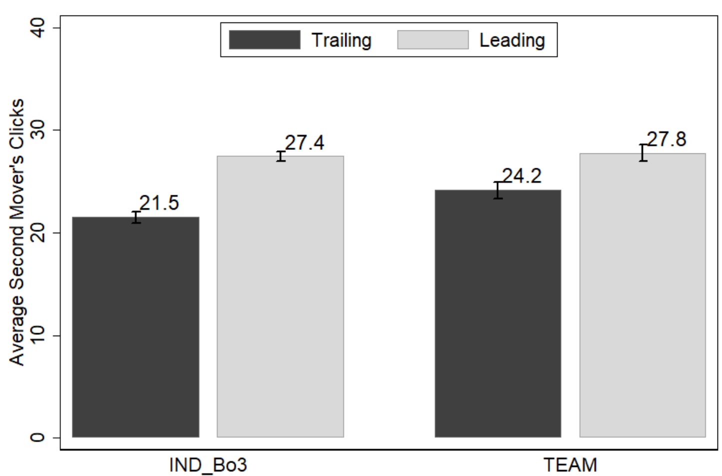


Figure 1: Average Second Mover's Clicks. *The error bars are ±SEM.*

To provide statistical evidence, we performed a random effects regression analysis of second movers' clicks by regressing the second mover's clicks on the binary variable—Lead—which takes the value of 1 in the round if this second mover was ahead and 0 if she was behind. The model also controls for the experience of playing the ball-catching task; the experience variable only accumulates in those rounds where a subject has actually worked on the ball-catching task, including the current round, and it is equal to the round variable if the subject has worked in all rounds. Table 2 reports the coefficient estimates. All standard errors are clustered at the session level using the standard panel bootstrap procedure with 500 replications.

Table 2: Random Effect Regressions of Second Mover's Clicks

	(1) IND_Bo3	(2) TEAM	(3) Pooled	(4) Pooled
Lead	5.319***	2.578**	2.650**	2.639**
	(0.645)	(1.137)	(1.080)	(1.131)
IND_Bo3			−2.576	−2.800*
			(1.713)	(1.544)
Lead × *IND_Bo3*			2.655**	2.638**
			(1.214)	(1.311)
Experience	−0.352*	−0.075	−0.296*	−0.297*
	(0.195)	(0.085)	(0.162)	(0.163)
Part1 Clicks				0.632***
				(0.062)
Constant	24.107***	25.161***	26.330***	11.220***
	(1.415)	(1.341)	(1.481)	(1.891)
σ_ω	10.839	13.105	12.024	9.864
σ_u	11.976	10.766	11.682	11.682
$overall R^2$	0.038	0.013	0.032	0.187
$N(matches)$	2016	864	2880	2880
$N(subjects)$	168	214	382	382
$N(clusters)$	8	8	16	16

Note: Standard errors are bootstrapped and clustered at the session level. σ_ω denotes the square root of the variation due to the persistent unobserved individual characteristics. σ_u represents the square root of the variation due to the transitory unobservables. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The estimates show that in IND_Bo3 and TEAM leaders made on average 5.32 and 2.58 more clicks than trailers, both of which were statistically significant at the 5% level. We termed this effect the psychological momentum effect. We also found that the momentum effect in IND_Bo3 was significantly stronger than in TEAM (p=0.029), as shown in the third column where we pooled data from both treatments and used TEAM as the benchmark. Finally, as a robustness check, in the last column we controlled for the individual's average

Table 3: Second Movers' Dropout Rates

Treatment	Trailing	Leading	Difference	SD	P-value
IND_Bo3	21.9%	6.6%	15.3%	0.019	<0.001
TEAM	16.4%	10.4%	6.0%	0.027	0.026

Note: Dropout rates are calculated by pooling over trailing and leading teams. P-values are from two-tailed tests using a standard bootstrap method allowing for clustering at the session level.

number of clicks in paid rounds of part 1. While the part 1 clicks significantly predicted the part 2 clicks, both the momentum effect and the treatment different remained significant.

Further analyses of the distribution of clicks show that the momentum effect was partly explained by trailers' greater propensity to drop out of the competition (i.e., no clicks were made) than leaders'. Dropping out or quitting behaviors are not uncommon in tournament-style situations and have previously been observed in both lab experiments (Schotter and Weigelt, 1992; Müller and Schotter, 2010) and field experiments (Fershtman and Gneezy, 2011). When comparing the proportions of dropping out between leaders and trailers, we used the bootstrap method to calculate the standard error for the difference in proportions to account for the possibility that some subjects might drop out disproportionally more often than others. Table 3 presents the results, showing that trailers were indeed much more likely to drop out than leaders in IND_Bo3 (21.9% vs. 6.6%). The difference was smaller but remained statistically significant in TEAM (16.4% vs. 10.4%).

In sum, our data reject the standard theory predictions (Hypotheses 1 and 2) which predict neither the momentum effect nor the treatment difference. Instead, we observed a psychological momentum effect in both individual and team contests; the effect was stronger in the individual contest than in the team contest.

3.2 Robustness

Given that the contests were repeated for multiple rounds in our experiment, was there any evidence that subjects learned to behave in accordance with the neutral response predicted by the standard theory? Table 4 re-estimates the specification used in Table 2 with an additional dummy indicating the first half (first six rounds) of a session. Contrary to the learning hypothesis, the estimates on the interaction term ($Lead \times FirstHalf$) show that the psychological momentum effects remained statistically significant in IND_Bo3 and TEAM. In fact, if there was any learning effect, it appeared that the psychological momentum effect was strengthened rather than weakened over the course of the experiment.

Given that most previous experimental studies typically used observed performance or output as a noisy measure of effort, we also replicated our previous analysis by using the

Table 4: Random Effect Regressions of Second Mover's Clicks in the First and Second Halves of All Rounds

	(1) IND_Bo3	(2) TEAM
Lead	6.120***	2.837***
	(0.616)	(1.052)
FirstHalf	0.941	1.189
	(0.924)	(1.312)
Lead × *FirstHalf*	−1.601***	−0.542
	(0.461)	(0.870)
Experience	−0.334	0.057
	(0.239)	(0.211)
Constant	23.521***	23.847***
	(1.503)	(2.311)
σ_ω	10.867	13.056
σ_u	11.976	10.773
$overall R^2$	0.039	0.012
$N(matches)$	2016	864
$N(subjects)$	168	214
$N(clusters)$	8	8

Note: Standard errors are bootstrapped and clustered at the session level. σ_ω denotes the square root of the variation due to the persistent unobserved individual characteristics. σ_u represents the square root of the variation due to the transitory unobservables. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

number of catches as an alternative measure of effort. Table 5 reports the results using the full sample. The results were qualitatively similar to the ones reported in Table 2 using the number of clicks as the dependent variable. Second movers caught significantly more balls when they were ahead than behind in IND_Bo3 and TEAM. Again, the momentum effect on catches was significantly stronger in IND_Bo3 than in TEAM (p=0.005).

4 Behavioral Models

In this section, we proceed by laying out two behavioral models which together explain our data. We also discuss two additional treatments to further test predictions from these models.

Table 5: Random Effect Regressions of Second Mover's Catches

	(1) IND_Bo3	(2) TEAM	(3) Pooled	(4) Pooled
Lead	3.563***	1.528**	1.536**	1.509**
	(0.268)	(0.629)	(0.679)	(0.682)
IND_Bo3			−0.938	−1.315
			(0.989)	(0.941)
$Lead \times IND\_Bo3$			2.025***	2.048***
			(0.723)	(0.735)
Experience	−0.292***	−0.250***	−0.285***	−0.285***
	(0.113)	(0.072)	(0.089)	(0.094)
$Part1\ Catches$				0.528***
				(0.060)
Constant	30.930***	31.631***	31.820***	15.014***
	(0.625)	(0.638)	(0.837)	(1.920)
σ_ω	5.587	5.863	5.655	5.078
σ_u	7.052	6.416	6.893	6.893
$overall R^2$	0.055	0.024	0.046	0.118
$N(matches)$	2016	864	2880	2880
$N(subjects)$	168	214	382	382
$N(clusters)$	8	8	16	16

Note: Standard errors are bootstrapped and clustered at the session level. σ_ω denotes the square root of the variation due to the persistent unobserved individual characteristics. σ_u represents the square root of the variation due to the transitory unobservables. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.1 Explaining the Treatment Difference: Team Spirit

A source of behavioral differences between competing alone and competing on a team is that a team situation might be associated with much richer social considerations, such as guilt, blame, responsibility, and social disapproval, than a strategically-equivalent individual situation. We refer to the general mechanism associated with the team situation as "team spirit." Team spirit may encompass various sub-mechanisms. In the following, we lay out a specific mechanism that is consistent with the treatment difference between TEAM and IND_Bo3. It is worth noting that this specific mechanism is an ex-post rationalization of our experimental results. There might be other mechanisms related to team spirit that can also explain our results. We will discuss the plausibility of some of them at the end of this subsection.

We assume that players in teams may feel guilty if they are perceived (by themselves or other team members) to be the one responsible for the team's defeat. Therefore, it is plausible that a trailer who loses will experience guilt to a greater extent than a leader who loses, simply because the trailer's loss leads *immediately* to the team's defeat. In the simplest formulation that is consistent with our experimental results, we assume that the leader will not experience guilt under any situation and therefore her prize incentive to win her battle remains unchanged. On the other hand, the trailer will experience a utility loss, $\theta(V-v)$, from feeling guilt when her team loses. θ is the guilt parameter and we assume the total amount of guilt felt by a losing trailer is proportional to the prize spread, that is, the prize loss each team member feels the losing trailer is responsible for. Therefore, her net prize incentive to win the battle will become larger than if she experiences no guilt, that is, $(V+v)/2-[v-\theta(V-v)]>(V-v)/2$. Hence, *we expect that being ahead or behind in an individual contest will cause a wider effort gap between leaders and trailers than in a team contest*. (It is worth noting that at face value the guilt aversion model appears to predict that trailers will exert higher effort than leaders. However, as our data have already shown that leaders exerted more effort than trailers in both contests, our intention here is to explain why the momentum effect was stronger in the individual contest than in the team contest. As we discuss in the next subsection, another behavioral model could explain the presence of the momentum effect. Thus, any effect of guilt will work on top of the momentum effect.)

A similar idea has been referred to in the psychology literature as responsibility aversion, which is defined as the preference to minimize one's causal role in outcome generation and thus perceived risk of responsibility (Leonhardt et al., 2011). Increased risk of responsibility is associated with the increased risk of experiencing guilt and blame. Assume that the trailer's loss is perceived as causal in the team's defeat whereas the leader's loss only leaves the uncertainty till the end of the third battle, and that the presence of uncertainty will lessen the trailer's perceived causal role in outcome generation. Then, *similar to the prediction of guilt aversion, the responsibility-averse trailer will have greater incentives than the leader to win her own battle*.

We prefer to use the term "responsibility-alleviation effect" coined by Charness (2000) to capture the common idea behind guilt/responsibility aversion that players generally avoid being in the position that bears greater responsibility. But if players find themselves in that position, responsibility augments internal impulses toward loyalty, honesty, and generosity. In our case, the trailer exerts greater effort to win the battle, which "alleviates" responsibility, blame, or guilt. The alleviation may also be related to people's reluctance in letting teammates down (Babcock et al., 2015), which essentially expresses a very similar idea.

One possible interpretation of the responsibility-alleviation effect is that trailers might "alleviate" their responsibility in their own battle by convincing themselves that they would not be responsible for the team's defeat even if they did not win the second battle. In other words, they might shift the blame or responsibility to the losing first mover and it would give them excuses for not fighting hard in their own battle. This reasoning would predict the opposite of what we have found about trailers who actually fought harder in TEAM compared to IND_Bo3. Thus, we highlight that the responsibility-alleviation effects refers to the guilt associated with the *immediacy* of losing the whole match due to trailers' loss, and such guilt in turn causes responsibility that can only be alleviated by fighting harder themselves.

4.1.1 Testing Team Spirit: Team Contest with Chat

To better understand the effect of competing in a team on individual behavior in team contests, we implemented an additional team treatment called TEAMCHAT, in which we manipulated the team spirit, or more specifically the responsibility that individuals might feel toward their team members by allowing one-minute intra-team communication at the beginning of each round. Past research has found that intra-team communication helps develop parochial altruism and promote cooperation, but at the cost of fiercer and less efficient inter-team competition (Sutter and Strassmair, 2009; Cason et al., 2012). Likewise, we also expect that intra-team communication will help foster stronger accountability toward one's own team and therefore increase players' efforts (Chen and Lim, 2013).[7] All other respects of TEAMCHAT were kept the same as TEAM, except that the team contest was repeated for only 10 rounds because we intended to keep the length of a session and the monetary incentive per unit of time similar to those in TEAM. After players knew about their mover types, they could send and receive messages for one minute before the contest started. They were allowed to chat about anything without identifying themselves in real life or using any offensive language. This treatment, with its enriched team environment and more social closeness among the teammates, allows us to further test for the team spirit and responsibility-alleviation effect, which might drive the difference between competing alone and competing on a team (Sutter and Strassmair, 2009).[8] Comparing TEAMCHAT to TEAM, we form the following hypothesis:

Hypothesis 3. *The effort gap between leaders and trailers is narrower in TEAMCHAT than in TEAM.*

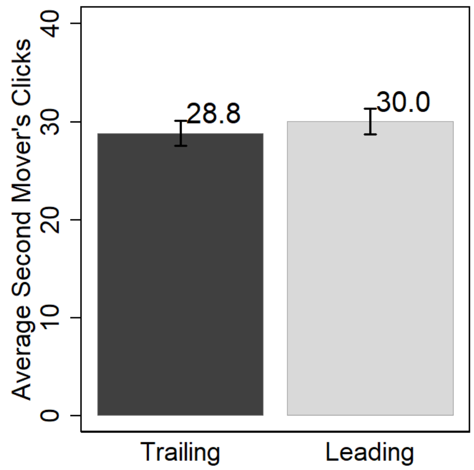


Figure 2: Average Second Mover's Clicks in TEAMCHAT. *The error bars are ±SEM.*

4.1.2 Results: Team Contest with Chat

Figure 2 displays the average clicks for TEAMCHAT. Consistent with the responsibility-alleviation effect, leaders and trailers clicked similarly often. Table 6 confirms this null difference in a random effects regression similar to Table 2. In fact, both leaders and trailers in TEAMCHAT clicked more than in TEAM (the estimate on TEAM was negative and significant at the 1% level; we only used the UK data for making a cleaner comparison), suggesting that team communication helped foster a stronger sense of belonging to a team where both leaders and trailers felt more responsible. The interaction term in column (2) of Table 6 was marginally statistically significant. This suggests that trailers' clicks increased even more than leaders' presumably to avoid being perceived as responsible for their team's defeat. Given that in TEAM we observed significant differences in dropouts between leaders and trailers and that partially explained the effort gap, we next test whether dropout behavior was different between TEAM and TEAMCHAT.

Looking at leaders' and trailers' dropout propensities, we observed nearly zero difference in TEAMCHAT (see Table 7). Comparing the dropout behavior between TEAM and TEAMCHAT, we found that subjects in TEAMCHAT were less likely to drop out than in TEAM (Fisher exact test, p=0.001). In particular, trailers in TEAMCHAT dropped out significantly less than in TEAM (Fisher exact test, p=0.001), while leaders dropped out

[7] This might be only true in ex-ante homogeneous ability groupings, like ours, where subjects do not receive any information about performance differential between teammates. In a setting with ex-ante heterogeneous groupings, Brookins, Lightle, and Ryvkin (2018) find that intra-team communication does not necessarily lead to higher effort levels among team members.

[8] We ran three sessions of TEAMCHAT with 30 subjects each at the University of Surrey.

Table 6: Random Effect Regressions of Second Mover's Clicks in TEAMCHAT

	(1) TEAMCHAT	(2) Pooled
Lead	0.716	0.649
	(0.445)	(0.598)
TEAM		-5.194^{***}
		(1.513)
Lead × *TEAM*		2.137^{*}
		(1.268)
Experience	0.122	−0.064
	(0.363)	(0.117)
Constant	29.141^{***}	30.089^{***}
	(1.531)	(0.685)
σ_ω	11.313	12.892
σ_u	10.861	10.727
$overall R^2$	0.003	0.017
$N(matches)$	300	1020
$N(subjects)$	89	267
$N(clusters)$	3	9

Note: Standard errors are bootstrapped and clustered at the session level. σ_ω denotes the square root of the variation due to the persistent unobserved individual characteristics. σ_u represents the square root of the variation due to the transitory unobservables. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

similarly often in both treatments (Fisher exact text, p=0.127). Overall, the evidence from TEAMCHAT is consistent with Hypothesis 3.

A content analysis of chat messages between team members (presented in Online Appendix A.3) shows that subjects often expressed a desire to work as hard as possible and also encouraged others to do the same. These messages might have created expectations within teams not to drop out regardless of previous battle outcomes, consistent with the general mechanism of the responsibility-alleviation effect. We also found some hints at the responsibility-alleviation effect in the survey responses. We asked subjects why their effort differed between being ahead and behind (see Online Appendix A.1). For example, there

Table 7: Second Movers' Dropout Rates in TEAMCHAT

Treatment	Trailing	Leading	Difference	SE	P-value
TEAMCHAT	6.7%	7.3%	-0.6%	0.023	0.783

Note: Dropout rates are calculated by pooling over trailing and leading teams. P-values are from two-tailed tests using a standard bootstrap method allowing for clustering at the session level.

are comments such as "I felt more responsible for my team position. When we were losing, I tried catching tokens as much as possible, regardless of cost sometimes. Although it didn't always help, but I did my best for victory"; "I felt more pressure, I wanted to make a difference in the team"; "When I saw that the other team was winning I felt more determined to beat them and win for my team." While these quotes did not necessarily imply trailers worked harder than leaders, they were consistent with our findings that trailers had extra motivations to work when competing on teams.

4.1.3 Other Possible Explanations

Here, we discuss some of other possible explanations for TEAM and IND_Bo3 treatment differences that are either inconsistent with the data or hard to separate from using our current approach.

Social efficiency. The finding that trailers competed harder in teams than when competing alone might be due to their greater concerns for social efficiency. That is, in addition to receiving the prize for themselves, their teammates also received the same prize. In theory, social efficiency concerns mean that the prize spread increases for both leaders and trailers: if team members fully incorporate teammates' prizes into their utility functions then the prize spread increases by 3 times for both leaders and trailers. So the comparative static prediction is that both leaders and trailers will spend more effort in TEAM than in IND_Bo3. However, our data show that only trailers' efforts were greater in teams than when alone (p=0.062, the p-value is from a random effects regression that regresses the number of trailers' clicks on a treatment dummy of TEAM as opposed to IND_Bo3 with standard errors bootstrapped and clustered at the session level); leaders' efforts did not differ between team and individual contests (p=0.925, the p-value is from a similar regression of leaders' clicks). We noted that leaders' efforts were not demonstrating a ceiling effect. Indeed, we found that third movers exerted higher efforts than leader second movers (see Table A2 in Online Appendix A.2; on average 32.2 vs. 26.1 clicks in TEAM and 34.2 vs.29.4 clicks in TEAMCHAT; $ps < 0.001$, p-values are from random effects regressions that regress the number of clicks on a dummy of playing as a third mover as opposed to a second mover with standard errors bootstrapped and clustered at the session level).

Joy of winning for the team. Players might derive joy from winning specifically when their victory in their own battle leads to their team's victory. If so, leaders should compete harder in teams than when competing alone because they were in a position to win a decisive battle for their team. We found that trailers *but not leaders* competed harder in teams, which was inconsistent with the hypothesis of joy of winning for the team. However, if players derive joy of winning from every battle that is won by themselves or their teammates, leaders may be less motivated to win for their team as they would only enjoy one winning compared to the trailers who potentially could enjoy two winnings (one by themselves and one by their third mover teammate) (Fu et al., 2015a). This kind of behavior is also consistent with our data and may not be easily distinguishable from the responsibility-alleviation effect using our current approach.

Signaling to third movers. Trailers might try to encourage their third mover teammate by competing hard themselves. However, third movers' efforts did not depend on second movers' positions. When we performed a random effects regression analysis of third movers' efforts by regressing them on their first mover teammate's winning or losing, we found no significant relationship between the two variables (see Table A4). This indicates that third movers on trailing teams had equal chances of winning their battles to those on leading teams. Subjectively, if second movers *consistently* believed their winning could encourage third movers to compete harder, they should learn that third movers did not in fact respond to their "signal." Learning this should not be difficult in our setting since it was very likely that a subject had experience of being both a second mover and a third mover. But as Table 4 shows, second movers' clicks did not change in TEAM across rounds. Moreover, if signaling was the main motivation of trailer second movers, this should be equally true in both TEAM and TEAMCHAT. However, the treatment difference in trailers' efforts refutes this hypothesis.

Social disapproval of being free-riders. The team situation might heighten the role of social disapproval or social pressure of being free-riders who would be subject to punishment, if possible (Babcock et al., 2015). We found this explanation plausible and deeply linked to guilt aversion or responsibility aversion. But our current approach does not allow us to clearly distinguish social disapproval (which is more about social than self) from responsibility alleviation (which is more about self than social).

4.2 Explaining the Psychological Momentum Effect: Disappointment Aversion

Reference-dependent preferences such as disappointment aversion were originally developed for asocial decision-making situations. More recently, they have been applied to social situations including contests (Gill and Prowse, 2012; Gächter et al., 2018). To see how disappointment aversion affects second movers' behavior, we calculate a second mover's valuation of winning her own battle by additionally taking into account that second movers experience emotions of disappointment/elation in relation to the final contest outcome if the contest goes on to the third battle.

First, consider the second mover on the leading team. She reasons that, if she wins, she receives the prize V with certainty. If she loses, in addition to the material utility from receiving a prize, her expected utility also has a gain-loss utility component. We follow the literature by modeling a linearized version of disappointment aversion in a loss aversion type framework. Suppose that a leader's material utility is linear in money and her reference utility is $k(V+v)$, $v/(V+v) \leq k \leq V/(V+v)$, where k measures the sensitivity in reference point adjustments. If the leader has fully adjusted to the new situation of being tied (in cases where she would lose her own battle), her reference utility is simply her expected monetary payoff when she loses, i.e., $(V+v)/2$. Generally, $k > 1/2$ means under-adjustment to the tied situation: the leader's reference utility is still higher than the expected one; conversely, $k < 1/2$ means over-adjustment.

The leader's utility in the event that the third battle is won is additive by the material and gain-loss utilities: $V + g(V - k(V+v))$, where V is the material utility of the winner's prize, g is the preference parameter in the gain domain, and $g(V - k(V+v))$ is the gain-loss utility associated with earnings higher than expected (i.e., elation). Similarly, the leader's utility in the event that the third battle is lost is given by $v + l(v - k(V+v))$, where v is the material utility of the loser's prize, l is the preference parameter in the loss domain, and $l(v - k(V+v))$ is the gain-loss utility associated with earnings lower than expected (i.e., disappointment). An individual is said to be disappointment averse if $\lambda = l - g > 0$, and λ measures the strength of disappointment aversion. Since the leader's team expects to win the third battle with 50% probability, her expected payoff from losing her own battle is then $(V + v + g(V - k(V+v)) + l(v - k(V+v)))/2$. Therefore, the net prize incentive for the leader to win the battle is the difference in valuations of winning and losing:

$$V - \frac{V + v + g(V - k(V+v)) + l(v - k(V+v))}{2}. \tag{1}$$

Next, consider the second mover on the trailing team. She reasons that, if she loses, she receives the prize v for sure. If she wins, her expected utility also has a gain-loss utility component in addition to material utility. Symmetrically to a leader who loses, suppose that a trailer's material utility is linear in money and her reference utility is $(1-k)(V+v)$, $v/(V+v) \leq k \leq V/(V+v)$.[9] If the trailer has fully adjusted to the new situation of being tied (in cases where she would win her own battle), her reference utility is simply her expected monetary payoff when she wins, i.e., $(V+v)/2$. Similar to the leader's case, we can then express the trailer's expected payoff from winning her own battle as $(V + v + g(V -$

[9] We can relax the assumption of the symmetry in reference utility by allowing two different sensitivity parameter k_1 and k_2 for the leader and trailer respectively. As long as we assume these two parameters do not differ too much, the following momentum effect holds.

$(1-k)(V+v)) + l(v-(1-k)(V+v)))/2$. Therefore, the net prize incentive for the trailer to win the battle is:

$$\frac{V+v+g(V-(1-k)(V+v))+l(v-(1-k)(V+v))}{2} - v. \qquad (2)$$

It is easy to verify that *disappointment aversion predicts that the prize incentive for the leader (1) is always higher than that for the trailer (2), thus generating a momentum effect that the leader will exert greater effort than the trailer*, as is true in our data. Intuitively, if a third battle has to be fought, then both leaders and trailers would incur some negative utility due to disappointment aversion. This increases the prize spread for leaders and decreases it for trailers, thus causing diametrically different incentives to win the second battle.

To see this more clearly, we focus on the case where leaders/trailers have fully adjusted to the new situation of being tied, i.e., $k = 1/2$. In this special case, the leader's prize incentive can be expressed as $(V-v)/2 + \lambda(V-v)/4$, and the trailer's prize incentive as $(V-v)/2 - \lambda(V-v)/4$. The disappointment deficit, $-\lambda(V-v)/4$, is incurred when the leader loses or when the trailer wins and is proportional to the material prize spread, $V-v$. Since the disappointment deficit, by definition, is always negative, its presence encourages the leader while discouraging the trailer to win the battle relative to the case of no disappointment aversion.[10] Intuitively, the disappointment deficit captures uncertainty people dislike in the tied situation.

4.2.1 Testing Disappointment Aversion: Best-of-Five Contest

We have suggested disappointment aversion as a plausible explanation for the observed psychological momentum effect in IND_Bo3 and TEAM. However, there might be some other explanations for the psychological momentum effect. One possibility is that players might be reference-dependent around the goal of winning: the closer they were to the victory, the harder they fought (Wu, Heath, and Larrick, 2008). This argument is conceptually similar to disappointment aversion, but the major difference is that there must be a tangible goal of winning, not merely a higher probability of winning. In the best-of-three contest, this conceptual difference does not matter to the momentum effect because of the asymmetrical nature of the outcomes between winning and losing: winning leads to a certain payoff and losing leads to an unresolved outcome for leaders; the opposite is true for trailers. For both types of reference-dependence explanations winning (losing) always brings about a certain

[10] In Online Appendix A.4, we consider an extension of the current model by additionally allowing second movers to experience elation/disappointment related to winning or losing their own battles. We show that the qualitative prediction of the momentum effect holds under a reasonable assumption.

outcome for leaders (trailers), and they kick in reference-dependent utilities whether goal-based or disappointment-aversion-based.

Therefore, to discriminate between these two explanations, we must restore the symmetry in the nature of the outcome and make it always uncertain. One way to do this is to study second movers' behavior in a best-of-five contest where all but the second battle are replaced by separate fair coin tosses. In such a contest, the second battle outcome cannot possibly resolve the uncertainty about the contest outcome or lead to a certain goal or payoff, and therefore, the alternative goal-based reference-dependent explanation would have no bite here. It is worth noting that some other possible explanations that rely on the resolved certainty by winning or losing would lose their predictive power in the best-of-five too. These include that leaders might be averse to uncertainty or they might want to feel in control of their fate which would motivate them to fight harder to ensure certainty (resolved certainty by winning) and that trailers might "choke under pressure" as their failure would bring about their team's defeat for sure (resolved certainty by losing). However, we show below that disappointment aversion still predicts a similar psychological momentum effect in such a best-of-five contest.

First, consider a second mover on a leading team. If she wins, she receives the prize V with the probability of $\frac{7}{8}$ and v with the probability of $\frac{1}{8}$. In both cases, her expected utility also has a gain-loss utility component. If she wins, her reference utility is $k_1(V+v)$, $v/(V+v) \leq k_1 \leq V/(V+v)$. If she loses, her reference utility is $k_2(V+v)$, $v/(V+v) \leq k_2 \leq V/(V+v)$. We assume that $k_1 \geq k_2$, reflecting that the leader's reference utility after winning her own battle is higher than after losing it. For example, if she has fully adjusted to the new situation after the second battle, her reference utility is simply her expected monetary payoff, i.e., $\frac{7}{8}(V+v)$ when she wins and $\frac{1}{2}(V+v)$ when she loses.

Therefore, we can write down the leader's expected payoff after taking into account the gain-loss utility as follows. The leader's expected payoff from winning her battle is

$$\frac{7}{8}(V + g(V - k_1(V + v))) + \frac{1}{8}(v + l(v - k_1(V + v))). \tag{3}$$

Her expected payoff from losing her battle is

$$\frac{1}{2}(V + g(V - k_2(V + v))) + \frac{1}{2}(v + l(v - k_2(V + v))). \tag{4}$$

The net prize incentive for the leader to win the battle is the difference in valuations of winning and losing.

Similarly, consider a second mover on a trailing team. If she wins, her reference utility is given by $(1-k_2)(V+v)$, $v/(V+v) \leq k_2 \leq V/(V+v)$. If she loses, her reference utility is given by $(1-k_1)(V+v)$, $v/(V+v) \leq k_1 \leq V/(V+v)$. For example, if the trailer has fully adjusted to the new situation after the second battle, her reference utility is simply her expected monetary payoff, i.e., $\frac{1}{2}(V+v)$ when she wins and $\frac{1}{8}(V+v)$ when she loses. We can then express the trailer's expected payoff after taking into account the gain-loss utility as follows. The trailer's expected payoff from winning her battle is

$$\frac{1}{2}(V+g(V-(1-k_2)(V+v)))+\frac{1}{2}(v+l(v-(1-k_2)(V+v))). \tag{5}$$

Her expected payoff from losing her battle is

$$\frac{1}{8}(V+g(V-(1-k_1)(V+v)))+\frac{7}{8}(v+l(v-(1-k_1)(V+v))). \tag{6}$$

The net prize incentive for the trailer to win the battle is the difference in valuations of winning and losing.

It can be proven that the leader's net prize incentive is strictly higher than the trailer's when $k_1 > \frac{1}{2}$, thus leading to a similar momentum effect as in the best-of-three case where the leader will exert greater effort than the trailer.[11]

We note that both the average second mover's effort and the predicted momentum effect in the best-of-five contest are smaller than those in the best-of-three with the same payoff structure. It is because the prize spread for both competing sides are smaller in the best-of-five since the contest unfolds more slowly and changes in the probability of winning are smoother. In sum, we make the following hypothesis:

Hypothesis 4. *Leaders fight harder than trailers in IND_Bo5. This momentum effect is weaker than in IND_Bo3.*

4.2.2 Results: Best-of-Five Contest

We implemented a new treatment—IND_Bo5—in which, like IND_Bo3, two players fought against each other in a best-of-five contest. But they only competed in the second battle and all other battle outcomes were determined by separate fair coin tosses. The player who first accumulated three battle victories won the whole contest.[12]

[11] Rearranging and simplifying the two net prize incentive expressions, it can be found that the condition for the leader's prize incentive to be higher than the trailer's is that $g(\frac{1}{2}-\frac{7}{8}k_1-\frac{1}{8}(1-k_1))+l(\frac{1}{2}-\frac{7}{8}(1-k_1)-\frac{1}{8}k_1) > 0$. Note that the two terms in the brackets always add up to zero. When $k_1 > \frac{1}{2}$, the first term is strictly negative and the second term is strictly positive. Thus, the expression above holds given the assumption of disappointment aversion that $0 < g < l$.

[12] As in IND_Bo3, the contest in IND_Bo5 was repeated for 12 rounds. Matching was randomized at the session level in every round. The payoff structure of the real-effort task and the (winner and loser) prizes remained the same. We conducted the experiment at the University of Surrey and ran one session with 30 subjects.

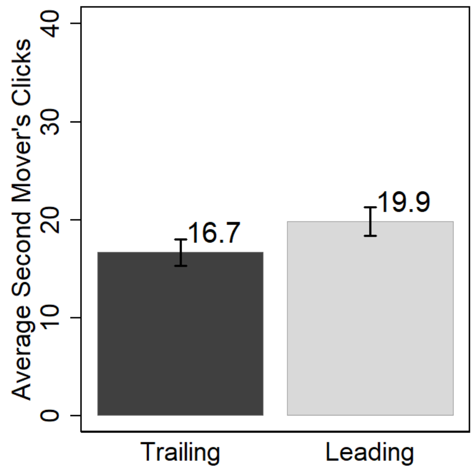


Figure 3: Average Second Mover's Clicks in IND_Bo5. *The error bars are ±SEM.*

Figure 3 displays the average clicks, showing that second movers clicked more when they were ahead than when they were behind, as predicted by the disappointment aversion model. Table 8 further quantifies the difference in effort by performing a random effects regression analysis, similar to Table 2. The estimate shows that leaders made on average 3.5 more clicks than trailers, a significant difference at the 1% level. But the effect size was weaker than in IND_Bo3 (we only used the UK data for making a cleaner comparison), a marginally statistically significant difference. We also observed a similar dropout pattern as in IND_Bo3. Table 9 shows that trailers were significantly more likely to drop out than leaders. Taken together, we conclude that the psychological momentum effect was a robust phenomenon in our individual contests, suggesting that disappointment aversion is a more plausible explanation than other mechanisms such as goal-based reference dependence, choking under pressure, or uncertainty aversion, which would predict similar effort levels between leaders and trailers in IND_Bo5.

In addition, we also have some hints at subjects' experiencing disappointment aversion in their decisions from their survey responses. We asked subjects if their effort differed between being ahead and behind and if so why. Examples are "If I was behind after the first round I was happy to take the 400 guaranteed credits rather than risk losing credits by winning the second round only to lose the third to randomness"; "Because there is more chance of winning when I am ahead by 1 point, therefore the number of clicks or credit lost does not matter as much. I clicked less when I was behind by 1 point as the number of clicks would have been taken off my losing score and would not have left very much credit"; "Because if I won the second stage when I was already ahead I was guaranteed a better prize, however if I

Table 8: Random Effect Regressions of Second Mover's Clicks in IND_Bo5

	(1) IND_Bo5	(2) Pooled
$Lead$	3.474^{**}	3.468^{***}
	(1.723)	(1.357)
IND_Bo3		4.611^{***}
		(1.079)
$Lead \times IND\_Bo3$		2.304^{*}
		(1.398)
$Experience$	-1.781^{***}	-1.031^{***}
	(0.188)	(0.264)
$Constant$	28.097^{***}	23.229^{***}
	(2.813)	(1.713)
σ_ω	12.097	11.677
σ_u	12.313	12.398
$overall R^2$	0.116	0.094
$N(matches)$	360	1080
$N(subjects)$	30	90
$N(clusters)$	30	3

Note: Standard errors are bootstrapped and clustered at the session level (column 1 has only one session so standard errors are at the subject level). σ_ω denotes the square root of the variation due to the persistent unobserved individual characteristics. σ_u represents the square root of the variation due to the transitory unobservables. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

was not ahead I was risking more because even if I won the second stage I was not guaranteed the bigger prize. The smaller prize was not large enough to allow the risk of spending it all." These comments essentially entail considerations of disappointment aversion with regards to the dislike of uncertainty in a third battle.

Table 9: Second Movers' Dropout Rates in IND_Bo5

Treatment	Trailing	Leading	Difference	SE	P-value
IND_Bo5	33.3%	21.6%	11.6%	0.044	<0.001

Note: Dropout rates are calculated by pooling over trailing and leading teams. Standard errors are bootstrapped allowing clustering at the subject level. P-values are from two-tailed tests.

5 Conclusion

People form teams in various social circumstances, including sports teams, corporations and political parties. However, individual incentives to fight for their team are not always perfectly in line with the team's best interests. Both rational calculations and emotional responses affect individual decisions to fight or shirk. In this paper, we are interested in how individuals compete when fighting on a team as opposed to when fighting alone. Specifically, we investigate individual effort in response to the situation of being ahead and behind, since in many cases competition unfolds over multiple stages. We designed our experiments ensuring that the standard economic model predicts a neutral response to being either ahead or behind, and no difference between fighting alone and fighting for a team. Therefore, the source of treatment differences is likely to be psychological.

In contrast to the standard economic theory prediction, our experimental data exhibit a psychological momentum effect in that players who are ahead fight harder than those who are behind in both individual and team contests. Furthermore, the momentum effect is larger in individual than in team contests. Importantly, the narrowed effort gap between leaders and trailers in teams is primarily constituted by trailers' greater efforts. This suggests that in our experiment the psychological influence of a team situation is mainly about encouraging trailers to fight harder, whereas the effect on leaders' efforts is null.

Since the standard theory is inadequate to explain our findings, we turn to behavioral models based on disappointment aversion and team spirit. On the one hand, disappointment-averse players dislike losing the whole contest more than they enjoy winning it. This can create the observed momentum effect. On the other hand, team spirit encourages players, and particularly trailers, to feel more responsible and fight harder for their team. In this regard, our findings complement the earlier finding by Chen and Lim (2013) that socialization among teammates in a simultaneous team contest promotes effort through their concern about their teammates' welfare.

References

Abbink, K., J. Brandts, B. Herrmann, and H. Orzen (2010): "Intergroup conflict and intra-group punishment in an experimental contest game," *American Economic Review*, 100, 420–447.

Ahn, T., R. M. Isaac, and T. C. Salmon (2011): "Rent seeking in groups," *International Journal of Industrial Organization*, 29, 116–125.

Ansolabehere, S., J. M. de Figueiredo, and J. M. Snyder (2003): "Why is there so little money in U.S. politics?" *Journal of Economic Perspectives*, 17, 105–130.

Babcock, P., K. Bedard, G. Charness, J. Hartman, and H. Royer (2015): "Letting down the team? Social effects of team incentives," *Journal of the European Economic Association*, 13, 841–870.

Bell, D. E. (1985): "Disappointment in decision making under uncertainty," *Operations Research*, 33, 1–27.

Berger, J. and D. Pope (2011): "Can losing lead to winning?" *Management Science*, 57, 817–827.

Bornstein, G. (1992): "The free-rider problem in intergroup conflicts over step-level and continuous public goods." *Journal of Personality and Social Psychology*, 62, 597–606.

——— (2003): "Intergroup conflict: Individual, group, and collective interests," *Personality and Social Psychology Review*, 7, 129–145.

Bornstein, G., U. Gneezy, and R. Nagel (2002): "The effect of intergroup competition on group coordination: An experimental study," *Games and Economic Behavior*, 41, 1–25.

Brookins, P., J. P. Lightle, and D. Ryvkin (2018): "Sorting and communication in weak-link group contests," *Journal of Economic Behavior & Organization*, 152, 64–80.

Büyükboyaci, M. and A. Robbett (2017): "Collaboration and free-riding in team contests," *Labour Economics*, 49, 162 – 178.

Cason, T. N., R. M. Sheremeta, and J. Zhang (2012): "Communication and efficiency in competitive coordination games," *Games and Economic Behavior*, 76, 26–43.

Charness, G. (2000): "Responsibility and effort in an experimental labor market," *Journal of Economic Behavior & Organization*, 42, 375–384.

Charness, G., L. Rigotti, and A. Rustichini (2007): "Individual behavior and group membership," *American Economic Review*, 97, 1340–1352.

Chen, H. and N. Lim (2013): "Should managers use team-based contests?" *Management Science*, 59, 2823–2836.

Chen, Y. and S. X. Li (2009): "Group identity and social preferences," *American Economic Review*, 99, 431–457.

Dechenaux, E., D. Kovenock, and R. M. Sheremeta (2015): "A survey of experimental research on contests, all-pay auctions and tournaments," *Experimental Economics*, 18, 609–669.

Dong, L. and L. Huang (2018): "Is there no 'I' in team? Rational players in dynamic team competition," *Journal of Economic Psychology*.

Feng, X. and J. Lu (2018): "How to split the pie: Optimal rewards in dynamic multi-battle competitions," *Journal of Public Economics*, 160, 82–95.

Fershtman, C. and U. Gneezy (2011): "The tradeoff between performance and quitting in high power tournaments," *Journal of the European Economic Association*, 9, 318–336.

Fischbacher, U. (2007): "z-Tree: Zurich toolbox for ready-made economic experiments," *Experimental Economics*, 10, 171–178.

Fosu, A. K. (2013): *Achieving development success: Strategies and lessons from the developing world*, New York, NY: Oxford University Press.

Fu, Q., C. Ke, and F. Tan (2015a): ""Success breeds success" or "pride goes before a fall"? Teams and individuals in best-of-three contests," *Games and Economic Behavior*, 94, 57–79.

Fu, Q., J. Lu, and Y. Pan (2015b): "Team contests with multiple pairwise battles," *American Economic Review*, 105, 2120–2140.

Gächter, S., L. Huang, and M. Sefton (2016): "Combining "real effort" with induced effort costs: The ball-catching task," *Experimental Economics*, 19, 687–712.

——— (2018): "Disappointment aversion and social comparisons in a real-effort competition," *Economic Inquiry*, 56, 1512–1525.

Gill, D. and V. Prowse (2012): "A structural analysis of disappointment aversion in a real effort competition," *American Economic Review*, 102, 469–503.

Gunnthorsdottir, A. and A. Rapoport (2006): "Embedding social dilemmas in intergroup competition reduces free-riding," *Organizational Behavior and Human Decision Processes*, 101, 184–199.

Häfner, S. (2017): "A tug-of-war team contest," *Games and Economic Behavior*, 104, 372–391.

Konrad, K. A. (2009): *Strategy and dynamics in contests*, New York, NY: Oxford University Press.

Kőszegi, B. and M. Rabin (2006): "A model of reference-dependent preferences," *Quarterly Journal of Economics*, 121, 1133–1165.

Landis, J. R. and G. G. Koch (1977): "The measurement of observer agreement for categorical data," *Biometrics*, 33, 159–174.

Leibbrandt, A. and L. Sääksvuori (2012): "Communication in intergroup conflicts," *European Economic Review*, 56, 1136–1147.

Leonhardt, J. M., L. R. Keller, and C. Pechmann (2011): "Avoiding the risk of responsibility by seeking uncertainty: Responsibility aversion and preference for indirect agency when choosing for others," *Journal of Consumer Psychology*, 21, 405–413.

Loomes, G. and R. Sugden (1986): "Disappointment and dynamic consistency in choice under uncertainty," *Review of Economic Studies*, 53, 271–282.

Mago, S. D. and R. M. Sheremeta (2019): "New Hampshire effect: Behavior in sequential and simultaneous multi-battle contests," *Experimental Economics*, 22, 325–349.

Markussen, T., E. Reuben, and J.-R. Tyran (2014): "Competition, cooperation and collective choice," *Economic Journal*, 124, F163–F195.

Müller, W. and A. Schotter (2010): "Workaholics and dropouts in organizations," *Journal of the European Economic Association*, 8, 717–743.

Nalbantian, H. R. and A. Schotter (1997): "Productivity under group incentives: An experimental study," *American Economic Review*, 87, 314–341.

Rapoport, A. and G. Bornstein (1987): "Intergroup competition for the provision of binary public goods." *Psychological Review*, 94, 291–299.

Schotter, A. and K. Weigelt (1992): "Asymmetric tournaments, equal opportunity laws, and affirmative action: Some experimental results," *Quarterly Journal of Economics*, 107, 511–539.

Sheremeta, R. M. (2018): "Behavior in group contests: A review of experimental research," *Journal of Economic Surveys*, 32, 683–704.

Sherif, M., O. Harvey, B. White, W. Hood, and C. Sherif (1961): *Intergroup cooperation and competition: The robber's cave experiment.*, Norman, OK: University of Oklahoma Book Exchange.

Siegel, R. (2014): "Asymmetric contests with head starts and nonmonotonic costs," *American Economic Journal: Microeconomics*, 6, 59–105.

Smith, V. (1982): "Microeconomic systems as an experimental science," *American Economic Review*, 72, 923–955.

Sutter, M. and C. Strassmair (2009): "Communication, cooperation and collusion in team tournaments—An experimental study," *Games and Economic Behavior*, 66, 506–525.

Tajfel, H., M. G. Billig, R. P. Bundy, and C. Flament (1971): "Social categorization and intergroup behaviour," *European Journal of Social Psychology*, 1, 149–178.

Tajfel, H. and J. Turner (1979): "An integrative theory of intergroup behavior," in *The Social Psychology of Intergroup Relations*, ed. by S. Worchel and W. Austin, Monterey, CA: Brooks/Cole, 33–47.

Tan, J. H. and F. Bolle (2007): "Team competition and the public goods game," *Economics Letters*, 96, 133–139.

Wu, G., C. Heath, and R. P. Larrick (2008): "A prospect theory model of goal behavior," .

A Online Appendix (Supplementary Materials for "Fight Alone versus Fight for a Team")

A.1 Experimental Instructions

[Same for all treatments]

Instructions

Welcome to the experiment. Please read these instructions carefully. For participating in this experiment you will receive a £3 show-up fee. In addition you can earn money by completing tasks in two parts of the experiment. You will receive separate instructions before the start of each part.

During the experiment, your earnings are calculated in tokens. At the end of the experiment, every 1000 tokens will be converted to £1 in cash and your cash payment will be the sum of your earnings from both parts, in addition to the show-up fee.

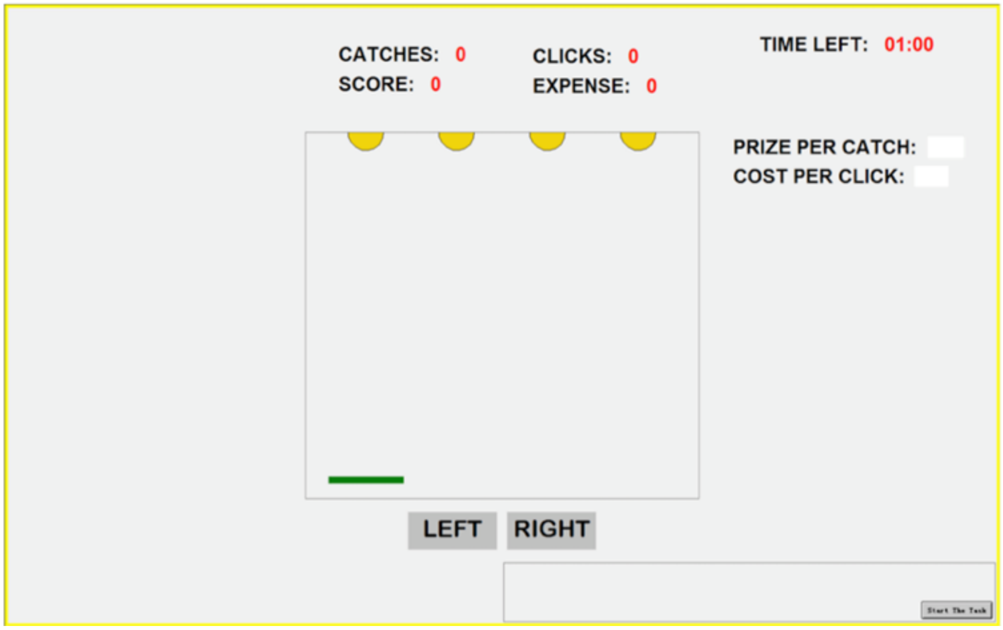
Before we start the experiment, please read and sign the CONSENT FORM on your desks that you are willing to participate in this experiment and consent to the use of your data.

If you have a question, please raise your hand and someone will come to your desk to answer it.

Instructions for Part 1

In this part, you will be asked to work on a computerized ball-catching task for 4 periods. The first period serves as a practice period for you to familiarize yourself with the ball-catching task. The next three periods will be for real and your earnings in this part will be the sum of your earnings in these three paying periods.

Each period lasts one minute. In each period, there will a task box in the middle of the task screen like the one shown below:



Once you click on the “Start the Task” button, the timer will start and balls will fall randomly from the top of the task box. You can move the tray at the bottom of the task box to catch the balls by using the mouse to click on the LEFT or RIGHT buttons. To catch a ball, your tray must be below the ball before it touches the bottom of the tray. When the ball touches the tray your catches increase by one.

You will receive a prize of 20 tokens for each ball you catch and incur a cost of 10 tokens for each mouse click you make. In each period, the number of balls you have caught so far (displayed as CATCHES) and the number of clicks you have made so far (CLICKS) are shown right above the task box. Also shown above the task box are SCORE, which is CATCHES multiplied by the prize per catch, and EXPENSE, which is CLICKS multiplied by the cost per click.

At the end of the period your earnings in tokens for the period will be your SCORE minus your EXPENSE.

When you are ready, please press the “Start the Task” button at the lower right corner on the task screen.

Instructions for Part 2

[IND_Bo3]

In this part, there are 12 periods. In each period, you will be randomly matched with another participant in this room. The random matching is completed by the computer and has nothing to do with your decisions in previous parts of the experiment.

The whole matching process will remain anonymous throughout the entire experiment.

You will not be told the identities of your matched participants. Also note that the matching will be re-done randomly in each period. It is very unlikely that you will be matched with the same participant twice.

Your Task in Each Period

In each period, you will compete in a best-of-three contest with the other participant for a winner prize of 1200 tokens and a loser prize of 400 tokens.

The competition consists of up to three stages. In the first stage, the computer will randomly determine whether you win or lose the first stage. At the end of the first stage, you will be informed if you won or lost the first stage.

In the second stage, you and your matched participant will independently work on the ball-catching task. The participant who catches more balls at the end of the task will win the second stage. If you catch the same number of balls as your matched participant, the computer will randomly select the winner of the stage. Each mouse click on the LEFT or RIGHT buttons incurs a cost of 10 tokens to you. The number of balls caught so far (displayed as CATCHES) and the number of clicks made so far (CLICKS) will be shown right above the task box on your screen. Also shown above the task box will be EXPENSE, which is CLICKS multiplied by the cost per click. At the end of the second stage, you will be informed if you won or lost the second stage.

If one participant has won both stages, the competition will end and the winning participant will receive the winner prize of 1200 tokens and the losing participant will receive the loser prize of 400 tokens. If each participant has won one of the two stages, the computer will randomly determine whether you win or lose the third stage. The participant who wins in the third stage will receive the winning prize and the participant who loses in the third stage will receive the loser prize.

Your earnings in each period will be (winner or loser) prize minus your EXPENSE.

Your Earnings in Part 2

Your earnings in this part will be the sum of your earnings from all 12 periods.

[TEAM]

In this part, there are 12 periods. In each period, you will be randomly matched with two other participants in this room to form a team. The random matching is completed by the computer and has nothing to do with your decisions in previous parts of the experiment.

Your team will be randomly matched with another team consisting of three other participants in the room. The random matching of two teams is also completed by the computer and has nothing to do with any of the decisions in previous parts of the experiment.

The whole matching process will remain anonymous throughout the entire experiment.

You will not be told the identities of either your team members or the members of the other matched team. Also note that both the matching with two other team members and the matching between two teams will be re-done randomly in each period. It is very unlikely that you will be matched with the same team members and the same other team members twice.

Your Task in Each Period

In each period, your team will compete in a best-of-three contest with the other team for a winner prize of 1200 tokens for each member of the winning team and a loser prize of 400 tokens for each member of the losing team.

The competition consists of up to three stages. You will participate only in one of three stages. The computer will randomly determine your participation order in the competition. You will be told whether you are the First Mover, the Second Mover, or the Third Mover before the start of each period. In the first stage two First Movers, one from each team, will compete. In the second stage two Second Movers will compete and in the third stage, if necessary, two Third Movers will compete. The winning team in each period will be the one that wins two out of three stages. The rule for winning each stage is as follows.

During the first stage, two First Movers will simultaneously work on the ball-catching task. The team whose First Mover catches more balls at the end of the task will win the first stage. If the two First Movers catch the same number of balls, the computer will randomly select the winner of the stage. Each mouse click on the LEFT or RIGHT buttons incurs a cost of 10 tokens to the First Mover who makes the click. For each First Mover, the number of balls caught so far (displayed as CATCHES) and the number of clicks made so far (CLICKS) are shown right above the task box on the First Movers screen. Also shown above the task box is EXPENSE, which is CLICKS multiplied by the cost per click. While the First Movers are working on the task, the other team members should wait quietly and patiently.

At the end of the first stage, all team members of both teams will be informed of which team won the first stage.

The second stage proceeds in the same fashion as the first stage. The Second Movers will participate in this stage while the other team members should wait quietly and patiently. The team whose Second Mover catches more balls at the end of the task will win the second stage. Each Second Mover will also incur an EXPENSE herself by clicking. At the end of the second stage, a similar summary screen will show which team won the second stage.

If one team has won both stages, the competition ends and each member from the winning team will receive the winner prize of 1200 tokens and each member from the losing team will receive the loser prize of 400 tokens. If each team has won one of the two stages, the Third

Movers will compete in the third stage following the same competition rule for the first two stages. The team whose Third Mover catches more balls at the end of the task will be the winning team. At the end of the third stage, a similar summary screen as in the first two stages will be shown.

Your earnings in each period will be (winner or loser) prize minus your EXPENSE. If the third stage is not necessary, the Third Mover earnings will be simply the (winner or loser) prize.

Your Earnings in Part 2

Your earnings in this part will be the sum of your earnings from all 12 periods.

[TEAMCHAT]

In this part, there are 10 periods. In each period, you will be randomly matched with two other participants in this room to form a team. The random matching is completed by the computer and has nothing to do with your decisions in previous parts of the experiment.

Your team will be randomly matched with another team consisting of three other participants in the room. The random matching of two teams is also completed by the computer and has nothing to do with any of the decisions in previous parts of the experiment.

The whole matching process will remain anonymous throughout the entire experiment. You will not be told the identities of either your team members or the members of the other matched team. Also note that both the matching with two other team members and the matching between two teams will be re-done randomly in each period. It is very unlikely that you will be matched with the same team members and the same other team members twice.

Your Task in Each Period

In each period, your team will compete in a best-of-three contest with the other team for a winner prize of 1200 tokens for each member of the winning team and a loser prize of 400 tokens for each member of the losing team.

The competition consists of up to three stages. You will participate only in one of three stages. The computer will randomly determine your participation order in the competition. You will be told whether you are the First Mover, the Second Mover, or the Third Mover before the start of each period. In the first stage, two First Movers, one from each team, will compete. In the second stage, two Second Movers will compete and in the third stage, if necessary, two Third Movers will compete. The winning team in each period will be the one that wins two out of three stages.

Before the start of each period, you will be asked to communicate with your team members via a text chat box on the screen for 60 seconds. You can discuss anything you like, including what you think is the best approach to win the competition, what you plan to do, or what you would like others to do. However, there are three important restrictions on the types of messages that you may send.

- You may not send a message that attempts to identify you to other team members. Thus, you may not use your real name, nicknames, or self-descriptions of any kind ("Tom Smith here", "I'm the guy in the red shirt sitting near the door", "It's me, Sandy, from French class", or even 'As a woman [Latino, Asian, English, etc.], I think...").
- There must be no use of abusive language, and threats or promises pertaining to anything that is to occur after the experiment ends.
- All of the communication must be in English.

The experimenter will screen your messages. If your message is found to violate any of the rules, you may be excluded from the payment in this experiment.

After the communication, the contest will begin. The rule for winning each stage in the contest is as follows.

During the first stage, two First Movers will simultaneously work on the ball-catching task. The team whose First Mover catches more balls at the end of the task will win the first stage. If the two First Movers catch the same number of balls, the computer will randomly select the winner of the stage. Each mouse click on the LEFT or RIGHT buttons incurs a cost of 10 tokens to the First Mover who makes the click. For each First Mover, the number of balls caught so far (displayed as CATCHES) and the number of clicks made so far (CLICKS) are shown right above the task box on the First Movers screen. Also shown above the task box is EXPENSE, which is CLICKS multiplied by the cost per click. While the First Movers are working on the task, the other team members should wait quietly and patiently.

At the end of the first stage, all team members of both teams will be informed of which team won the first stage.

The second stage proceeds in the same fashion as the first stage. The Second Movers will participate in this stage while the other team members should wait quietly and patiently. The team whose Second Mover catches more balls at the end of the task will win the second stage. Each Second Mover will also incur an EXPENSE by clicking. At the end of the second stage, a similar summary screen will show which team won the second stage.

If one team has won both stages, the competition ends and each member from the winning team will receive the winner prize of 1200 tokens and each member from the losing team will receive the loser prize of 400 tokens. If each team has won one of the two stages, the Third

Movers will compete in the third stage following the same competition rule for the first two stages. The team whose Third Mover catches more balls at the end of the task will be the winning team. At the end of the third stage, a similar summary screen as in the first two stages will be shown.

Your earnings in each period will be (winner or loser) prize minus your EXPENSE. If the third stage is not necessary, the Third Mover earnings will be simply the (winner or loser) prize.

Your Earnings in Part 2

Your earnings in this part will be the sum of your earnings from all 10 periods.

End of Study Survey

[for the team treatments]

Q1. Please indicate which of the following statements best describe yourself in the experiment. a) I clicked more often to catch more balls when my team is ahead by 1:0 than when my team is behind by 0:1 b) I clicked more often to catch more balls when my team is behind by 0:1 than when my team is ahead by 1:0 c) I clicked equally often regardless of whether my team is ahead by 1:0 or is behind by 0:1

Q2. Please explain the reason behind your answer to Q1

Q3. Suppose you were the second mover and your team was ahead by 1:0. You then lost in the second stage and later learnt that your teammate lost in the third stage. From 1 to 10, how disappointed were you in this outcome?

Q4. Suppose you were the second mover and your team was behind by 0:1. You then won in the second stage and later learnt that your teammate lost in the third stage. From 1 to 10, how disappointed were you in this outcome?

Q5. Suppose you were the second mover and your team was ahead by 1:0. You then lost in second stage and later learnt that your teammate lost in the third stage. From 1 to 10, how guilty did you feel for losing your own second stage?

Q6. Suppose you were the second mover and your team was behind by 0:1. You then lost in the second stage. From 1 to 10, how guilty did you feel about losing your own second stage?

Q7. Suppose you were the first mover and you won in the first stage. You then learnt that second mover teammate lost in the second stage and your third mover teammate lost in the third stage. From 1 to 10, how much did you blame the outcome on the second mover? How much did you blame the outcome on the third mover?

Q8. Suppose you were the third mover and you learnt that your teammates lost in the first and second stages. From 1 to 10, how much did you blame the outcome on the first mover? How much did you blame the outcome on the second mover?

[for the Individual treatment]

Q1. Please indicate which of the following statements best describe yourself in the experiment. a) I clicked more often to catch more balls when I am ahead by 1:0 than when I am behind by 0:1 b) I clicked more often to catch more balls when I am behind by 1:0 than when I am ahead by 0:1 c) I clicked equally often regardless[s of whether I am ahead by 1:0 or am behind by 0:1

Q2. Please explain the reason behind your answer to Q1

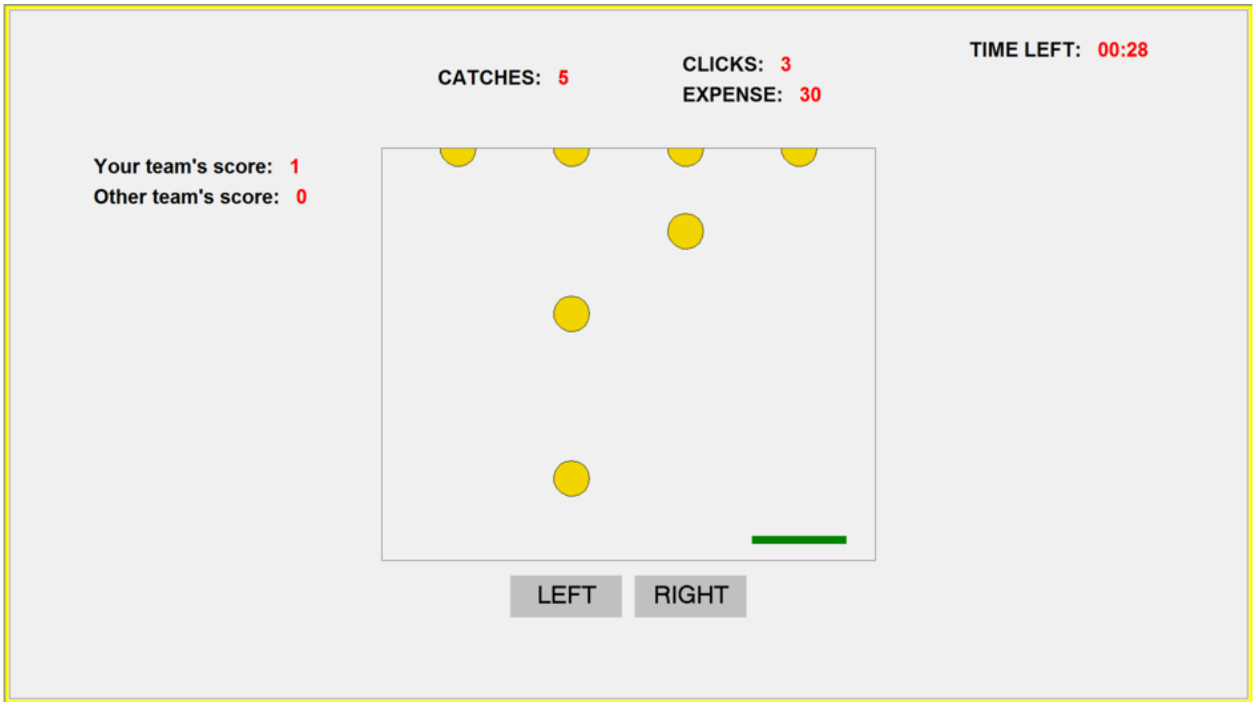
Q3. Suppose you were ahead by 1:0 but you lost in the next two stages. From 1 to 10, how disappointed were you in this outcome?

Q4. Suppose you were behind by 0:1. You won in the second stage but then lost in the third stage. From 1 to 10, how disappointed were you in this outcome?

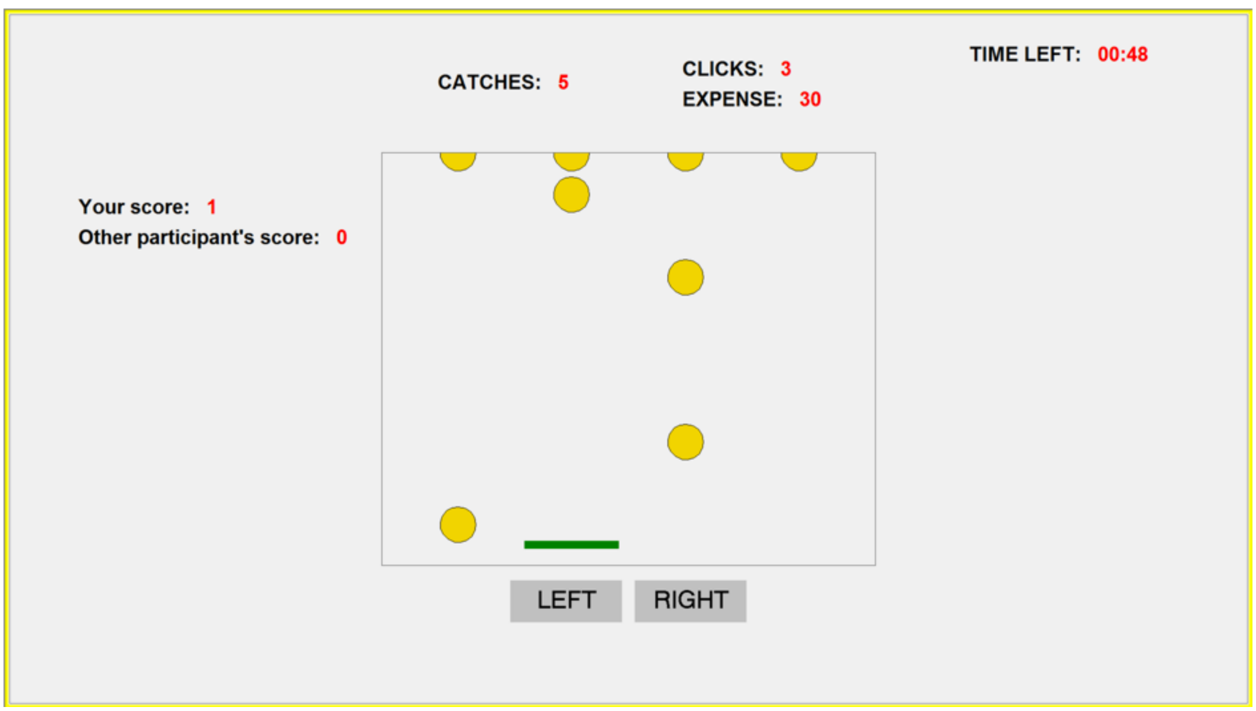
Q5. Suppose you were ahead by 1:0 but you lost in the next two stages. From 1 to 10, how much regret did you feel about losing the second stage?

Q6. Suppose you were behind by 0:1 and you lost in the second stage. From 1 to 10, how much regret did you feel about losing the second stage?

[Sample screenshot for second movers in TEAM and TEAMCHAT]



[Sample screenshot for players in IND_Bo3]



A.2 Additional Tables and Figures

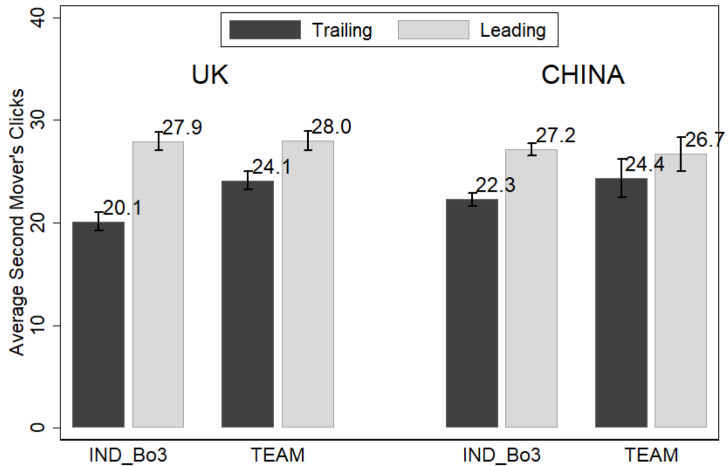


Figure A1: Average Second Mover's Clicks (separately for UK and China sessions). *The error bars are ±SEM.*

Table A1: Descriptive Statistics for Second Movers (separately for UK and China sessions)

Treatment	Obs.	Clicks				Catches			
		Mean	SD	Min	Max	Mean	SD	Min	Max
UK									
IND_Bo3									
Leading	360	27.93	16.95	0	84	31.52	8.67	8	50
Trailing	360	20.12	16.92	0	70	27.24	10.00	6	49
TEAM									
Leading	360	27.99	17.60	0	76	31.49	8.50	7	49
Trailing	360	24.13	16.85	0	79	30.01	8.92	7	47
China									
IND_Bo3									
Leading	648	27.18	14.53	0	91	33.40	6.95	9	52
Trailing	648	22.29	16.53	0	74	29.82	10.27	4	51
TEAM									
Leading	72	26.69	14.17	0	60	33.29	7.86	7	45
Trailing	72	24.36	16.01	0	66	31.10	9.80	4	44

Table A2: Descriptive Statistics for All Movers (separately for UK and China sessions)

Treatment	Obs.	Clicks				Catches			
	Obs.	Mean	SD	Min	Max	Mean	SD	Min	Max
UK									
IND_Bo3									
All	720	24.03	17.37	0	84	29.38	9.59	6	50
TEAM									
1st Mover	720	25.58	16.88	0	73	30.18	8.12	6	50
2nd Mover	720	26.06	17.33	0	79	30.75	8.74	7	49
3rd Mover	340	32.22	17.45	0	83	34.16	7.37	8	48
TEAMCHAT									
1st Mover	300	29.29	14.78	0	70	32.18	6.63	0	46
2nd Mover	300	29.43	15.90	0	77	32.60	8.22	0	45
3rd Mover	300	34.23	15.15	0	69	36.44	6.04	10	50
IND_Bo5									
All	360	18.26	18.63	0	80	25.66	10.87	6	47
China									
IND_Bo3									
All	1296	24.73	15.93	0	91	31.61	8.95	4	52
TEAM									
1st Mover	144	27.10	15.60	0	70	32.74	8.54	5	46
2nd Mover	144	25.53	15.11	0	66	32.19	8.92	4	45
3rd Mover	74	32.31	15.73	0	68	35.69	7.09	8	46

Table A3: Random Effect Regressions of Second Mover's Clicks (separately for UK and China sessions)

	UK			**China**		
	(1) IND_Bo3	(2) TEAM	(3) Pooled	(4) IND_Bo3	(5) TEAM	(6) Pooled
Lead	5.788***	2.775**	2.861**	5.056***	1.616	1.616
	(1.211)	(1.197)	(1.188)	(0.658)	(1.913)	(1.888)
IND_Bo3			−2.862*			−3.237*
			(1.518)			(1.772)
$Lead \times IND\_Bo3$			2.859*			3.440*
			(1.669)			(2.011)
Experience	−0.656**	−0.108	−0.449**	−0.183	−0.088	−0.165
	(0.327)	(0.090)	(0.215)	(0.187)	(0.055)	(0.180)
Constant	25.395***	25.136***	26.949***	23.392***	25.144***	26.515***
	(1.192)	(1.588)	(1.787)	(1.817)	(0.191)	(0.992)
σ_ω	11.050	13.512	12.776	10.508	11.385	10.672
σ_u	12.227	10.683	11.597	11.799	11.255	11.755
$N(matches)$	720	720	1440	1296	144	1440
$N(subjects)$	60	178	238	108	36	144

Note: Standard errors are bootstrapped and clustered at the session level. σ_ω denotes the square root of the variation due to the persistent unobserved individual characteristics. σ_u represents the square root of the variation due to the transitory unobservables. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A4: Random Effect Regressions of Third Mover's Clicks in Teams (UK sessions)

	(1) TEAM	(2) TEAMCHAT
Lead	−0.098	−2.143
	(1.624)	(2.394)
Experience	−0.464**	−1.195**
	(0.188)	(0.537)
Constant	34.664***	30.045***
	(2.906)	(2.088)
σ_ω	12.763	10.737
σ_u	11.526	9.486
$N(matches)$	340	158
$N(subjects)$	156	80

Note: Standard errors are bootstrapped and clustered at the session level. σ_ω denotes the square root of the variation due to the persistent unobserved individual characteristics. σ_u represents the square root of the variation due to the transitory unobservables. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

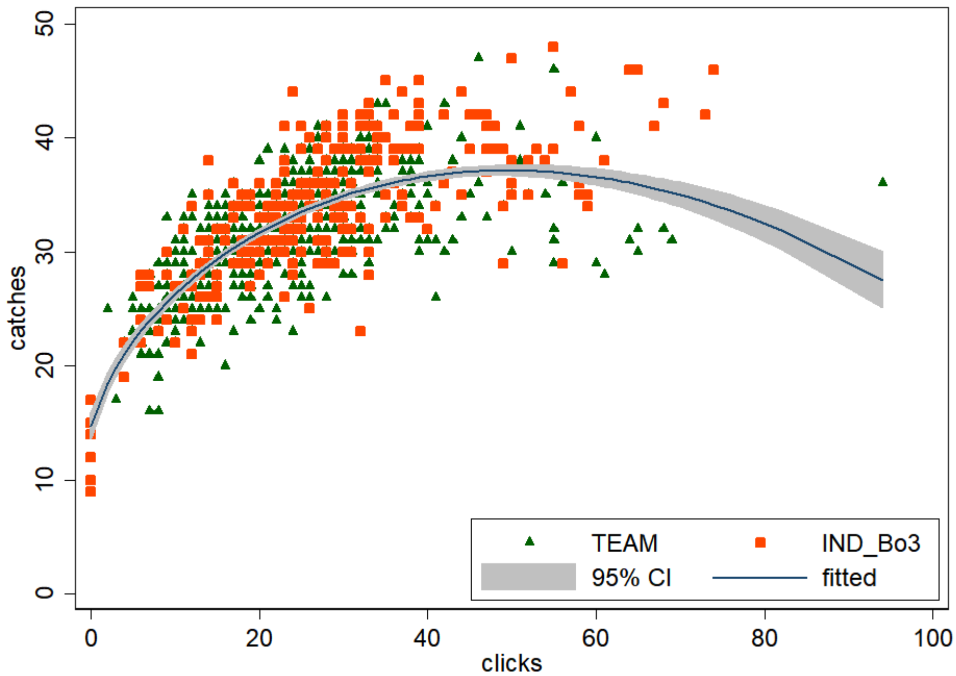


Figure A2: The Relation Between Clicks and Catches and the Estimated Production Functional Form

A.3 Content Analysis of the Chat Data

We developed a coding system for different types of messages based on reading through parts of the conversations to establish empirically relevant categories of argumentation. Two research assistants were independently trained to code the messages in each round, assigning a tick for each of the categories that showed up in the communication stage for each team member.

The messages could be categorized into four main categories:

- Messages of cheering characters are labeled as *Cheer* (e.g. "We are the dream tea," "we are awesome," "good luck!"),
- Messages with a promise to one's team members are labeled as *Promise* (e.g. "I will try my best!" or a response of "OK/ Agreed/ I will" to the statement by a team member, "catch many balls," "try to win," "do your best," etc.),
- Messages urging team members to catch as many balls as possible and disregard the cost of clicks are labeled as *MaxCatches* (e.g. "move as much to catch as much, you win by catching as many balls as possible, I have won 2 games so far with this tactic," "You need to get all the balls - don't worry about the clicks")
- Messages advising team members to try to minimize the expense are labeled as *MinClicks* (e.g. "don't ever move from the first to the last, unless you see two balls coming, only ever move within two spaces," "dont overclick, you will lose tokens if you do").

All other messages were not categorized as they did not deal with the game or the outcome of the game.[13] There were just two instances of messages about strategic effects between battles: third movers urged the first and second movers to do their best so that the outcome did not depend on the third battle, to which the first and second movers responded with "OK" and "will try my best" and these were categorized as Promise. There were no messages pertaining to the strategic situation of second movers or discussion of strategic neutrality. We hence discount the possibility of conscious information sharing and thus learning of the dynamically neutral rational strategy out of team discussion.

The level of agreement between the two coders was assessed by computing the Cohens kappa coefficient.[14] We find a "Moderate" to "Substantial" agreement in all four categories

[13] Examples include discussing yesterdays football match, whether they like the experiment or not, or greeting each other.

[14] Cohen's kappa coefficient (k) is a statistical measure of inter-coder agreement used to assess the agreement between two independent coders. $k = \frac{Pr(a)-Pr(e)}{1-Pr(e)}$ where $Pr(a)$ is the probability of agreement between

Table A5: Observed Frequency of Categories in Chats

	Proportion	Cheer	Promise	MaxCatches
Cheer	0.317***			
Promise	0.114**	(0.000)		
MaxCatches	0.230***	(0.129)	(0.000)	
MinClicks	0.089***	(0.000)	(0.071)	(0.000)

Note: P-values from paired sample sign tests are in parentheses. * Cohen's Kappa coefficient between 0.3 and 0.4. ** Cohen's Kappa coefficient between 0.4 and 0.6. *** Cohen's Kappa coefficient above 0.6.

of messages with the Cohen's Kappa coefficient always greater than 0.50. In our analysis, we use only those messages that both coders agreed on the category. Table A5 reports the level of agreement between the coders per each message category. In this table, we also calculate the proportion of subjects sending each message category. This is the number of times players sent a message of certain category divided by the total number of times players could have sent a message, which is 890 (89 subjects across the ten rounds). For example, if we only had one player sending a cheering message to her team members in all 10 rounds, this would count as 10/890 for the proportion of Cheer. We find that the most frequent message is of cheering nature and the least frequent message is about minimizing clicking: 38.6% Cheer; 16.2% Promise; 30.7% MaxCatches; and 12.0% MinClicks. Pairwise comparisons of proportion of messages sent show significant differences at the 10% level, except we cannot reject the hypothesis that Cheer and MaxCatches messages were sent equally frequently.

In Table A6, we analyze whether the messages exchanged within a team affect second mover's effort and how the type of the message interacts with second mover being on a leading or trailing team. We use the same set of independent variables as in regressions reported in the main text plus dummies for each message category and a variable for the number of message lines exchanged within a second movers team as a measure of team bonding. Column (1) shows that messages of MaxCatches motivate second movers to make 5 more clicks compared to those whose team did not exchange a MaxCatches message. None of the other categorized messages has a significant effect on second mover's clicks. Column (2) additionally controls interactions of category dummies and whether a second mover is on a leading or trailing team. We find that in response to MaxCatches messages, second movers on a trailing team click significantly more often than those on a leading team. Moreover, in response to messages containing promises, second movers on a leading team click significantly

coders and $Pr(e)$ is the probability that the agreement is reached by chance. If the coders are in complete agreement, then $k = 1$. If there is no agreement among the coders, other than what would be expected by chance, then $k = 0$. Kappa values between 0.41 and 0.60 are considered a "Moderate" agreement, and those above 0.60 indicate a "Substantial" agreement (Landis and Koch, 1977).

more often than those on a trailing team. Hence, it appears that trailers are more responsive to MaxCatches, whereas leaders are encouraged by Promise.

Table A6: Second Movers Clicks and Messages

	(1)	(2)
Lead	−0.251	−0.814
	(1.504)	(4.276)
Cheer	−2.707	−3.526
	(1.719)	(2.475)
Promise	0.419	−2.591
	(1.609)	(2.177)
MaxCatches	4.954***	8.313***
	(1.860)	(2.569)
MinClicks	−2.375	−3.430
	(1.725)	(2.328)
NumberMessage	0.340	0.345
	(0.227)	(0.229)
Lead × *Cheer*		1.488
		(3.397)
Lead × *Promise*		5.946**
		(3.034)
Lead × *MaxCatches*		−6.009*
		(3.580)
Lead × *MinClicks*		1.641
		(2.974)
σ_ω	9.814	10.088
σ_u	10.873	10.791
Obs.	293	293

Note: All regressions further include self-reported risk and competitive attitudes, gender, age, nationality, experience dummies, and intercept. Standard errors are in parentheses. σ_ω denotes the squared root of the variation due to the persistent unobserved individual characteristics. σ_u represents the squared root of the variation due to the transitory unobservables. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.4 An Extension of the Disappointment Aversion Model

In the main text, we assume that second movers experience emotions of elation/disappointment in relation to the final match outcome. Here, we present an extension to the basic model by additionally letting a leader feel elation if she wins her own *second* battle and letting a trailer feel disappointment if she loses. To see that this does not change our qualitative prediction of the momentum effect under a reasonable assumption, let the loser prize $v = 0$ and the adjustment parameter $k = 1/2$ to keep the model tractable. A leader's valuation of winning the second battle becomes

$$V + g_0(V - Vp_L),$$

where $p_L = p(e_L, e_T)$ is the leader's probability of winning the second battle, g_0 is the elation parameter if the leader wins, and elation is evaluated around the reference point Vp_L which is the leader's expected prize before the second battle starts. Her valuation of losing the second battle is

$$[V + g(V - \frac{V}{2}) + l(0 - \frac{V}{2})]/2,$$

which the leader's prize incentive in relation to the final match outcome and is exactly the same as in our basic model. Therefore, the net prize incentive for the leader to win the second battle is the difference in valuations of winning and losing:

$$V + g_0(V - Vp_L) - [V + g(V - \frac{V}{2}) + l(0 - \frac{V}{2})]/2. \tag{7}$$

Similarly, a trailer's valuation of winning the second battle is

$$[V + g(V - \frac{V}{2}) + l(0 - \frac{V}{2})]/2,$$

which is the trailer's prize incentive in relation to the final match outcome and is exactly the same as in our basic model. Her valuation of losing the second battle becomes

$$l_0(0 - \frac{V}{2}p_T),$$

where p_T is the trailer's probability of winning the second battle, $p_T + p_L = 1$. l_0 is the disappointment parameter if the leader loses, and disappointment is evaluated around the reference point $\frac{V}{2}p_T$ which is the trailer's expected prize before the second battle starts. Therefore, the net prize incentive for the trailer to win the second battle is the difference in valuations of winning and losing:

$$[V + g(V - \frac{V}{2}) + l(0 - \frac{V}{2})]/2 - l_0(0 - \frac{V}{2}p_T), \tag{8}$$

We can verify that the condition for the momentum effect is $\frac{\lambda}{2} > -g_0(1 - p_L) + l_0 p_T/2$. Assuming that $l_0 = 2g_0$ (loss looming twice as large as gain is often used as a rule of thumb), this condition is always satisfied.