Momentum in contests and its underlying behavioral mechanisms*

Greg Kubitz[1], Lionel Page[2], and Hao Wan[2]

[1]Queensland University of Technology
[2]University of Queensland

Abstract

We investigate the existence and nature of momentum in performance in contests and whether momentum arises for reasons in part unrelated to rational strategies in contests. To address this question, we look at a setting where strategic considerations should not generate momentum: a sequence of two rounds of independent contests. We show that if we relax the assumption of payoff maximizing agents, positive momentum (success tends to be followed by more success) or negative momentum (success tends to be followed by less success) can arise through several behavioral mechanisms that have, until now, not been widely considered in the literature. We examine these predictions in an experiment. Using random variations in the participants' winning chances in a first contest to identify the causal effect of success on later performance, we find that a positive momentum exists. Using several experimental conditions which modulate the effect of the different possible mechanisms, we find that the pattern of momentum is most compatible with players having adaptive preferences, whereby they may gain or lose interest in the second contest after respectively winning or losing the first one. These results suggest that standard models of contests do not fully capture the behavioral dynamics existing in competitive settings.

Keywords: Psychological momentum, adaptive preferences, regret, loss aversion

JEL codes: C72, C73, C91, D91

*Greg Kubitz, School of Economics and Finance, Queensland University of Technology, Brisbane, Australia. Email: gregory.kubitz@qut.edu.au. Lionel Page, School of Economics, University of Queensland, Brisbane, Australia. Email: lionel.page@uq.edu.au; Hao Wan, School of Economics, University of Queensland, Brisbane, Australia. Email: hao.wan@uq.net.au.

1 Introduction

Competitions are pervasive in society. In education, children compete for the best grades to get places in elite universities; in firms, people compete to get promotions; in the industry, companies compete to find innovations and get the corresponding patents; in academia, researchers compete to receive research grants; in politics, candidates compete to obtain elected positions; in legal conflicts, opposite parties compete to convince judges of their cause. From being a student at school to being a worker in an organization, people's career path is mostly determined by how they fare in a series of repeated and related *contests*, agonistic games where players invest unrecoverable resources to win a prize (Konrad 2009). Despite the importance of contests in determining individuals' social successes and failures, our understanding of how people navigate through them is still limited.

Discussions on contests often suggest a strong path dependency. Terms like *positive momentum*, *snow-ball effect*, or *winner effect* refer to the idea that success begets success. While on the contrary it is sometimes thought that winners may face *negative momentum* and experience lower performance after success. This may be the case because they *rest on their laurels*, or because losers may fight harder because they have their *back to the wall*. The understanding of both the source and direction of momentum carry significant policy implications. For instance, positive momentum can create a "Matthew effect," where a single stroke of luck can dramatically influence future outcomes, often leading to pronounced inequalities. If a policymaker harbours preferences regarding the distribution of resources in society — whether that leans towards equality or towards a merit-based distribution — recognising the origins of this momentum could be beneficial. Such knowledge would enable the policymaker to tailor the structure of social competitions, thereby fostering a resource distribution more closely aligned with their policy preferences.

Experimental evidence (Mago et al. 2013, Descamps et al. 2022) and field evidence (Gauriot & Page 2019) support the existence of positive momentum in contests. The exact nature of the mechanisms underlying momentum in contests is however still an open question. A key issue is whether momentum is rationalizable with payoff maximizing agents. Momentum is, instead, often ascribed to non-rationalizable psychological mechanisms. In that perspective, several recent studies have aimed to tease out rational and purely behavioral mechanisms, with mixed results (Malueg & Yates 2010, Mago et al. 2013, Cohen-Zada et al. 2017, Gauriot & Page 2018, Descamps et al. 2022).

In the present study, we investigate theoretically and experimentally whether purely behavioral mechanisms may drive momentum in contests. To do so, we look at a setting where no rational mechanism should be present: a sequence of two contests with independent prizes and different opponents. In each contest, players decide how much effort they want to expend to increase their chance of winning the contest's prize. We model the behavior of two players in this simple setting and we show that momentum can emerge from a range of behavioral effects which have not been fully investigated in the literature until now: the effect of past success on the utility of future prizes due to loss aversion, wealth effects or adaptive preferences, and the effect of past outcomes on the ability to generate high performance in later contests due to feelings of regret or self-efficacy.

We study these theoretical predictions in a lab experiment where participants play two independent rounds of contests, against opponents which are randomly selected in each round. This randomization allows us to cleanly identify both the effect of winning and of the margin of victory in the first round on performance in the second round, using the opponent's performance in the first round as an exogenous source of variation. Our design also allows us to look at whether a path dependency emerges as a consequence of a change in behavior of the winners (winner effect) or the losers (loser effect).

We find clear evidence of positive momentum, with winners of the first contest having a higher performance than the losers and being more likely to win the next contest. This effect is driven by the winning or losing outcome of the first contest and we do not find evidence of momentum stemming from the margin of victory or loss. When looking at the effect of the first contest on future performances, we cannot reject the hypothesis that the positive momentum emerges as a joint effect of a winner and loser effect. Among the possible explanations for positive momentum, the performance in the second round contest is compatible with the effect of adaptive preferences, whereby participants' relative interest in the round 2 contest's prize is influenced by the result in round 1.

This paper makes several contributions to the literature on contests. Recently, this literature has grown substantially, theoretically (Konrad 2009, Vojnović 2015), experimentally (Dechenaux et al. 2014), and using field data (e.g. Klumpp & Polborn 2006, Malueg & Yates 2010, Gauriot & Page 2019). A key question arising from the study of real-world contests is whether the behavior observed from participants is rationalizable as equilibrium strategies of payoff maximizing agents, or whether cognitive limitations and psychological biases drive some key aspects of human decisions in such situations. In that perspective, one of the phenomena that have particularly attracted interest is the study of the dynamics of behavior in contests: the fact that the chances of later successes can be influenced by previous successes.

In economics, game theoretic models have shown that a so-called positive *strategic momentum* can arise in dynamic contests where an overall prize is determined by the success in a series of rounds of contests. The reason for such momentum is that players ahead in a dynamic contest tend to have a greater incentive to win in the remainder of the contest (Harris & Vickers 1985, Klumpp & Polborn 2006, Konrad & Kovenock 2009). It leads to a "discouragement effect" with players lagging in the contest having an incentive to lower their investment in the later part of the contest. The existence of such momentum in dynamic contests has been supported by several empirical studies (Klumpp & Polborn 2006, Malueg & Yates 2010, Mago et al. 2013, Gauriot & Page 2019). It has recently been suggested that a strategic momentum may also arise in repeated contests because players have incomplete information about their relative strength. In that case, players learn about their relative strength from past wins and losses (Ederer 2010, Kubitz 2023). Players who update rationally their belief about their relative strength upward after a success may rationally invest more resources in later contests (Descamps et al. 2022).

In contrast, the term *psychological momentum* has been used to refer to momentum induced by psychological mechanisms which are not rationalizable. Cohen-Zada et al. (2017) defines this type of momentum as "the tendency for an outcome to be followed by a similar outcome not caused by any strategic incentive of the players." Several studies have pointed to the possible existence of such a type of momentum. In a lab experiment, Gill & Prowse (2014) found that women were more likely to display lower performance after a loss in a series of strategically unrelated contests. In a field study looking at sporting athletes (judo), Cohen-Zada et al. (2017) found that for athletes with identical numbers of success and failures, athletes are more likely to be successful in a later contest if they ended the series of past contests on a success, even though the order of past success and failures does not have direct strategical importance. Previous studies are however not unanimous on the positive nature of psychological momentum. In a well-known study, Berger & Pope (2011) found that being behind in a competition may lead to higher performance later, possibly due to reference-dependent preferences and loss aversion.

Our study contributes to our understanding of momentum by providing new evidence both on the existence of momentum and on its behavioral nature. First, we find clear evidence of positive momentum in our sequential contest setting. This result adds to the evidence on the existence of positive momentum in contests. In our setting of repeated individual contests with different, randomly assigned opponents, the contestant's own performance and the outcome of the first contest are the only factors of the first contest that may impact the second contest. Because the prize of each contest is independent of the outcome in the other contest, the outcome of the initial contest cannot directly influence the objective value of the prize of the second contest and therefore cannot create strategic momentum. Moreover, to identify the behavioral impacts of the contest outcome, i.e., winning or losing and the margin of victory or loss, we control for the contestant's own performance and use their opponent's score as the source of random variation on the contest outcome. Therefore, the fact that we find evidence of momentum in our setting is significant. It shows that the traditional game theoretic explanations of momentum are not able to explain all types of momentum in contests.

Second, we investigate the source of this momentum. We identify a significant difference in performance in the second contest between contestants that just win the first contest versus just lose the first contest. Noticeably, we do not find evidence of momentum stemming from the margin of victory or loss. Only the win/loss outcome of the first contest influences the second contest. Looking at the source of this momentum, we cannot reject the hypothesis that it comes both from an increase in the performance of winners (winner effect) and a decrease in the performance of the losers (loser effect).

Finally, we provide a behavioral theory framework to formalize how psychological momentum can arise between independent contests. We consider several behavioral factors previously mentioned in the literature: wealth effect, loss aversion, adaptive preferences, experienced regret, and self-efficacy. We use this framework to identify the direction and channel of momentum of each factor. Combining the theoretical predictions with the experimental evidence we find that adaptive preferences are the mechanism most favored by the empirical pattern we observe in the data. Adaptive preferences can explain momentum by changing the relative interest in winning the second contest after winning or losing the first one. On the one hand, the winner can grow a "hunger for more" and feel a greater subjective value for the prize in round 2. On the other hand, the loser may be prone to a fox-and-sour-grapes effect and feel a lower subjective value for the prize in round 2.

The remainder of the paper is as follows: Section 2 presents a model of sequential contests to investigate possible mechanisms leading to psychological momentum. Section 3 presents the design of the experiment. Section 4 presents and analyses the results of the experiment, followed by a final conclusion in Section 5.

2 Theoretical framework

We investigate the possible behavioral mechanisms generating path dependency in the setting of two sequential contests where a contestant competes in two independent contests against different opponents. In that setting, we consider alternatively the possible impact of different behavioral mechanisms by looking at how equilibrium behavior changes when the contestants have preferences which deviate from strict payoff maximization due to non-monetary preferences or psychological effects.

We assume that contestants' choices depend only on the current contest payoffs, specifically that contestants in the first contest are myopic and do not anticipate how current choices will affect payoffs in the second contest. We do this mainly for technical convenience. Our predictions and resulting experimental hypotheses compare equilibrium efforts between contestants in the second contest and therefore first contest strategies that are employed to impact second contest outcomes are not of primary interest.

In what follows, we employ a contest model where effort maps to production with additive noise à la Lazear & Rosen (1981). Given production levels, the outcome of the contest is deterministic except in the case of a tie. This model is used instead of the Tullock contest model as it better matches the experimental task and what participants observe between each round.[1] Regardless, most of the theoretical predictions generated by the tournament model can also be generated with a Tullock contest model that has similar assumptions on the shape of the cost and impact functions.[2]

2.1 General set-up

Two ex-ante symmetric players $i = 1, 2$ compete in the first of two independent contests. Contestant $i = 1$ then competes with a third contestant, $i = 3$, in the second contest. It is assumed that the third contestant is ex-ante symmetric to the first two contestants and has also competed in the first contest against a unique fourth contestant. In contest t, where $t \in \{1, 2\}$, players simultaneously make irrecoverable and non-negative efforts b_{it}. Let the costs to expend these efforts in contest t be $c(b_{it})$. We assume the cost function is twice continuously differentiable with $c'(b_{it}) > 0$ and $c''(b_{it}) > 0$ along with the limit conditions $\lim_{b_{it}\to 0} c'(b_{it}) = 0$ and $\lim_{b_{it}\to\infty} c'(b_{it}) = \infty$.

In each round, the contestant with the highest output wins the prize in that round. Output can be influenced by the chosen effort, b_{it}, the contestant specific ability, a_i, and a random noise that is independently and identically distributed across contests and contestants, ε_{it}. We denote this impact function as $y_{it} = f(b_{it}, a_i) + \varepsilon_{it}$, where y_{it} is the output of contestant i in round t. We take $f : \mathbb{R}_+ \times \mathbb{R}_{++} \to \mathbb{R}_+$ to be twice continuously differentiable in each component with $\frac{\partial f(b_{it},a_i)}{\partial b_{it}} > 0$, $\frac{\partial^2 f(b_{it},a_i)}{\partial b_{it}^2} \leq 0$, $\frac{\partial f(b_{it},a_i)}{\partial a_i} > 0$ whenever $b_{it} > 0$, and $\frac{\partial^2 f(b_{it},a_i)}{\partial b_{it}\partial a_i} \geq 0$. These conditions imply that for a given ability level, the expected output is increasing and (weakly) concave down

[1] In the task, the participant that completes the most strings wins the prize, and moreover participants can observe the margin of victory which aligns with the difference in output in the tournament model. The Tullock contest model adds noise to the outcome of the contest given the production of each contestant. Moreover, there is no clear definition of a margin of victory in that model.

[2] The results on the effects of regret cannot be generated with a Tullock model as regret is generated from the margin of victory or defeat which is not clearly defined in the Tullock model.

in efforts, and for positive effort, ability increases output. Finally, higher ability (weakly) improves marginal productivity of effort. The contest success function is given by

$$p_{it}(y_{it}, y_{-it}) = \begin{cases} 1 & \text{if } y_{it} > y_{-it} \\ \frac{1}{2} & \text{if } y_{it} = y_{-it} \\ 0 & \text{if } y_{it} < y_{-it} \end{cases}.$$

Define $\varepsilon_t \equiv \varepsilon_{-it} - \varepsilon_{it}$, and assume it has a continuous cumulative distribution function $G(\varepsilon_t)$ that is twice continuously differentiable with density $g(\varepsilon_t) = G'(\varepsilon_t)$. We assume that $g(\varepsilon_t)$ is symmetric around and uni-modal at 0 and positive on the real line. Given the efforts and abilities of the two contestants, the winning probability of player i can be written as $G(f(b_{it}, a_i) - f(b_{-it}, a_{-i}))$.

The utility of winning depends on the monetary value of the prize for the round, v_t, and is denoted $u(v_t)$. In the second contest, both contestant 1 and contestant 3's histories are private information. The payoffs for player i in period t are

$$\pi_{it} = u(v_t)p_{it}(y_{it}, y_{-it}) - c(b_{it}). \tag{1}$$

Given the impact function, the distribution of the noise term and the uncertainty around the relative ability of the contestants, expected payoffs can be written as

$$\mathbb{E}_{a_i,a_{-i},b_{-it}}[\pi_{it}] = u(v_t)\mathbb{E}_{a_i,a_{-i},b_{-it}}[G(f(b_{it}, a_i) - f(b_{-it}, a_{-i}))] - c(b_{it}). \tag{2}$$

The first order condition for effort provision in contest t is given by

$$u(v_t)\mathbb{E}_{a_i,a_{-i},b_{-it}}\left[g(f(b_{it}, a_i) - f(b_{-it}, a_{-i}))\frac{\partial f(b_{it}, a_i)}{\partial b_{it}}\right] = c'(b_{it}). \tag{3}$$

In what follows, we assume that the first order condition is sufficient for payoff maximization. We will use this condition to consider the impact of possible behavioral mechanisms that lead to different predicted efforts in each of the two rounds. As a baseline, we first note that if contestants have history independent payoffs and the distribution of ability is degenerate at $\bar{a}$, the effort by contestant i in each of the two contests will only vary based on the value of the prize in each contest. This baseline equilibrium level of effort in each contest, b_i^*, would satisfy

$$u(v_t)g(0)\frac{\partial f(b_i^*, \bar{a})}{\partial b_{it}} = c'(b_i^*). \tag{4}$$

We now consider possible behavioral deviations from this general setting. We introduce, alternatively, different behavioral assumptions, and look at how it affects the dynamics of performance between the two contests in each case.

2.2 Effect of past outcomes

In this section, we take the ability distribution to be degenerate, but allow the utility function of winning and the impact function to depend on past outcomes. We will consider three cases. The first is where the *prizes* from the first contest impacts the future marginal utility of winning the second prize. The second is where the *outcome* of winning or losing the first contest impacts the marginal utility of winning the second prize. Lastly, we consider the case of regret, where the difference between the maximum possible payoff in round one and the actual payoff received impacts the marginal productivity of effort.

In all three cases, all contestants would choose the same effort in the first contest as there is no outcome history. The first order condition in this first round is identical to (4). At the end of the first contest, contestants learn if they have won the contest and observe both their own and their first-round opponent's outputs. In the second round, the history of each player is private information. For each case, we will consider the impact of the outcomes of the first contest on effort provision in the second contest.

2.2.1 Effect of past payoffs

We denote the utility of winning the second contest given history h as $u_h(v_2)$. If past payoffs impact the utility of winning the second contest, then contestants' relevant history can be summarized as a binary outcome $h \in \{\ell, w\}$. Assuming symmetry of efforts within each group, we can denote the efforts of the two groups in the second contest as b_{w2} and $b_{\ell 2}$. Given that there is equal chance contestant 3 won or lost the first contest, the first order condition for contestant 1 given history h can be written as

$$u_h(v_2)\frac{\partial f(\hat{b}_{h2}, \bar{a})}{\partial b_{h2}} \frac{1}{2}\left[g(0) + g(f(\hat{b}_{h2}, \bar{a}) - f(b_{-h2}, \bar{a}))\right] = c'(\hat{b}_{h2}). \tag{5}$$

In equilibrium, (5) holds for both contestants who won the first round, $h = w$, and contestants who lost the first round , $h = \ell$. Due to symmetry of $g(\cdot)$ around zero the two conditions imply

$$\frac{u_\ell(v_2)}{c'(b^*_{\ell 2})}\frac{\partial f(b^*_{\ell 2}, \bar{a})}{\partial b_{\ell 2}} = \frac{u_w(v_2)}{c'(b^*_{w2})}\frac{\partial f(b^*_{w2}, \bar{a})}{\partial b_{w2}}. \tag{6}$$

With increasing marginal cost of effort and (weakly) decreasing marginal productivity of effort, (6) implies that $b^*_{\ell 2} \lesseqgtr b^*_{w2}$ when $u_\ell(v_2) \lesseqgtr u_w(v_2)$.

We consider here two ways past payoffs can impact the utility of winning the second contest: decreasing marginal utility in wealth and loss aversion. The first case corresponds to the possibility of wealth effects across the two contest rounds. If the utility of a contestant based on their total winnings is $U(v)$, then $u_\ell(v_2) = U(v_2)$ and $u_w(v_2) = U(v_2 + v_1) - U(v_1)$. Decreasing marginal utility, specifically $U(v) > U(v + v_0) - U(v_0)$ for all $v, v_0 > 0$, would imply that $u_\ell(v_2) > u_w(v_2)$. Therefore the marginal utility of success will decrease with a past success and lead to a negative momentum: past winners will exert less effort in the second contest because they value its prize less than past losers.

The second case corresponds to the situation where players have reference-dependent preferences with loss-aversion. Loss aversion implies that losses below the reference point have a larger impact on utility than equal-sized gains above the reference point. Given a reference point v_r, for any $v \geq 0, v' > 0$ the utility function over total winnings satisfies $U(v_r + v + v') - U(v_r + v) < U(v_r - v) - U(v_r - v - v')$.

We take as a reference point the contestant's ex-ante expected winnings from the two contests: $v_r = \mathbb{E}[v] = \frac{1}{2}v_1 + \frac{1}{2}v_2$. Whenever $v_1 \geq v_2$, $v_1 - v_r \geq 0$. Then $u_\ell(v_2) = U(v_2) - U(0) = U(v_r - (v_1 - v_r)) - U(v_r - (v_1 - v_r) - v_2)$ and $u_w(v_2) = U(v_1 + v_2) - U(v_1) = U(v_r + (v_1 - v_r) + v_2) - U(v_r + (v_1 - v_r))$. The loss aversion condition then implies that the marginal utility of winning the second contest after losing the first is higher than after winning the first: $u_\ell(v_2) > u_w(v_2)$.

Loss aversion is frequently parameterized by a loss multiplier $\lambda > 1$ where $U(v_r - v) - U(v_r - v - v') = \lambda(U(v_r + v + v') - U(v_r + v))$. Under this parameterization, $\frac{u_\ell(v_2)}{u_w(v_2)} = \lambda$, which implies, from (6), the following relationship between efforts of contestants who have won the first round and lost the first round:

$$\frac{u_\ell(v_2)}{u_w(v_2)} = \frac{c'(b^*_{\ell 2})}{c'(b^*_{w2})} \frac{\frac{\partial f(b^*_{w2}, \bar{a})}{\partial b_{w2}}}{\frac{\partial f(b^*_{\ell 2}, \bar{a})}{\partial b_{\ell 2}}} = \lambda.$$

Assuming cost and productivity are power functions with parameters $\alpha > 1 > \beta > 0$ so that $c(b) = k_c b^\alpha$ and $f(b, \bar{a}) = k_f(\bar{a}) b^\beta$, then the difference in efforts are increasing in average effort: $b^*_{\ell 2} - b^*_{w2} = b^*_{w2}\left(\lambda^{\frac{1}{\alpha - \beta}} - 1\right)$. This implies that when the prize in the second contest is relatively small, and efforts are lower, the likelihood the contestant that lost the first round wins the second decreases.

Prediction 1 (Effect of marginal utility)**.** *With either wealth effects or with expectation-based loss aversion the marginal utility of winning the second contest is higher after losing the first contest, $u_\ell(v_2) > u_w(v_2)$. It follows that*

i a winner of the first contest will have a lower average performance than the loser of the first contest, $b^*_{\ell 2} > b^*_{w2}$;

ii the differences in average performance decreases as the prize in the second contest decreases.

The possibility of a negative momentum has received less empirical support, but it has been suggested in the past (Simon 1971, Berger & Pope 2011) with loss aversion being one of the possible drivers. The evidence about such negative momentum is however mixed (Klein Teeselink et al. 2023).

It has also been argued that loss aversion could lead to a positive momentum if leaders consider their lead as the status quo which they want to preserve (Schneemann & Deutscher 2017). In our set up, since the prizes of the two contests are not linked, there is no intermediate lead to possibly lose. Our experimental design with the second prize no larger than the first is therefore well suited to test the effect of loss aversion in a situation where its effect should unambiguously lead to negative momentum.[3]

2.2.2 Adaptive preferences

Another possible way for past outcomes to influence players' utility for later possible outcomes is the case of adaptive preferences. Elster (1983) famously explained how people may adjust how much they care about something as a function of their ability to get it. For instance, people may adapt their preferences according to the fox-and-sour-grapes structure: after failing to get something they desire, they may decide that they do not care about it. The notion of adaptive preferences was used in social welfare theory by Sen (1995).

In the context of our set-up, we may consider the situation where participants may re-assess how much they care about winning a contest after the outcome of the first contest: winners may be encouraged to consider that winning is important while losers may be tempted to downplay the importance of the contests' prizes. Again, the relevant history is summarized by winning or losing the first contest, $h \in \{\ell, w\}$. Adaptive preferences would directly imply $u_w(v_2) > u_\ell(v_2)$. Such a flexible evolution may be credible to the extent that part of the utility of winning may be non-monetary and therefore more malleable following introspection (Sheremeta 2010).

Prediction 2 (Effect of adaptive preferences)**.** *With adaptive preferences $u_\ell(v_2) < u_w(v_2)$ and therefore a winner of the first contest will have a higher average performance than the loser of the first contest, $b^*_\ell < b^*_w$.*

[3]When contestants are loss averse and play choice-acclimating personal Nash equilibrium, weaker contestants put in less effort than strong contestants, see Fu et al. (2022). In some settings, this could generate a positive momentum due to learning about relative ability. However, in our setting, this will not generate a positive momentum once the contestant's own output in the first contest is controlled for. See the discussion in Section 2.3.

2.2.3 Regret

An interesting possibility, until now not investigated in repeated contests is the possible role of regret. The idea that regret may influence performance is often expressed in discussions about performance in contests. In their monograph investigating strategies and performance in tennis, Klaassen & Magnus (2014) specifically mention such a possible effect of regret in a discussion of the Nadal-Federer 2008 Wimbledon final. They point out that after losing a breakpoint on Nadal's serve while being ahead in the last set, Federer's disappointment with this missed opportunity may have affected negatively his performance afterward. He ended up losing the set and the match.

Regret theory, proposed roughly at the same time by Loomes & Sugden (1982) Bell (1982), and Fishburn (1982), assumes that people experience negative utility from missed opportunities. For simplicity, and in line with the myopia assumed in the initial contest, we only consider *experienced regret* (ex-post). That is, we do not consider the possibility of anticipated regret where decision-makers form expectations (ex-ante) about the likely regret they may face after each decision.

We assume that the amount of regret experienced by an individual only depends on the difference between realized payoffs and the payoffs if the payoff maximizing effort was chosen given the realized output of the other contestant, y_{-it}, and the realized noise in own productivity, ε_{it}.[4] Define the amount of experienced regret R_{i2} of each player when entering the second round contest as:

$$R_{i2}(b_{i1}, \varepsilon_{i1}, y_{-i1}) = \pi_{i1}^{best} - \pi_{i1}, \tag{7}$$
$$\text{where} \quad \pi_{i1}^{best} = \sup_{b_{i1}} u(v_1)p_{i1}(f(b_{i1}, \bar{a}) + \varepsilon_{i1}, y_{-i1}) - c(b_{i1}).$$

After the first contest, both the winner and the loser of the first round will experience a positive amount of regret with probability one when they exert positive efforts. For any positive winning differential, the winning contestant could have achieved higher payoffs by reducing effort so that the winning margin was smaller. The losing contestant on the other hand, could have either increased effort to just win the contest, or put in no effort at all, whichever achieves higher payoffs. We use the notation R_{i2}^{ℓ} and R_{i2}^{w} to denote regret for the contestant that respectively lost and won the first contest.

For the winner of the first contest, the realized payoff is $\pi_{i1} = u(v_1) - c(b_{i1})$. The best possible payoff is $\pi_{i1}^{best} = u(v_1) - c(b_{i1}^{best})$ where $b_{i1}^{best} = \max\{0, \hat{b}_{i1}\}$ and $\hat{b}_{i1}$, which is the effort that matches the production of the two contestants, satisfies $f(\hat{b}_{i1}, \bar{a}) + \varepsilon_{i1} = y_{-i1}$. Then the regret of the winner following the first contest is

[4] It is assumed that the contestant knows own effort and can observe their output, and therefore can infer the realization of the noise term in productivity.

$R_{i2}^{w} = c(b_{i1}) - c(b_{i1}^{best})$.

For the loser of the first contest, the realized payoff is $\pi_{i1} = -c(b_{i1})$. The best possible payoff is $\pi_{i1}^{best} = \max\{0, \hat{\pi}_{i1}\}$ where $\hat{\pi}_{i1} = u(v_1) - c(\hat{b}_{i1})$. Regret of the losing contestant is given by $R_{i2}^{\ell} = c(b_{i1}) + \max\{0, u(v_1) - c(\hat{b}_{i1})\}$.

From this characterization, it follows that the loser always feels weakly more regret than the winner. Moreover, a winner that wins by a small margin ('just wins') feels less regret than one that wins by a large margin and a loser that loses by a small margin ('just loses') feels more regret than one that loses by a large margin. Therefore regret experienced by contestant i is not continuous in the difference of productivity $y_{i1} - y_{-i1}$. Specifically, there is a discrete negative jump in regret where the difference in productivity is zero, i.e., as the contestant goes from just losing to just winning, see Figure 1.

Following the common suggestion that people may "linger on missed opportunities", we consider the case where regret may have a negative psychological effect, either due to cognitive load or frustration, which reduces the productivity of the contestant. This can be modeled as an increase in the marginal cost of effort or in the reduction in the marginal productivity of effort.[5] Here we assume that in the second round contest the impact of regret from the first round contest acts via a discounting factor on the marginal productivity, with higher regret leading to lower marginal productivity. Specifically for history $h_i = R_{i2}$, $f_{h_i}(b_{i2}, \bar{a}) = \frac{f(b_{i2}, \bar{a})}{1+R_{i2}}$. Using (3), the first order condition of effort provision in the second contest for a contestant with regret R_{i2} can be written as

$$\frac{u(v_2)}{1 + R_{i2}} \mathbb{E}_{b_{-i2}, h_{-i}} \left[g\left(f_{h_i}(b_{i2}, \bar{a}) - f_{h_{-i}}(b_{-i2}, \bar{a})\right) \frac{\partial f(b_{i2}, \bar{a})}{\partial b_{i2}} \right] = c'(b_{i2}). \qquad (8)$$

For any conjectured distribution of effort by an opposing contestant, sufficient convexity of the cost of effort implies that the LHS of (8) will cross the RHS once from above. Therefore, when higher regret lowers the marginal benefit of increasing effort, it leads to lower effort provision in the second contest. We can then establish the following fact about the contestants' regret and performance in the second round contest as a consequence:

Prediction 3 (Effect of regret on performance)**.** *Following the first contest outcome, a contestant:*

i experiences the most regret, and the largest drop in performance after a close defeat;

ii experiences the least regret, and the smallest drop in performance after a close success;

[5] The two ways of modeling this do not change the qualitative impacts of regret in Prediction 4.

iii who has won the first contest experiences greater regret (and a larger drop in performance) after success by a large margin;

iv who has lost the first contest experiences lower regret (and a smaller drop in performance) after failures by a large margin.

Figure 1 illustrates Prediction 4. A player who wins the first contest by a small margin has a higher probability of winning the second compared to a player who wins the first contest by a large margin; a player who loses the first contest by a small margin has a lower probability of winning the second compared to a player who loses the first contest by a large margin.

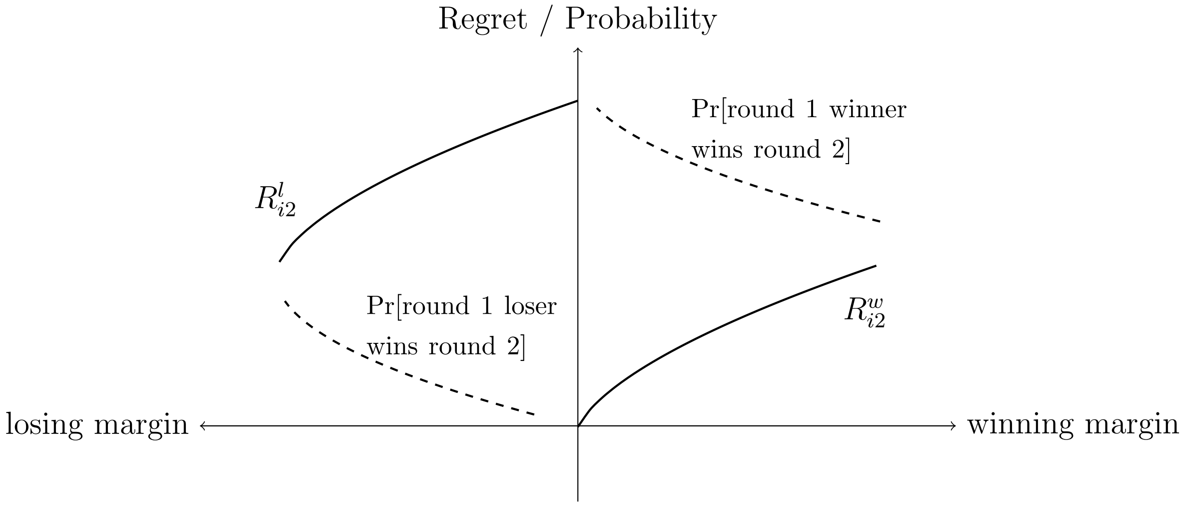


Figure 1: Regret after the first contest and probability of winning the second contest.

2.3 Self-efficacy

In Section 2.2 a key assumption is that contestants have symmetric ability. While this assumption may be credible in some settings where contestants' differences are small, in settings where the potential differences are large, information about absolute and relative ability may play an important role. In particular, belief updating from past outcomes may generate a positive strategic momentum in many contest settings. This would occur when: 1) contestants start with an imperfect knowledge of their absolute and/or relative ability and progressively learn from the outcome of past contests; 2) contestants who learn they are likely to be stronger should expend higher effort in equilibrium.

This information revelation mechanism was found by Descamps et al. (2022) in the study of a best-of-3 contest. Players appeared to get more confident after a first win and exert more effort as a consequence. Winning or losing the first round contest and the associated difference in output provided them with additional information on their relative strength in a contest setting where the stronger player should expend more effort.

In our set-up this information revelation mechanism for a strategic momentum is absent. First, while the contestant's own output in the first contest will provide information about their ability, the outcome of the first contest and the winning margin provide no additional information about absolute ability. Second, contestants are re-matched with new players in the second round, and as a consequence, they do not learn about the strength of their specific opponent from past outcomes. Therefore, if the distribution of abilities of the population are known, the winning margin of the first contest provides no additional information about ability relative to the contestant in the second round. If the ability distribution is unknown however, the winning margin can inform a contestant about their relative ability compared to the distribution of abilities, and therefore the ability of the contestant in the second round.

Formally, contestants are ex-ante symmetric with abilities are drawn $i.i.d.$ from a distribution $A(\cdot)$ that is uni-modal at its mean $\bar{a}$. We assume that contestants have no additional information about their own ability at the start of the first contest.[6] Due to symmetry, contestants choose the same effort in the equilibrium of the first contest. Outcomes from the first contest can provide information to the contestants about their draw a_i from the ability distribution.

Information about ability impacts the provision of effort in two ways. First, higher absolute ability leads to higher marginal productivity of effort when ability and effort are complementary, $\frac{\partial^2 f(b_{it},a_i)}{\partial b_{it}\partial a_i} > 0$. In this case, better performance in the first contest, all else equal, would lead to higher effort in the second. Second, given a uni-modal distribution of ability, participants with ability near the mean are more likely to be in close competition than those with relatively high or relatively low ability. These two impacts of learning about own ability are given in the following first order condition:

$$u(v_2)\mathbb{E}_{a_i,a_{-i},b_{-i2}}\left[g(f(b_{i2},a_i) - f(b_{-i2},a_{-i}))\frac{\partial f(b_{i2},a_i)}{\partial b_{i2}}\right] = c'(b_{i2}). \tag{9}$$

Information about own productivity is sufficient for the contestant to update beliefs about their own ability. Therefore the performance of the contestant would not vary with the margin or outcome of the first contest holding productivity of the contestant fixed assuming the distribution of abilities in the population, $A(\cdot)$, is known. However, relaxing this assumption by, for example, allowing the mean ability of the population $\bar{a}$ to take on two values $\bar{a}_{high}$ or $\bar{a}_{low}$ allows the contestant

[6] When contestants are myopic in the first contest, assuming they have some additional information about their own ability will lessen the impact of learning, but will not change the qualitative impacts of first contest history on second contest performances.

to update beliefs about their relative ability in the second contest from the winning margin in the first contest. However, given the symmetry of $g(\cdot)$ about zero and $A(\cdot)$ about the mean, the updating about relative ability would not lead to momentum from one contest outcome to the other. Winning or losing by a small margin in the first contest would symmetrically inform the contestant that the second contest is more likely to be competitive, leading to higher performances than if the contestant won or lost by a large margin.

The literature in psychology has however stressed the importance of *self-efficacy*, the belief in one's own ability as having possible effects in performance which are not related to strategic behavior (Bandura 1997). It can be the case, because self-efficacy reduces anxiety and self-doubt and helps a contestant to reach a high level of performance by being *in the zone*. We therefore consider here the possibility for self-confidence to play a role on performance for non-strategic reasons.

To capture the impact of self-efficacy, we allow for the productivity function to depend not only on ability but on confidence generated by the margin of victory from the first contest. Specifically for $y_{i1}, y_{-i1} > 0$ we define the percent margin as $\Delta y_{i1} \equiv \frac{y_{i1} - y_{-i1}}{y_{i1}}$ and let the history dependent productivity be $f_{h_i}(b_{i2}, a_i) = \frac{1}{1-\Delta y_{i1}} f(b_{i2}, a_i)$. Then the first order condition becomes

$$\frac{u(v_2)}{1-\Delta y_{i1}} \mathbb{E}_{a_i, a_{-i}, b_{-i2}, h_{-i}} \left[g(f_{h_i}(b_{i2}, a_i) - f_{h_{-i}}(b_{-i2}, a_{-i})) \frac{\partial f(b_{i2}, a_i)}{\partial b_{i2}} \right] = c'(b_{i2}). \quad (10)$$

Again, for any conjectured distribution of effort by an opposing contestant, sufficient convexity of the cost of effort implies that the LHS of (10) will cross the RHS once from above. The following predictions result:

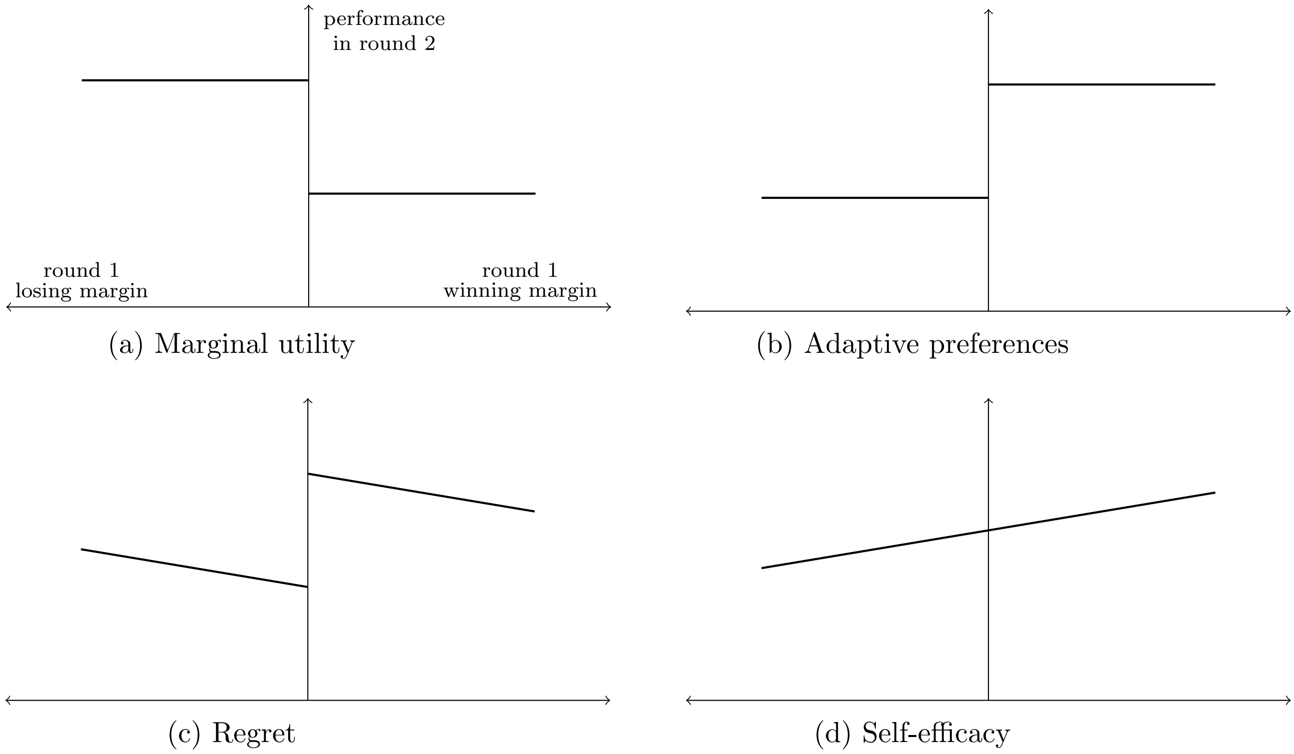
Prediction 4 (Self-efficacy)**.** *Following the first contest outcome, a contestant:*

i *gains more confidence, and has a larger gain in performance, after a success by a large margin;*

ii *loses more confidence, and has a larger drop in performance, after a failure by a large margin.*

2.4 Summary of the possible path dependencies

Figure 2 summarises graphically the different possible path dependencies from the different mechanisms we considered. We test these different possible mechanisms in a lab experiment which allows us to study the existence of path dependencies and investigate how they may vary in a way compatible with specific mechanisms.



(a) Marginal utility (b) Adaptive preferences (c) Regret (d) Self-efficacy

Figure 2: Different behavioral mechanisms and their predicted pattern of momentum. The winning or losing margin in the first contest is on the x axis and the level of performance in the second contest is on the y axis.

3 Experimental Design

Our experimental design consists of two rounds of a contest game. Each contest game is independent. The game takes the form of a real-effort task, adapted from Descamps et al. (2022).[7]

3.1 Experimental Procedures

Experimental sessions were held at the University of Queensland's Behavioural and Economic Science Cluster (BESC) laboratory. The experiment was programmed using oTree (Chen et al. 2016). In total, there were 297 participants, who were all university students and staff. Each participant received a base show-up fee of \$10, and additonal payment depending on their performance in the experiment. Overall, they received an average payment of \$25.63 and a maximum possible payment of \$44.2 (payoffs are in Australian dollars).

[7]We use a real-effort task as some of the possible psychological mechanisms are less likely to occur in a chosen effort task. For example, any source of momentum that comes from impacts on productivity, such as our proposed mechanisms of regret or behavioral self-efficacy, are not likely to occur in a chosen effort setting where participants simply choose a number.

At the start of the session, the procedures and rules of the experiment are explained to the participants. A trial period precedes the main experiment for the participants to familiarize themselves with the contest game and the experiment's interface. The experiment places participants in games consisting of two contest rounds. Prior to each contest round, participants are randomly re-matched into pairs to compete. The contests were based on real effort tasks in order to place participants in an ecologically valid situation where real performance drives their success or failure. Participants are asked to type strings of 8 characters backward in 7 minutes, and each time a string is correctly typed in reverse order, a new one appears. In order to create an objective opportunity cost of effort, in addition to its subjective cost, each participant is given an initial endowment of \$2.1, and they lose \$0.005 for each second spent. In each round, the player with the higher number of finished strings compared to their opponent wins that contest's prize.[8] The experimental material is included in the Appendix.

The experiment featured three different conditions, varying the contests' prizes and the information given to the participants.

Condition A: both round one and round two have a prize of \$15.

Condition B: round one has a prize of \$25, and round two has a prize of \$5.

Condition C: the prize structure is the same as *B*, but participants also receive information on the distribution of the performances of other participants in the session at the end of Game 2.

Each participant played the two contest rounds for all three conditions. *Condition A* and *Condition B* were randomly ordered as the first and second games. Condition C was always the final two-round contest played.

The larger prize in round 1 relative to round 2 of *Condition B* allows us to test predictions about the effect of loss aversion and regret in case of loss in round 1. If a negative momentum exists in *Condition A* due to loss aversion, it would be less likely to arise in Condition B due to the smaller difference in expected efforts between winners and losers (see Prediction 1). On the contrary, if a positive momentum exists due to regret in *Condition A*, then it should be larger in *Condition B* since the loss in payoff after not winning the first round is larger in *Condition B*.

In *Condition C* participants are provided with the information on the distribution in performance of all of the other participants in their experimental session in games 1 and 2 (*Conditions A and B*). Specifically, they are given the frequencies of performances in 10-string bins, i.e., the number of times 0-10 strings were reversed, 11-20 strings were reversed, etc. This information drastically reduces the informa-

[8] Note our model contains a noise effect in each contest. We assume here that this noise reflects the stochastic nature of performance with the number of strings completed being the result of the effort expended by the participant and of a round specific random variation (e.g. driven by the specific difficulty of the strings faced or to round specific variations in focus).

tional content of the outcome in round 1. While in games 1 and 2, a participant could infer that the first contest outcome reveals something about the distribution of ability in the experimental session through the number of strings their opponent reversed, it is unlikely to be the case in Condition C, since participants already have excellent information about this distribution prior to starting Game 3.[9] As a consequence, if there is a strategic momentum in Game 1 and Game 2 due to the participants' belief about their strength relative to others in the session, this momentum should disappear in Game 3. Any remaining momentum related to self-efficacy would be psychological.[10]

To avoid order effect (fatigue), whether *Condition A* or *Condition B* is performed first was randomly determined. *Condition C* revealed information about the distribution of performances in the experimental session and was always the last condition for that reason. Only one of the three conditions was selected randomly for payment in each session. The randomness of the selection was clearly communicated to participants and the chosen condition was revealed at the end of the session. Paying both rounds within a condition allows us to investigate psychological momentum stemming from winning or losing a prize in round 1 on the performance in round 2. Paying for only one condition reduces the spill-overs between the three conditions.[11]

3.2 Hypotheses

Based on our theoretical framework we make the following hypotheses.

Hypothesis 1 (Marginal Utility)**.** *A player* ***losing*** *the first round contest will display a* ***higher*** *level of performance in the second round contest than the player who won.*

1. *This effect should be smaller in conditions B and C.*

Hypothesis 1 corresponds to the situation where a player losing in the first contest has a higher marginal utility for the prize in the second round contest, either because of a wealth effect (decreasing marginal utility) or due to reference-dependent preferences (loss aversion). As a consequence, the player will make more effort and be more likely to win than the player who won in the first-round contest.

[9]In a room with 30 participants, the participants see a distribution of performance with 120 observations in round 1 of Game 3. The outcome of round 1 only adds one additional observation to this distribution.

[10]An alternative method to turn off the informational value of winning round 1 would be to have round 1 and round 2 be different tasks. We did not pursue this method as it may also eliminate any psychological momentum from winning this round.

[11]While the presence of these cross game spill-overs may add noise to our results, they do not systematically impact any identified momentum within each condition.

Hypothesis 2 (Adaptive preferences)**.** *A player **losing** the first round contest will display a **lower** level of performance in the second round contest than the player who **won**.*

1. *This effect should be present across all conditions.*

Hypothesis 2 corresponds to the situation where a player experiences a change in utility for winning the prize in the second round contest, due to adaptive preferences after the first round. One possible effect is an increase in the utility of winning that could increase the motivation of the winner to expend effort. Another possibility is a fox-and-sour-grapes effect that would reduce the incentive for the loser to do so. As a consequence, the player losing in the first round will make less effort and be less likely to win than the player who won in the first-round contest.

Hypothesis 3 (Regret)**.** *A player **losing** the first round contest will display a **lower** level of performance in the second round contest than the player who won.*

1. *The effect will be smaller for players losing by a wide margin.*
2. *The effect will be smaller for players winning by a wide margin.*
3. *This effect should be larger in Condition B and C.*

Hypothesis 3 corresponds to the situation where a player losing in the first contest experiences a lower efficacy of effort in the second round contest. As a consequence, the player will have lower performance and be less likely to win than the player who won in the first-round contest.

Hypothesis 4 (Self-efficacy)**.** *A player **losing** the first round contest will display a **lower** level of performance in the second round contest than the player who won.*

1. *The effect will be larger for players losing by a wide margin.*
2. *The effect will be larger for players winning by a wide margin.*
3. *This effect should be smaller and purely behavioral in Condition C.*

Hypothesis 4 corresponds to the situation where a participant losing in the first contest loses confidence and as a consequence is less productive in the second round contest. This participant is less likely to win than the player who won in the first round contest. A larger losing margin would have a larger negative impact on confidence while a larger winning margin would have a larger positive impact. Any strategic momentum from the participant updating her beliefs about her ability relative to other participants will not be present in *Condition C*. Therefore any remaining impacts of self-efficacy will be purely behavioral.

Table 1 summarizes how the different conditions are expected to impact the effects of each mechanism considered

	Decreasing marginal utility	Adaptive preferences	Regret	Self-efficacy
Condition A	- -	++	+	++
Condition B	-	++	++	++
Condition C	-	++	++	+

Table 1: How experimental conditions are expected to modulate the different possible effects of the outcome of the first contest on the performance in the second contest. An effect with two symbols is larger than an effect with one symbol.

4 Identification strategy

4.1 Identification of momentum

The identification of the causal effect of past successes on later performance is challenging due to the possible endogeneity of past performance as an explanatory variable: past performance can be linked to later performance due to unobservable external factors and the personal characteristics of the players. We follow Descamps et al. (2022) and consider the performance y_{it} of each player i in round t as generated by the following model:

$$\begin{cases} y_{i2} = \alpha + \tau win_{i1} + \delta + u_i + \varepsilon_{i2} \\ y_{i1} = \alpha + u_i + \varepsilon_{i1} \end{cases} \tag{11}$$

The variable win_{i1} is a dummy taking the value 1 if player i won in round 1, and 0 otherwise. The parameter δ accounts for any factor that could induce time-variations in performance between the two contests. It can account for things that affects players performance directly like learning or exhaustion, or for things that affect the players' motivation like the winning prize (when it varies over time). The term u_i is an individual effect which accounts for heterogeneity, such as individual differences in ability or preference for competition. Finally, ε_{it}, is an individual specific disturbance which captures residual variations in effort in a given round t for a given individual i.

Model (11) has a dynamic panel data structure. Therefore, usual estimation procedures, such as OLS, regressions with player fixed effects, or regression on first differences Δy_{i1}, will all deliver biased estimates (see Descamps et al. 2022).

To address this issue, we use two types of strategies. First, since opponents are randomly matched in each contest, for a given score of a player in round 1, the variations in the first-round opponents' score create variations in the player's success that are as good as random. For instance, a player whose score was 30 in the first round may either win or lose that round depending on the performance of the opponent that was randomly allocated to the player. Following Gill & Prowse (2014), we leverage this fact to estimate the effect of winning in round 1 on a player's performance in round 2 by using the score of the player's opponent in round 1 as an instrumental variable for the player's success in round 1. The 2SLS system of equation is:

$$\begin{cases} y_{i2} = \beta_{2,0} + \beta_{2,1} win_{i1} + \eta_{2,i} \\ win_{i1} = \beta_{1,0} + \beta_{1,1} y_{j1} + \eta_{1,i} \end{cases} \tag{12}$$

Second, we look into the effect of the winning/losing margin in round 1 on the performance in round 2. Ideally, we would like to estimate the parameter $\beta_{2,2}$ in the equation:

$$y_{i2} = \beta_{2,0} + \beta_{2,1} win_{i1} + \beta_{2,2} margin_{i1} + \eta_{2,i} \tag{13}$$

where the variable $margin_i = y_{1,i} - y_{1,j}$ represents the difference in performance between player's i performance the player's opponent j in round one. Unfortunately, there are two endogenous variables in this equation, win_{i1} and $margin_{i1}$ and we only have one instrumental variable, the performance of the opponent y_{j1}. We can therefore not estimate this equation using an IV approach. To address this issue, we use the fact that, conditional on the player's performance in round 1, variations in outcomes (winning vs losing) and variations in the margin of this outcome are entirely driven by the performance of the opponent.[12] To estimate the effect of winning, we can, therefore, estimate the following model:

$$y_{i2} = \beta_{2,0} + \beta_{2,1} win_{i1} + \sum_k \gamma_k \mathbb{1}_{y_{i1}=k} + \eta_{i2} \tag{15}$$

And to estimate the effect of winning and the margin of the outcome in the first contest, we can estimate the following model:

$$y_{i2} = \beta_{2,0} + \beta_{2,1} win_{i1} + \beta_{2,2} margin_{i1} + \sum_k \gamma_k \mathbb{1}_{y_{i1}=k} + \eta_{i2} \tag{16}$$

[12] One possibility would be to estimate separately the equation:

$$y_{i2} = \beta_{2,0} + \beta_{2,2} margin_{i1} + \eta_{2,i} \tag{14}$$

for winners and for losers in round 1. But winners/losers are determined by how their opponent's performance y_{j1} compared to theirs y_{i1}. This approach would make y_{j1} endogenous in the first stage equation.

where the dummy variables $\mathbb{1}_{y_{i1}=k}$ capture the fixed effect of each level of performance of player i in round one on the player's performance in round two. Model (15) and Model (16) identify the effect of the winning/losing outcome in round 1 and their margin *within* the levels of performance of player i in round one.

4.2 Winner and loser effects

An important aspect of our experimental design is that it allows us to look at whether this momentum is driven by a winner effect (an increase in performance from past winners) or a loser effect (a decrease in performance from past losers). The momentum effect can indeed come from either or both of such effects. Past studies looking at the effect of past success on future success in games with the same two players do not disentangle these effects and only estimate momentum as a conjoint effect.

To consider these two effects separately, let's modify Model (11) in:

$$\begin{cases} y_{i2} = \alpha + \tau_w win_{i1} + \tau_l(1 - win_{i1}) + \delta + u_i + \varepsilon_{i2} \\ y_{i1} = \alpha + u_i + \varepsilon_{i1} \end{cases} \tag{17}$$

Here the path dependency in performance is generated by two different effects, a winner effect τ_w and a loser effect τ_l. Rewriting the first equation of Model (17), we have:

$$y_{i2} = (\alpha + \tau_l + \delta) + (\tau_w - \tau_l)win_{i1} + u_i + \varepsilon_{i2} \tag{18}$$

Taking the first difference between the player's performance in rounds 2 and 1 in a given game we have:

$$\Delta y_{i2} = (\tau_l + \delta) + (\tau_w - \tau_l)win_{i1} + \eta_{i2} \tag{19}$$

where $\eta_{i2} = \varepsilon_{i2} - \varepsilon_{i1}$.

We can estimate Model (19) using the score of the opponent of player i in the first round as an IV for win_{i1}. The identification of τ_l and τ_w is still imperfect because performance changes over time due to learning, fatigue or variations in prize size. These time variations are captured by the parameter δ. Estimating Model (19) gives two estimates: a constant equal to $\tau_l + \delta$ and the coefficient for win_{i1}, $\tau_w - \tau_l$. If $\delta \neq 0$, we have two equations and three unknowns and we cannot identify a winner and a loser effects. However, we can use the overall variations in performance from round to round, between the 6 rounds of the experiment to see whether δ is large. In practice, we observe a large increase in performance after the first two contest rounds of Game 1. This is likely due to learning. The players' average performances are afterwards fairly similar in the contest rounds of Game 2 in condition A. It suggests we can assume $\delta \approx 0$ in Model (19) for Game 2 of that condition, and retrieve the winner and loser effects from the estimations of the constant and the coefficient of win_{i1}.

Note however that in conditions B and C, the prizes are lower in the second round contest, there may therefore be lower incentives to expend effort that could take the form of a negative coefficient δ. We will consequently primarily use the results in Game 2 of Condition A to assess the relative importance of a winner and a loser effects.

5 Results

5.1 Descriptive statistics

Table 2 shows the descriptive statistics for the participants' performance, measured in the number of strings solved, observed in the experiment.

Figure 3 shows the scatterplots of the performance in the second contest as a function of the margin in the first contest. A linear regression line is shown on both sides of the winning threshold.

These scatterplots have two characteristics. First there is a positive correlation between round one and round two performances. This cannot be interpreted as a definite indication of positive momentum as it may simply reflect that better players in the first round also do better in the second round. Second, we observe a jump around the winning threshold with players who just won in the first round doing better in the second round than the players who just lost. Such jumps around very similar performance levels associated with very different outcomes can be indicative of a positive momentum (Gauriot & Page 2019).

	Pooled sample	*Condition A*	*Condition B*	*Condition C*
First contest				
Mean performance, $\overline{y}_1$	38.15	34.67	37.52	42.27
Standard deviation	16.46	16.53	16.46	15.53
N participants	891	297	297	297
Second contest				
Mean performance, $\overline{y}_2$	36.90	38.59	35.62	36.49
Standard deviation	17.86	15.92	17.60	19.78
N participants	891	297	297	297

Table 2: Descriptive statistics of performance

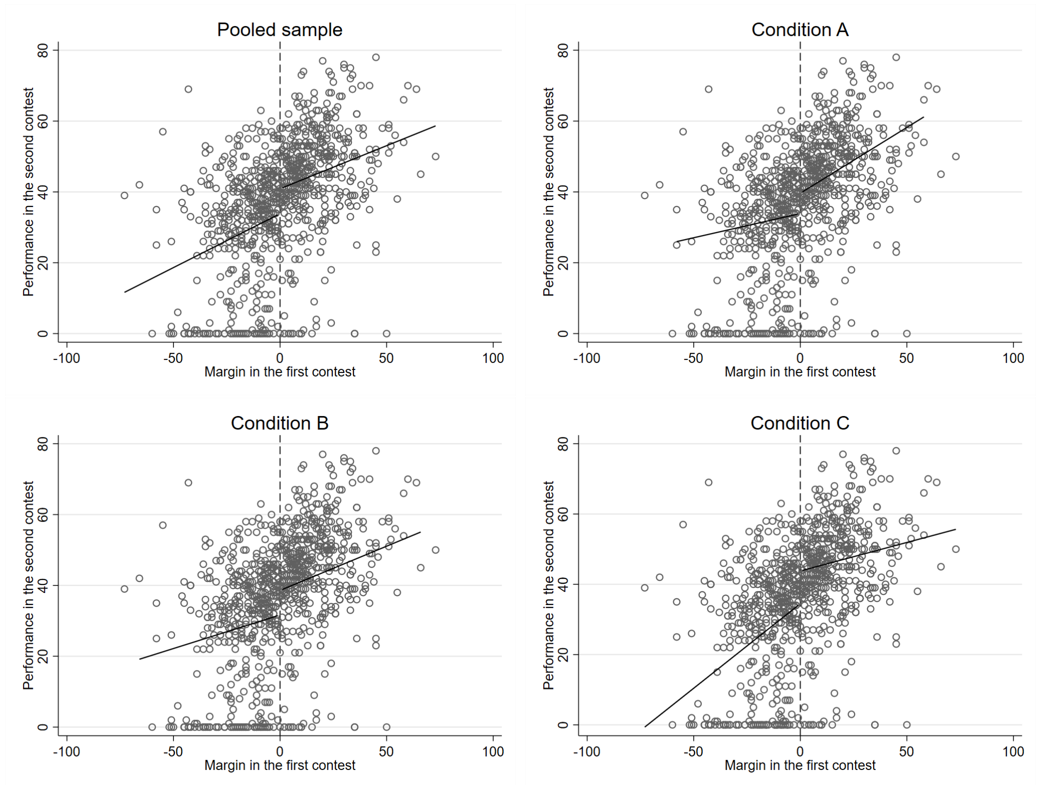


Figure 3: Participants' performance in the second round's contest as a function of the difference in performance in the first round contest. A linear regression line is added on each side of the winning threshold.

5.2 Momentum effect

Table 3 shows the results of models (12) and (16) on the existence of a momentum effect. The pattern of results supports the existence of positive momentum after winning in the first contest. Using the instrumental variable approach (Model (12)), the effect of winning in the first round contest in the pooled sample is a difference of 4.30 strings performed in the second round between the winner and the loser of the first round ($p = 0.06$). This effect represents 26% of a standard deviation. The effect is larger, 11.60 strings (75%), and significant at 0.01% for *Condition C.*

The results of Model (15), which uses variations in winning outcomes *within* the levels of performance of the player in round 1, are even clearer. It is equal to 6.50 strings ($p < 0.001$) in the pooled sample and it is positive and significant in each condition.

When taking account both the effect of winning/losing and the effect of the winning/losing margin (Model (16)), the effect of just winning in round 1 is associated with 4.35 more strings solved in round 2 ($p < 0.01$). Looking at each condition separately the effect is positive in each condition and significant at 5% in *Condition A*.

These results and the variations across conditions allow us to assess the different hypotheses we listed in Section 3.2. First, our results are not compatible with the prediction of a negative momentum generated by wealth effects (decreasing marginal utility) or by loss aversion. Instead of a negative momentum predicated by these effects, we observe a positive momentum. Second, our results are not compatible with a negative effect of regret on performance in our setting. We do not find a negative effect of the margin of success in round 1 on performance in round 2 which is predicated by the effect of regret. Third, the pattern does not seem to support the behavioral role of self-efficacy. The margin does not have a positive and significant effect in our estimations. The effect of the margin is small and not always positive. In the overall sample, the estimated effect is 0.07 ($p = 0.103$) which means that a margin of one standard deviation (21) would only lead an improvement of 1.4 string in the second contest, while just winning, which is not informative relative to just losing, leads to a significant improvement of 4.5 strings. Our results, therefore, seem to rule out a substantial effect of the margin of success.[13] In addition, the effect of winning is similar if not larger in *Condition C* compared to *Condition B*. By removing most of the informative content of winning, *Condition C* should be characterised by a smaller momentum than *Condition B*, if momentum is generated by the higher self-efficacy generated by a success.

The pattern of results is overall most compatible with the effect of adaptive preferences, whereby participants' interest for the prize of the contest in round 2 is greater after winning vs losing in round 1. For simplicity, Figure 4 shows the predictions from Table 3 graphically.[14]

[13] An additional analysis of the effects for very large margins of victory did not provide clear evidence pointing to a different conclusion.

[14] Note that the theoretical predictions do not imply that effects should be linear. Linear regression estimations of the effect of the margin of success/failure in round 1 have therefore to be seen as an approximation of the average effect of that margin. For completeness, we also estimated functional forms with nonlinear effects of the margin

	Model (12): Effect of winning			
	Pooled sample	*Condition A*	*Condition B*	*Condition C*
Performance after:				
Won	39.04	35.81	37.79	42.27
Lost	34.74	41.38	33.43	30.67
Difference	4.30†	-5.56	4.36	11.60***
p-value	(0.060)	(0.175)	(0.264)	(0.001)
	Model (15): Effect of winning			
	Pooled sample	*Condition A*	*Condition B*	*Condition C*
Performance after:				
Won	40.14	40.94	38.31	39.65
Lost	34.64	36.22	32.92	33.32
Difference	6.50***	4.72**	5.39*	6.32*
p-value	(<0.001)	(0.004)	(0.020)	(0.026)
	Model (16): Effect of winning and of the margin			
	Pooled sample	*Condition A*	*Condition B*	*Condition C*
Performance after:				
Just won (Margin=0)	39.13	41.19	37.66	39.33
Just lost (Margin=0)	34.64	35.97	33.55	33.63
Difference	4.48**	5.22*	4.11	5.70
p-value	(0.006)	(0.047)	(0.204)	(0.110)
Effect of margin:				
Margin	0.07	-0.02	0.05	0.02
p-value	(0.103)	(0.818)	(0.515)	(0.786)
N	891	297	297	297

Table 3: Effect of the first round outcome on the player's second round performance. p-values in brackets. Significant at * 5%, ** 1%, *** 0.1%.

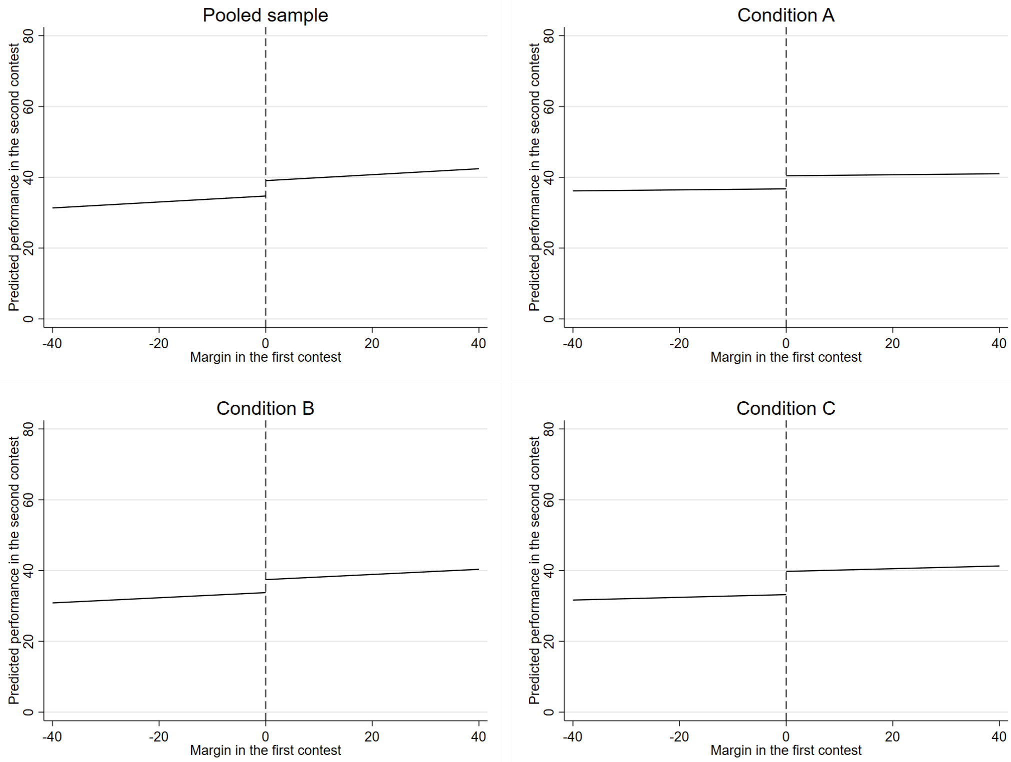


Figure 4: Participants predicted performance in the second round's contest as a function of the difference in performance in the first round contest. A linear regression line is added on each side of the winning threshold.

5.3 Winner and loser effects

As discussed in Section 4.2, a difficulty in the identification of winner and loser effects separately is the possible existence of a trend in the progression of performance between the two rounds of contest in each game due to learning, fatigue or change in monetary prizes. Table 4 shows the evolution of the players' average performance across the different rounds of contests played in the experiment. Looking at the first round of each game as a benchmark that is less likely to be influenced by path dependencies, we observe that players' performance increased markedly between Game 1 and Game 2 while the difference is much smaller between Game 2 and Game 3. Given this pattern of performance across time, we do not look at Game 1 as we expect the possibility of learning ($\delta > 0$). In addition, in conditions B and C, there is a difference in incentives between the first round contest (prize of \$25) and the second round contest (prize of \$5). This could result in a lower motivation and a lower performance ($\delta < 0$). We therefore focus only on the Game 2 from Condition A where it is likely that learning does not play as much of a role and where the prizes are identical in the first and second contests. We assume that $\delta \approx 0$ in Game 2 of condition A.

	Games		
	1	2	3
$\overline{y}_1$	31.48	40.71	42.27
$\overline{y}_{1,pm}$	5.17	6.06	6.22
$\overline{y}_2$	36.10	38.11	36.50
$\overline{y}_{2,pm}$	5.57	5.75	5.55

Table 4: Performances in each round k of contest: average number of strings, $\overline{y}_k$ and average number of strings per minute played, $\overline{y}_{k,pm}$.

Table 5 presents the results of our decomposition of the winner and loser effect. In Period 1, the momentum effect seems primarily driven by a positive winner effect. But this result could be the result of the general positive trend in performance leading both winners and losers to perform better in the second round of Game 1. When focusing on games 2 and 3, it appears that, instead, the path dependency is driven by a loser effect with losers in the first round experiencing a significant drop in performance in the second round of the game. But this result in conditions B and C could be driven by the lower prize in the second contest driving the performance of both contestants down. When looking at Condition A, the winner effect and the loser effect have roughly the same size and neither is significant. We can therefore not reject the hypothesis that the momentum is driven both by a winner and loser effect.

	Condition A	Condition B	Condition A & B	Condition C
Game 1				
Winner effect	13.40***	6.71†	10.90***	
	(0.001)	(0.087)	(0.001)	
Loser effect	-0.45	-2.77	-1.71	
	(0.877)	(0.468)	(0.475)	
Game 2				
Winner effect	4.52	1.49	2.65	
	(0.129)	(0.018)	(0.180)	
Loser effect	-3.91	-10.93***	-7.88*	
	(0.113)	(0.001)	(0.018)	
Game 3				
Winner effect				-1.80
				(0.336)
Loser effect				-9.76***
				(0.001)

Table 5: Decomposition of the winner and loser effects. p-values in brackets. Significant at * 5%, ** 1%, *** 0.1%.

Overall, these results are compatible with adaptive preferences driving momentum though we cannot identify whether, if it is the explanation, the effect comes primarily from winners experiencing an increase in their subjective valuation and therefore of their effort in the second contest, or from a fox-and-sour-grapes effect for losers. Past research on contests has found that there seems to be a purely subjective utility of winning (Sheremeta 2010). As a consequence, after a success or failure in the first contest, a participant may have some leeway to reassess the subjective value they attach to winning.

6 Conclusion

Past economic research on momentum has discussed two types of momentum. First, game theoretic models predict that a "strategic momentum" should exist in dynamic contests: past winners may exert more effort in equilibrium because they have greater marginal incentives to win (e.g. because they are closer to winning an overarching contest of which each contest is a subpart) and/or because they update their priors about their strength and stronger player benefit from exerting more effort. Second, it has been suggested that behavioral mechanisms that cannot be reduced to rational strategies from payoff maximizing players may be driving the existence of a "psychological momentum".

In the present study, we look at whether such a so-called "psychological momentum" exists and we investigate what could be its underlying behavioral mechanisms. To do so, we look at a setting where strategic momentum should not exist: sequences of two contests which are independent of each other. In such a setting, players who are payoff maximizing and have complete information should behave similarly in each contest, independently of the results in past contests. Furthermore, even if players are uncertain about their strength relative to other players, updating their priors should not lead to any momentum in equilibrium. Specifically, for a given performance of a contestant, winning should not increase expected future performance relative to losing.

Contrary to this prediction, we find that a significant positive momentum emerges between the two successive contests in our experiment. This result indicates that the so-called "strategic momentum" does not fully explain the type of momentum which can exist in competitive environments.

We show theoretically that several behavioral mechanisms can generate momentum between two independent contests: decreasing marginal utility due to wealth effects, loss aversion, adaptive preferences, regret, self-efficacy. Using different experimental conditions which modulate these different possible mechanisms, we find that the mechanism most compatible with our observations is the possible role of adaptive preferences (Elster 1983). Participants who win in the first contest increase their effort in the second contest in a way compatible with an increase of interest for contest. In comparison, participants losing in the first contest reduce their effort in the second contest in a way compatible with a loss of interest for the contest. Adaptive preferences have been suggested to be the result of cognitive dissonance, whereby people try to eliminate negative or conflicting impressions by changing either their beliefs or their preferences (Festinger 1957). A possible interpretation of our result is that after experiencing a failure in the first contest, players prefer to minimize the importance of winning in a contest, not to feel frustrated about their failure. This would, in turn, lead them to discount the importance of the contest in round 2. Our result cannot exclude other types of explanations that have not yet been considered and that would lead to a drop in interest/performance as a function of the result of the first round outcome. However, we believe that adaptive preferences appear as a new and interesting mechanism yet to be fully considered in the literature as a source of momentum.

Finally, we should point out that these results have relevance for policymakers interested in how resources are allocated in society. If the momentum is primarily driven by winners' increased engagement and losers' withdrawal, the design of social competitions could be reconsidered. For instance, a policymaker seeking equality might consider policies or mechanisms to rekindle the interest of those who've lost in previous contests, to prevent the accumulation of resources by a few consistent winners. On the other hand, if the policymaker's goal is to promote meritocracy, the momentum effect may be left largely untouched, as it arguably rewards skill and perseverance. In essence, understanding the source of momentum allows policymakers to design more targeted strategies that can help shape resource distribution in a way that aligns more closely with their societal objectives.

References

Bandura, A. (1997), *Self-efficacy: The exercise of control*, W. H. Freeman and Company.

Bell, D. E. (1982), 'Regret in decision making under uncertainty', *Operations Research* **30**(5), 961–981.

Berger, J. & Pope, D. (2011), 'Can losing lead to winning?', *Management Science* **57**(5), 817–827.

Chen, D. L., Schonger, M. & Wickens, C. (2016), 'otree—an open-source platform for laboratory, online, and field experiments', *Journal of Behavioral and Experimental Finance* **9**, 88–97.

Cohen-Zada, D., Krumer, A. & Shtudiner, Z. (2017), 'Psychological momentum and gender', *Journal of Economic Behavior and Organization* **135**, 66–81.

Dechenaux, E., Kovenock, D. & Sheremeta, R. M. (2014), 'A survey of experimental research on contests, all-pay auctions and tournaments', *Experimental Economics* **18**(4), 609–669.

Descamps, A., Ke, C. & Page, L. (2022), 'How success breeds success', *Quantitative Economics* **13**(1), 355–385.

Ederer, F. (2010), 'Feedback and motivation in dynamic tournaments', *Journal of Economics & Management Strategy* **19**(3), 733–769.

Elster, J. (1983), *Sour grapes*, Cambridge university press.

Festinger, L. (1957), *A theory of cognitive dissonance*, Vol. 2, Stanford university press.

Fishburn, P. C. (1982), *The Foundations of Expected Utility*, Vol. 31, Springer Netherlands, Dordrecht.

Fu, Q., Lyu, Y., Wu, Z. & Zhang, Y. (2022), 'Expectations-based loss aversion in contests', *Games and Economic Behavior* **133**, 1–27.

Gauriot, R. & Page, L. (2018), 'Psychological momentum in contests: The case of scoring before half-time in football', *Journal of Economic Behavior & Organization* **149**, 137–168.

Gauriot, R. & Page, L. (2019), 'Does success breed success? a quasi-experiment on strategic momentum in dynamic contests', *The Economic Journal* **129**(624), 3107–3136.

Gill, D. & Prowse, V. (2014), 'Gender differences and dynamics in competition: The role of luck', *Quantitative Economics* **5**(2), 351–376.

Harris, C. & Vickers, J. (1985), 'Perfect equilibrium in a model of a race', *The Review of Economic Studies* **52**(2), 193–209.

Klaassen, F. & Magnus, J. R. (2014), *Analyzing Wimbledon: The power of statistics*, Oxford University Press.

Klein Teeselink, B., van den Assem, M. J. & van Dolder, D. (2023), 'Does losing lead to winning? an empirical analysis for four sports', *Management Science* **69**(1), 513–532.

Klumpp, T. & Polborn, M. K. (2006), 'Primaries and the new hampshire effect', *Journal of Public Economics* **90**(6), 1073–1114.

Konrad, K. (2009), *Strategy and Dynamics in Contests*, Oxford University Press, New York.

Konrad, K. A. & Kovenock, D. (2009), 'Multi-battle contests', *Games and Economic Behavior* **66**(1), 256–274.

Kubitz, G. (2023), 'Two-stage contests with private information', *American Economic Journal: Microeconomics* **15**(1), 239–287.

Lazear, E. P. & Rosen, S. (1981), 'Rank-order tournaments as optimum labor contracts', *The Journal of political economy* **89**(5), 841–864.

Loomes, G. & Sugden, R. (1982), 'Regret theory: An alternative theory of rational choice under uncertainty', *The Economic Journal* **92**(368), 805–824.

Mago, S. D., Sheremeta, R. M. & Yates, A. (2013), 'Best-of-three contest experiments: Strategic versus psychological momentum', *International Journal of Industrial Organization* **31**(3), 287–296.

Malueg, D. A. & Yates, A. J. (2010), 'Testing contest theory: Evidence from best-of-three tennis matches', *The Review of Economics and Statistics* **92**(3), 689–692.

Schneemann, S. & Deutscher, C. (2017), 'Intermediate information, loss aversion, and effort: Empirical evidence', *Economic Inquiry* **55**(4), 1759–1770.

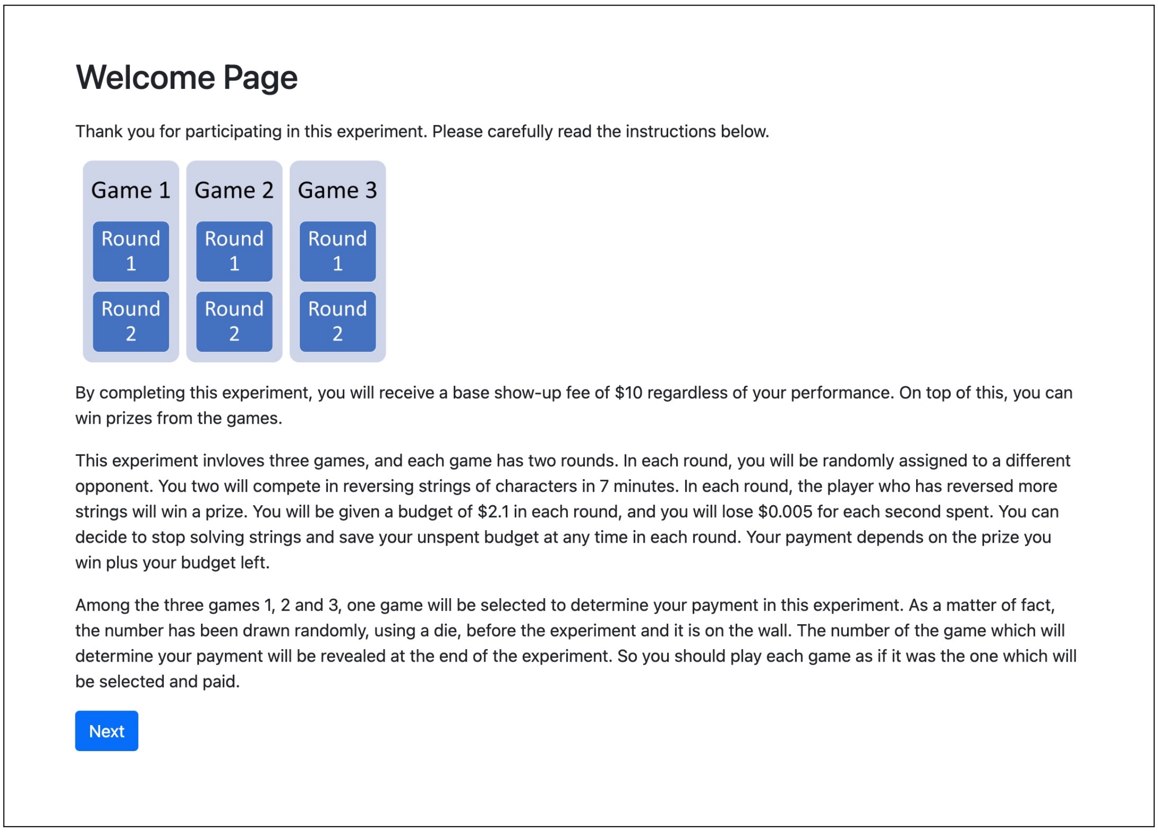
Sen, A. (1995), 'Gender inequality and theories of justice', *Women, culture and development: A study of human capabilities* pp. 259–273.

Sheremeta, R. M. (2010), 'Experimental comparison of multi-stage and one-stage contests', *Games and Economic Behavior* **68**(2), 731–747.

Simon, W. (1971), '"back-to-the-wall" effect?', *Science* **174**(4011), 774–775.

Vojnović, M. (2015), *Contest theory: Incentive mechanisms and ranking methods*, Cambridge University Press.

A Experimental material



Trial

Let us first practise reversing 4 string as fast as possible. For example, if you are given a string "Mtp6fpUc", you should type "cUpf6ptM" in the answer field. All characters are case-sensitive.

Please note this trial does not contribute to your scores or payoff in the experiement. It is only a warm-up. Please press "Next" to start the trial.

Next

Trial String - 1

Time left in the trial: **6:58**

Strings reversed: **0**

Budget left when you entered this page: **$2.1**

String to reverse: **4giedUic**

Press Enter on your keyboard when you have completed the string.

Trial - Stop the timer

Great! You have reversed 4 strings.

Remember, you are also given a budget of $2.1 in each round, and your will lose $0.005 for each second spent in the round. If you want to stop the timer in advance and save your unspent budget, you can choose "Stop" from the dropdown menu and click on "Confirm Stop". Once you have stopped the timer, you cannot go back and continue this round.

Let us practise stopping the timer on the next page.

Next

Please stop the timer

Time left in the trial: **5:29**

Strings reversed: **4**

Budget left when you entered this page: **$1.83**

String to reverse: **h2Da1tWK**

Press Enter on your keyboard when you have completed the string.

If you want to stop (and keep the remainder of your budget), choose "Stop" from the dropdown menu and click on "Confirm Stop".

✓ --------

Stop

Confirm Stop

Trial End

Great! You have completed the trial.

Now, let us start the real games. You will compete with another player trying to reverse as many strings as possible. Please press "Next" to start.

Next

GAME 1

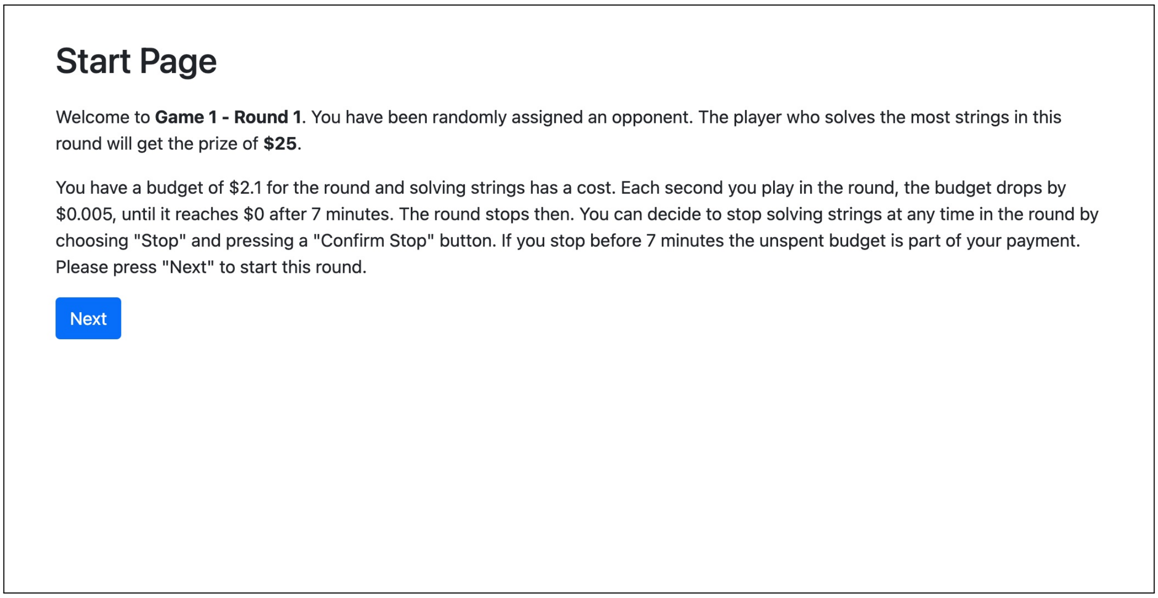
You are now starting Game 1, this game will have two rounds of competition.

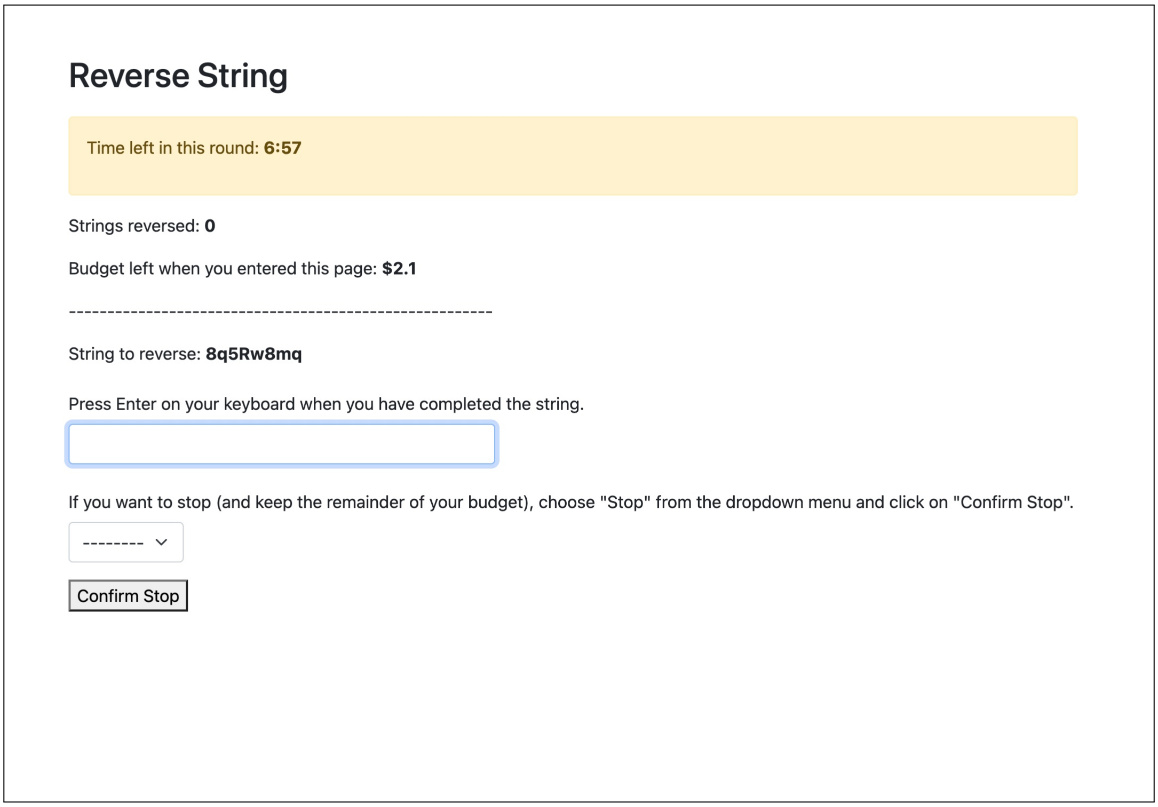
In round 1, the prize is $25

In round 2, the prize is $5

In each round, you will be opposed to a player in the room to compete for the round's prize. At the end of a round, the player who has solved the most strings wins the prize. If you both solve the same number of strings (tie), a random draw from the computer will determine which player wins the round's prize. You will face a new randomly selected opponent in each round. Please press "Next" to start Game 1.

Next


Start Page
Welcome to Game 1 - Round 1. You have been randomly assigned an opponent. The player who solves the most strings in this round will get the prize of $25.
You have a budget of $2.1 for the round and solving strings has a cost. Each second you play in the round, the budget drops by $0.005, until it reaches $0 after 7 minutes. The round stops then. You can decide to stop solving strings at any time in the round by choosing "Stop" and pressing a "Confirm Stop" button. If you stop before 7 minutes the unspent budget is part of your payment. Please press "Next" to start this round.
Next


Reverse String
Time left in this round: 6:57
Strings reversed: 0
Budget left when you entered this page: $2.1
String to reverse: 8q5Rw8mq
Press Enter on your keyboard when you have completed the string.
If you want to stop (and keep the remainder of your budget), choose "Stop" from the dropdown menu and click on "Confirm Stop".

Confirm Stop

Reverse String

Time left in this round: **5:03**

Incorrect. Please change your answer.

Strings reversed: **8**

Budget left when you entered this page: **$1.69**

String to reverse: **f5qNSpKg**

Press Enter on your keyboard when you have completed the string.

gKpsNq5f

If you want to stop (and keep the remainder of your budget), choose "Stop" from the dropdown menu and click on "Confirm Stop".

Confirm Stop

Results

You reversed **36** strings. Your opponent reversed **16** strings.

You **won** this round and got a prize of $25.

You spent $1.675 of your $2.1 endowment in the time spent reversing the strings.

Your total payoff in this round is **$25.43**.

Please press "Next" to start the next round.

Next

Start Page

Welcome to **Game 1 - Round 2**. You have been randomly assigned a different opponent. The player who solves the most strings in this round will get the prize of **$5**.

You have a budget of $2.1 for the round and solving strings has a cost. Each second you play in the round, the budget drops by $0.005, until it reaches $0 after 7 minutes. The round stops then. You can decide to stop solving strings at any time in the round by choosing "Stop" and pressing a "Confirm Stop" button. If you stop before 7 minutes the unspent budget is part of your payment. Please press "Next" to start this round.

Next

Results

You reversed **0** strings. Your opponent reversed **0** strings.

You and your opponent were tied. The system randomly decided that you **lost** the prize of $5.

You spent $0.015 of your $2.1 endowment in the time spent reversing the strings.

Your total payoff in this round is **$2.08**.

Please press "Next" to start the next round.

Next

GAME 2

You are now starting Game 2, this game will have two rounds of competition.

In round 1, the prize is $15

In round 2, the prize is $15

In each round, you will be opposed to a player in the room to compete for the round's prize. At the end of a round, the player who has solved the most strings wins the prize. If you both solve the same number of strings (tie), a random draw from the computer will determine which player wins the round's prize. You will face a new randomly selected opponent in each round. Please press "Next" to start Game 2.

Next

Start Page

Welcome to **Game 2 - Round 1**. You have been randomly assigned a different opponent. The player who solves the most strings in this round will get the prize of **$15**.

You have a budget of $2.1 for the round and solving strings has a cost. Each second you play in the round, the budget drops by $0.005, until it reaches $0 after 7 minutes. The round stops then. You can decide to stop solving strings at any time in the round by choosing "Stop" and pressing a "Confirm Stop" button. If you stop before 7 minutes the unspent budget is part of your payment. Please press "Next" to start this round.

Next

Results

You reversed **3** strings. Your opponent reversed **5** strings.

You **lost** this round and did not get the $15 prize.

You spent $0.125 of your $2.1 endowment in the time spent reversing the strings.

Your total payoff in this round is **$1.98**.

Please press "Next" to start the next round.

Next

Start Page

Welcome to **Game 2 - Round 2**. You have been randomly assigned a different opponent. The player who solves the most strings in this round will get the prize of **$15**.

You have a budget of $2.1 for the round and solving strings has a cost. Each second you play in the round, the budget drops by $0.005, until it reaches $0 after 7 minutes. The round stops then. You can decide to stop solving strings at any time in the round by choosing "Stop" and pressing a "Confirm Stop" button. If you stop before 7 minutes the unspent budget is part of your payment. Please press "Next" to start this round.

Next

Results

You reversed **8** strings. Your opponent reversed **1** strings.

You **won** this round and got a prize of $15.

You spent $0.705 of your $2.1 endowment in the time spent reversing the strings.

Your total payoff in this round is **$16.39**.

Please press "Next" to start the next round.

Next

Performance Statistics

This is the end of Game 2. Before we start Game 3, let us see some summary statistics of participants' performance in the previous two games of this experiment session.

The number of players who:

-reversed 0-10 strings: 23

-reversed 11-21 strings: 9

-reversed 21-30 strings: 12

-reversed 31-40 strings: 32

-reversed 41-50 strings: 29

-reversed 51-60 strings: 12

-reversed 61-70 strings: 2

-reversed 71-80 strings: 1

-reversed 81-90 strings: 0

-reversed 91-100 strings: 0

-reversed more than 100 strings: 0

Please note the total number = number of players * 2 games * 2 rounds. Please press "Next" to start Game 3.

Next

GAME 3

You are now starting Game 3, this game will have two rounds of competition.

In round 1, the prize is $25

In round 2, the prize is $5

In each round, you will be opposed to a player in the room to compete for the round's prize. At the end of a round, the player who has solved the most strings wins the prize. If you both solve the same number of strings (tie), a random draw from the computer will determine which player wins the round's prize. You will face a new randomly selected opponent in each round. Please press "Next" to start Game 3.

Next

Start Page

Welcome to **Game 3 - Round 1**. You have been randomly assigned a different opponent. The player who solves the most strings in this round will get the prize of **$25**.

You have a budget of $2.1 for the round and solving strings has a cost. Each second you play in the round, the budget drops by $0.005, until it reaches $0 after 7 minutes. The round stops then. You can decide to stop solving strings at any time in the round by choosing "Stop" and pressing a "Confirm Stop" button. If you stop before 7 minutes the unspent budget is part of your payment. Please press "Next" to start this round.

Next

Results

You reversed **16** strings. Your opponent reversed **36** strings.

You **lost** this round and did not get the $25 prize.

You spent $0.615 of your $2.1 endowment in the time spent reversing the strings.

Your total payoff in this round is **$1.49**.

Please press "Next" to start the next round.

Next

Start Page

Welcome to **Game 3 - Round 2**. You have been randomly assigned a different opponent. The player who solves the most strings in this round will get the prize of **$5**.

You have a budget of $2.1 for the round and solving strings has a cost. Each second you play in the round, the budget drops by $0.005, until it reaches $0 after 7 minutes. The round stops then. You can decide to stop solving strings at any time in the round by choosing "Stop" and pressing a "Confirm Stop" button. If you stop before 7 minutes the unspent budget is part of your payment. Please press "Next" to start this round.

Next

Results

You reversed **0** strings. Your opponent reversed **0** strings.

You and your opponent were tied. The system randomly decided that you **won** the prize of $5.

You spent $0.01 of your $2.1 endowment in the time spent reversing the strings.

Your total payoff in this round is **$7.09**.

Please press "Next" to start the next round.

Next

End

This is the end of the experiment. Thank you for your participation.

Now the envelope on the wall will be opened.