SHAME AND FAME IN COMPETITION[†]

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ABSTRACT. We explore how ex ante asymmetry between competitors generates psychological motives such as shame and fame, which in turn affect individuals' equilibrium effort. Using the framework of two-player asymmetric contests, we demonstrate that the interaction between the "shame-fame encouragement effect" and the standard discouragement effect of asymmetry generates a non-trivial comparative static - individual effort being single-peaked in the degree of asymmetry. Our experimental data from two types of laboratory real-effort games, designed to induce different degrees of shame-fame encouragement effect, provide strong supporting evidence for our theoretical findings.

> *A champion named Goliath, who was from Gath, came out of the Philistine camp. His height was six cubits and a span. He had a bronze helmet on his head and wore a coat of scale armor of bronze weighing five thousand shekels; ... He looked David over and saw that he was little more than a boy, glowing with health and handsome, and he despised him.*
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> *The Bible* (*New International Version*), *Samuel 17, 4-42.*

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1. Introduction

Ex ante asymmetry or unfairness in competition is ubiquitous. When Pebble developed a line of smartwatches that included the first commercially successful smartwatch, the media described the smartwatch battle between Pebble and Apple as similar to that between David and Goliath. While the rest of the smartwatch market waited on the sidelines for Apple to show its hand, Pebble leaped into the limelight by creating a classic David and Goliath story (Bradshaw, 2015).[1] When Apple announced its entrance into the music streaming market in 2015, some experts did not anticipate that Spotify, in the role of David, would gain fame in the industry, battle the Goliath of Apple, and file for a direct listing on the New York Stock Exchange in 2018 (Garrahan, 2015).

There are many other versions of the David and Goliath story outside the technology industry. In sports, examples include the victory of Mark Edmondson, the lowest-ranked player ever to win a Grand Slam event, over John Newcombe, the seven-time Grand Slam and defending champion, in the 1976 Australian Open; the Japanese Sumo competition between Akebono Tarō, the grand champion who was 6 feet 8 inches tall and weighed 514 lbs, and Mainoumi Shūhei, who weighed only 215 lbs; and the soccer match between Manchester United, one of the world's highest-paid teams, and FC Seoul, whose average salary was only approximately 5% of that of Manchester United. A medical malpractice lawsuit between an unsuccessful lawyer and a high-priced legal team with strong support from the hospital in question was dramatized in the 1982 movie titled "The Verdict". Additionally, there were some legendary stories in the late 1900s five- and six-year-old Go players who competed with the world's top-ranked grandmaster. Fershtman and Markovich (2010) argue that pharmaceutical companies in R&D races are usually asymmetric in their technological developments.

The critical feature of these examples is that there exists a significant degree of asymmetry between competitors in terms of their sizes, abilities, costs, available funds, and

[1] In contrast to the biblical story, Pebble shut down in December 2016, citing financial issues, while Apple survived.

technological structures and developments. Conventional wisdom suggests that the ex ante asymmetry and unfairness in competition demotivate competitors to exert efforts. To facilitate competition, it is thus recommended to minimize the degree of asymmetry and make the environment fair (for discussions in the context of affirmative action, see, e.g., Fu (2006) and Franke (2012), and for a comprehensive survey, see Mealem and Nitzan (2016)). However, all these examples provide mixed evidence – some of the competitions mentioned above were incredibly fierce, and David beating Goliath is not uncommon. This contrast between conventional wisdom and the actual outcomes of competitions provides an interesting puzzle that we aim to address in this paper.

In analyzing the asymmetric competitions mentioned above, we hypothesize that ex ante asymmetry or unfairness between competitors may generate an additional psychological motive for the competitors to work harder in competition. This logic is intuitive. People often tend to take Goliath's wins (or David's losses) for granted, and hence, Goliath's loss (or David's win) comes as more of a shock. Therefore, by failing to meet people's expectations, Goliath feels a substantial degree of shame when he loses. On the other hand, by performing beyond people's expectations, David gains a considerable amount of fame if he wins. Hence, competitors have additional incentives to exert more effort to avoid shame or to gain fame.[2]

[2]The example below provided about Mirra Andreeva's mindset before facing World No. 2 Aryna Sabalenka at the Madrid Open in 2023 perfectly fits the argument about the shame and fame effect that motivates competitors to work harder.

> *"I have nothing to lose. I have to go there and show the best tennis I can. There is no pressure at all for me. There is just some pressure on her, I think. She will play a 16-year-old girl. Yes, I am pretty excited to play tomorrow."*
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> *Mirra Andreeva, facing World No. 2 Aryna Sabalenka at the Madrid Open, 2023*

Mirra Andreeva, a 16-year-old girl, seemed to have nothing to lose in that match as she was facing a much more experienced and highly-ranked opponent. By acknowledging that there was some pressure on Sabalenka, Andreeva was able to relieve herself of the pressure and expectations of winning and instead focused on playing the best tennis she could. And if she were to win, she would gain a considerable amount of fame, which is an additional incentive for her to exert more effort. However, it also implies that Sabalenka may feel shame in case she could not beat Mirra, given her higher ranking and experience. This example highlights how asymmetric competition can motivate competitors to work harder, particularly when there is a clear perception of who is the favorite and who is the underdog.

We take the model of asymmetric contests (see, e.g., Baik (1994, 2004), Corchón (2007)) as our workhorse. In a two-player asymmetric contest, following the psychological game approach by Geanakoplos, Pearce, and Stacchetti (1989), we define such psychological motives as shame and fame and investigate how the asymmetry in competitions induces shame and fame, which, in turn, affect individual players' equilibrium effort levels. Our model of asymmetric contests with shame-fame motives reveals that the asymmetry in competition creates two opposing effects. The first is a direct "discouragement effect", which has been well-identified and understood in the previous literature. Asymmetry makes the environment less competitive so that David, the handicapped contestant, is demotivated to exert effort, which in turn demotivates Goliath, the favored contestant. The second effect, which is specific to our environment and will be referred to as "shame-fame encouragement effect", is an indirect effect via the channel of creating shame and fame. A more substantial degree of asymmetry in the contest makes the degree of shame and fame more significant and thus provides an additional motive for contestants to exert more effort. Thus, whether contestants exert more or less effort depends on the relative ranking between the two competing effects.

We show that when the degree of asymmetry is small, the shame-fame encouragement effect dominates the discouragement effect such that the equilibrium effort level increases in the degree of asymmetry. However, the discouragement effect catches up with and eventually dominates the encouragement effect as the degree of asymmetry increases. As a result, the equilibrium effort level is single-peaked in the degree of asymmetry. Furthermore, we show that when players are relatively more sensitive to shame, Goliath could exert more effort in the asymmetric contest than in the symmetric contest, whereas David could exert less effort in the asymmetric contest than in the symmetric contest.

In our experimental implementation of the asymmetric contest, we focus mainly on creating two different interfaces in which the exogenously given ex ante asymmetry between contestants endogenously induces *different degrees* of shame and fame and eventually affects contestants' effort choices. Our experimental design relies on two types of real-effort tasks. The first one is the "summation task" (Niederle and Vesterlund, 2007) in which two asymmetric/symmetric contestants compete by adding two numbers within a limited amount of time. The second one is the "encryption task" (Erkal et al., 2011) in which two contestants compete by decoding an alphabet sequence to a number sequence according to a given decoding table within a limited amount of time.[3] According to Charness et al. (2018), the first task belongs to the cognitive task while the second task does not.

There are several reasons why the summation task may generate more shame and fame for players than the encryption task. Firstly, summation tasks, or cognitive tasks in general, are often perceived as an indicator of intelligence (Cattell, 1987), and therefore success or failure in such tasks can have a significant impact on one's self-esteem and sense of competence. In contrast, encryption tasks may not have the same level of perceived importance or value attached to them. Secondly, summation tasks require more specific ability than encryption tasks that mainly reflect individual effort not ability (Erkal et al., 2011). Hence, summation tasks may lead to a greater sense of pressure and potential shame if a player is not able to perform well. Lastly, summation tasks may be more familiar and commonly used in academic and professional settings, which may increase the level of expectation and pressure on players to perform well (Pekrun et al., 2002). Encryption tasks, on the other hand, may be less commonly used and therefore may not have the same level of expectation or pressure attached to them (Erkal et al., 2011). We thus hypothesize that the shame-fame encouragement effect is significantly stronger in the summation task than in the encryption task.

[3]The encryption task was first introduced to Economics literature as a new real effort game in Erkal et al. (2011) to measure performance reflecting individual effort but not ability although the effort demanded for the task is considered to be moderately mental effort (Waloszek, 2021). The encryption task does not depend on knowledge acquired prior to the experiment as numbers were randomly assigned to the letters of the alphabet. Of course, subjects' ability to absorb new information or use a computer could differ, but these should be less of a concern in our relatively homogeneous subject pool. Also Benndorf et al. (2014) show that they can reduce learning effects simply by reshuffling the encryption table in addition to the word being encrypted. Following this result, we also reshuffled the encryption table.

Our experiment features a 2×3 design which involves six main treatments, three based on the summation task (S) and three based on the encryption task (E). In Treatment SGG, both contestants (Goliath) are asked to solve a series of summation problems of adding two two-digit numbers. In Treatment SDD, both contestants (David) are asked to solve a series of calculation problems of adding two three-digit numbers. In Treatment SGD, which has a non-negligible degree of asymmetry between contestants, one contestant in the role of Goliath solves a series of calculation problems of adding two two-digit numbers, and the other contestant in the role of David solves a series of calculation problems of adding two three-digit numbers. In Treatment EGG, both contestants are asked to solve a series of encryption problems of decoding an alphabet sequence of a length of two letters into a number sequence according to a given decoding table. In Treatment EDD, both contestants are asked to solve a series of encryption problems of decoding an alphabet sequence of a length of three letters. In Treatment EGD, which has a non-negligible degree of asymmetry between contestants, one contestant in the role of Goliath solves a series of encryption problems of decoding an alphabet sequence of a length of two letters, and the other contestant in the role of David solves a series of encryption problems of decoding an alphabet sequence of a length of three letters.

The data from the summation task environment provide strong evidence for the shame-induced encouragement effect; participants in the role of Goliath in the asymmetric contest exerted significantly more effort than in the symmetric contest, and participants in the role of David in the asymmetric contest exerted significantly less effort than in the symmetric contest. This result holds not only in the aggregate but also at the individual level. A majority of individuals who participated in the asymmetric contest (Treatment SGD) exerted a higher level of effort as a Goliath than their counterparts playing Goliath in the symmetric contest (Treatment SGG) and exerted lower level of effort as a David than their counterparts playing David in the symmetric contest (Treatment SDD). In contrast, no such encouragement effect was observed in the encryption task environment as expected; the average performances of the participants in the role of Goliath in the asymmetric contest (Treatment EGD) and in the symmetric contest (Treatment EGG) are not different from each other. This result cannot be attributed to the potential difference in the average abilities of the participants across different treatments as their average performances were the same when they were playing the role of observer. Similarly, loss aversion (Tversky and Kahneman, 1992; Baharad and Nitzan, 2008; Müller and Schotter, 2010) cannot organize our data because there is no reason to believe that the two real-effort game environments induce different degrees of loss aversion.

The findings of our study on the effects of shame and fame in competition have important policy implications in various domains, including sports, business, R&D race, education, healthcare, politics, environmental policy, and the non-profit sector. Our results suggest that creating an environment that induces a higher degree of shame-fame encouragement effect may motivate individuals to work harder and perform better, especially if a significant ex ante asymmetry or unfairness between competitors is unavoidable and/or if high levels of effort are required in a given circumstance. For instance, in sports and business, using incentive schemes that leverage the shame-fame encouragement effect could motivate athletes and employees to work harder and achieve better outcomes. In R&D race and environmental policy, policymakers may use our findings to design incentive schemes that encourage firms and individuals to invest more in R&D and adopt more sustainable practices. In education and the non-profit sector, designing exams, competitions, and donation campaigns that induce a moderate degree of shame-fame encouragement effect may motivate students and donors to work harder and contribute more. Overall, our study provides important insights into the psychological mechanisms underlying competitive behavior and can inform the design of effective incentive schemes in various settings.

This study contributes to the literature by enhancing our understanding of psychological motives (Geanakoplos et al. (1989), Battigalli and Dufwenberg (2007) and Battigalli and Dufwenberg (2009)) in lopsided competitions and their interactions with individual behaviors. To the best of our knowledge, this paper is the first to theoretically consider psychological motivations of shame and fame in the framework of asymmetric contests and experimentally identify how they emerge in the laboratory using real-effort games. Several other behavioral motives have been considered in the literature, such as the joy of winning, loss aversion (e.g., Cornes and Hartley (2003), Baharad and Nitzan (2008), Dechenaux et al. (2015)) and disappointment aversion (Gill and Prowse, 2012), but the focus was almost exclusively on the symmetric contest, with the few exceptions including Müller and Schotter (2010) and Gill and Stone (2010).

The rest of the paper is organized as follows. The remainder of this section reviews the related literature. Section 2 presents the theoretical environment and equilibrium analysis. In Section 3, we report results from the comparative statics analysis. The experimental design and hypotheses are presented in Section 4. Section 5 discusses the experimental results. Section 6 concludes.

1.1. Related Literature. This study relates to several strands of literature. First, this study contributes to the literature on games with belief-dependent motives (Geanakoplos et al. (1989), Battigalli and Dufwenberg (2007) and Battigalli and Dufwenberg (2009)) and related laboratory investigations. There are several experimental studies in the literature that provide support for the theoretical models (see, e.g., Guerra and Zizzo (2004), Charness and Dufwenberg (2006), Dhaene and Bouckaert (2010), Dhaene and Bouckaert (2010), Dufwenberg et al. (2011), as well as the survey Attanasi and Nagel (2008)), but the literature on psychological games focuses primarily on non-competitive environments with trust, partnership and reciprocity. To the best of our knowledge, we are the first to provide experimental evidence of the role of the psychological movies of shame and fame in *competition*.

The psychological motives of shame and fame have been discussed in some other economic environments such as charitable giving and public good games (Samek and Sheremeta, 2014, 2017), field experiments on voter turnout (Gerber et al. (2010), Panagopoulos (2010)), and rank-order tournaments (Gill and Stone (2010), Gill, Kissová, Lee, and Prowse (2018), Hossain, Shi, and Waiser (2015)). In particular, in the field-experimental context of charitable giving, Samek and Sheremeta (2017) show that recognizing only the highest or only the lowest donors has the strongest effect in increasing charitable giving, and they argue that selective recognition creates "tournament-like incentives". Our paper presents a full-blown analysis of shame and fame in the context of asymmetric contests and discusses how the monetary incentives provided in the contest interact with the non-monetary, psychological incentives of shame and fame to determine the equilibrium effort levels.

Second, our study is an extension of the literature on asymmetric contests and related laboratory investigations. The theoretical literature on contests has shown that asymmetry between players leads to a lower level of aggregate effort (Baik (2004, 1994), Cornes and Hartley (2005), Corchón (2007), Franke et al. (2013), Nti (1999, 2004), Stein (2002), Stein and Rapoport (2004), and Yamazaki (2008)). The key insight from the literature is that a weaker player, either with a lower probability of winning or a higher cost of effort, finds it unprofitable to try to beat the stronger player and therefore reduces his costly efforts. This reduction, in turn, allows the stronger player to bid more passively than he would in a contest in which he faces a player of the same strength. In the literature, this effect is called the "discouragement effect" of asymmetry (Konrad (2009), Corchón (2007), Dechenaux et al. (2015)). Confirming the theoretical insights, the experimental literature on asymmetric contests (e.g., Fonseca (2009), Anderson and Freeborn (2010), and Kimbrough et al. (2014)) shows that even if there exists significant overbidding in the sense that subjects spend more than the Nash equilibrium prediction, the introduction of asymmetry in the contest generates effort patterns consistent with the theoretical predictions. That is, a higher degree of heterogeneity among players results in a lower level of effort in contest experiments.[4]

Our study is also related to Baharad and Nitzan (2008). Focusing on general symmetric contests from a behavioral perspective, Baharad and Nitzan (2008) allow for systematic bias in players' perceptions of their winning probabilities by assuming

[4]Fallucchi and Ramalingam (2017) consider a lottery contest with asymmetric abilities and find that players' effort level in the lab is higher than that in the symmetric contest. However, their result is qualitatively different from ours because the higher effort level obtained in their experiments is solely driven by the behavior of disadvantaged players. The higher effort level obtained in our experiments is driven by the behavior of advantaged players.

Tversky and Kahneman (1992)'s inverse S-shaped distortion function, which transforms the objective probability of winning into the subjective probability. Additionally, they theoretically identify that this kind of distortion of probabilities can be an unnoticed incentive for the reduction or expansion of effort in contests. Unlike their behavioral considerations on the perception of the probability of winning, our study examines the effects of psychological value on shame and fame from winning and losing in contests.

Müller and Schotter (2010) considers a three-player all-pay auction with asymmetric ability, where each player's individual ability is his/her private information. The authors' primary objective is to experimentally investigate the optimal allocation of multiple prizes in contests proposed by Moldovanu and Sela (2001). They find that the actual efforts observed in the laboratory are not consistent with the theoretical predictions. Handicapped players in their experiments tend to drop out and exert little or no effort and favored players overbid. This bifurcation result was hidden in their aggregate-level data analysis but revealed through the individual-level analysis. They show that loss aversion proposed by Kahneman and Tversky (1979) can successfully organize their experimental data. It is important to emphasize that loss aversion generates exactly the same behavioral prediction for our two real-effort game environments (summation task and encryption task) and thus cannot organize our data.

Last but not least, our study employs the two real-effort experiments in which subjects compete for a prize via the summation tasks or the encryption tasks, following a growing number of experimental studies (Van Dijk et al. (2001),Vandegrift et al. (2007), Vandegrift et al. (2007), Niederle and Vesterlund (2007),Bartling et al. (2009), Carpenter et al. (2010), Cason et al. (2010), Freeman and Gelber (2010), Erkal et al. (2011), Gill and Prowse (2012), Kuhnen and Tymula (2012), etc.).

2. Model and Equilibrium Analysis

We consider a lottery contest with two contestants, David (D) and Goliath (G), and an observer (O).[5] Each contestant $i = D, G$ independently and simultaneously exerts

[5]The observer is not an active player. It is a device to facilitate the inducement of the psychological motives of shame and fame. We will further elaborate on the role of the observer in Appendix A.

irreversible efforts $x_i \in X_i \equiv [0, \infty)$ to win the contest. The winner receives a prize $v_i \equiv v$. Let P_i denote the winning probability of the player i. Following Leininger (1993), Baik (1994, 2004) and Clark and Riis (1998), we have

$$P_G(x_G, x_D; \gamma) = \frac{\gamma x_G}{\gamma x_G + x_D} \quad \text{and} \quad P_D(x_G, x_D; \gamma) = \frac{x_D}{\gamma x_G + x_D} \tag{1}$$

if $x_G + x_D > 0$ and otherwise $P_i = 0$, where $\gamma \geq 1$ is a parameter that captures the asymmetry or unfairness between the two players. When $\gamma = 1$, no asymmetry exists. When $\gamma > 1$, Goliath is favored and David is handicapped in the contest.

We say that Goliath is affected by *shame*, as his preference is represented by the following utility function:

$$\Pi_G = v \cdot \left(\frac{\gamma x_G}{\gamma x_G + x_D}\right) - x_G - \theta \cdot s(\gamma) \cdot \left(\frac{x_D}{\gamma x_G + x_D}\right) \tag{2}$$

where $s(\gamma) \geq 0$ is the *shame* Goliath feels if he does not win the contest and $\theta > 0$ reflects the degree of shame relative to the value of the prize.[6]

Similarly, we say that David is affected by *fame*, as his preference is represented by the following utility function:

$$\Pi_D = v \cdot \left(\frac{x_D}{\gamma x_G + x_D}\right) - x_D + k \cdot \theta \cdot f(\gamma) \cdot \left(\frac{x_D}{\gamma x_G + x_D}\right) \tag{3}$$

where $f(\gamma) \geq 0$ is the *fame* David enjoys when he wins the contest, $k \cdot \theta > 0$ reflects the degree of fame relative to the value of the prize and $k \in (0, \infty)$ is an exogenously given parameter that captures how sensitive David is to fame relative to how sensitive Goliath is to shame, which we call the *relative shame-fame sensitivity*.

We now derive $f(\cdot)$ and $s(\cdot)$ using the belief-dependent utility *à la* the psychological game approach developed by Geanakoplos et al. (1989).[7] Let $\alpha_O^i(\cdot) \in \Delta X_i \equiv B_O^1$ denote the first-order belief of the observer O about the strategy of player i, $i = G, D$.

[6] As depicted in equations (2) and (3), we model shame (fame) as being realized conditional on losing (winning), which is a distinctive feature different from the "joy of winning".

[7] As our game has only one decision node for each player, the only relevant beliefs are the initial beliefs, and the revision of beliefs considered by Battigalli and Dufwenberg (2007) and Battigalli and Dufwenberg (2009) is not relevant.

Given the first-order belief (α_O^G,α_O^D), let $b_i \in \Delta B_O^1 \equiv B_i^2$ denote player i's second-order belief about α_O^i, $i = G, D$.[8] Denote $b = (b_G, b_D) \in B = (B_G^2, B_D^2)$.

Define L_O^i, observer O's first-order estimate of player i's likelihood of winning, as follows:

$$L_O^i = L_O^i(\alpha_O^G, \alpha_O^D; \gamma) = \int_{X_G} \int_{X_D} P_i(x_G, x_D; \gamma)\alpha_O^G(dx_G)\alpha_O^D(dx_D). \tag{4}$$

Let $\mathcal{L}_i$ denote player i's estimate of L_O^i, i.e., the second-order estimate of the likelihood of winning. Then,

$$\mathcal{L}_i(b;\gamma) = \mathcal{L}_i(b_G, b_D; \gamma) = \int_{\alpha_O^G} \int_{\alpha_O^D} L_O^i(\alpha_O^G, \alpha_O^D; \gamma) b_G(d\alpha_O^G) b_D(d\alpha_O^D). \tag{5}$$

Define

$$Y_G(b;\gamma) = \begin{cases} |\mathcal{L}_G(b;\gamma) - \mathcal{L}_G(b;\gamma = 1)| & \text{if David wins,} \\ 0 & \text{otherwise} \end{cases}$$

and

$$Y_D(b;\gamma) = \begin{cases} |\mathcal{L}_D(b;\gamma = 1) - \mathcal{L}_D(b;\gamma)| & \text{if David wins,} \\ 0 & \text{otherwise.} \end{cases}$$

The expression $Y_G(b;\gamma)$ measures how much favor the observer believes is given to Goliath measured by the increase in the (second-order estimate of) likelihood of winning induced by the asymmetry ($\gamma > 1$). It thus measures how much Goliath "lets down" observer O when Goliath could not win. Similarly, the expression $Y_D(b;\gamma)$ measures how much disadvantage the observer believes is given to David, measured by the decrease in the likelihood of winning induced by the asymmetry ($\gamma > 1$). It measures how much David "surprises" observer O when David wins. By definition of $\mathcal{L}_i$, $Y_G(b;\gamma) = Y_D(b;\gamma) \equiv Y(b;\gamma)$. Define $s(\gamma) = f(\gamma) = Y(b;\gamma)$.

Let $\sigma = (\sigma_G, \sigma_D) \in \Sigma$ denote a mixed-strategy profile. Following Geanakoplos et al. (1989), the solution concept is the psychological Nash equilibrium (hereafter used interchangeably with equilibrium).

[8] We depart from the standard psychological game formulation, which derives and begins with the first- and second-order beliefs of every player about everyone else's strategy, by formulating shame and fame as psychological motives that derive from one's second-order belief about what the observer (but not his/her opponent) believes.

Definition 1 (Psychological Nash equilibrium)**.** *A psychological Nash equilibrium is a pair* (σ^*, b^*) *such that*

(1) *Given* b^*, $\Pi_i(b_i^*, (\sigma_i^*, \sigma_{-i}^*)) \geq \Pi_i(b_i^*, (\sigma_i, \sigma_{-i}^*))$ *for all* $\sigma_i \in \Sigma_i$ *and for all* $i \in \{G, D\}$.
(2) *Given* b^*, *the strategy profile* σ^* *is psychologically consistent, i.e.,* $b^* = \sigma^*$.

By invoking Condition (1) of the psychological Nash equilibrium, we take $Y(b^*; \gamma) \equiv Y(\gamma)$ as given. The first-order conditions for maximizing Π_G and Π_D reduce to

$$v\gamma(\gamma x_G + x_D) - v\gamma^2 x_G + \gamma\theta Y(\gamma) x_D = (\gamma x_G + x_D)^2 \tag{6}$$

and

$$(v + k\theta Y(\gamma))(\gamma x_G + x_D) - (v + k\theta Y(\gamma)) x_D = (\gamma x_G + x_D)^2 \tag{7}$$

For notational efficiency, we define the shame-/fame-adjusted valuation of the prize for each player as follows:

$$V_G = V_G(\gamma) \equiv v + \theta Y(\gamma) \text{ and } V_D = V_D(\gamma) \equiv v + k\theta Y(\gamma),$$

while V_G and V_D denote the shame-adjusted valuation of the prize for Goliath and the fame-adjusted valuation of the prize for David, respectively.

From the equations (6) and (7), the following reaction functions are obtained:

$$x_G = [-x_D + \sqrt{\gamma x_D V_G}]/\gamma \tag{8}$$

and

$$x_D = -\gamma x_G + \sqrt{\gamma x_G V_D}. \tag{9}$$

It is straightforward to show that the second-order conditions are also satisfied, i.e., $\frac{\partial^2 \Pi_G}{\partial x_G^2} < 0$ for all $x_G \geq 0$ and $\frac{\partial^2 \Pi_D}{\partial x_D^2} < 0$ for all $x_D \geq 0$. Then, we have our first proposition as follows.

Proposition 1. *Given b^*, let $(\hat{x}_G, \hat{x}_D)$ denote the unique strategy profile that satisfies Condition (1) of Definition 1. Then, we have*

$$\hat{x}_G = \frac{\gamma V_G^2 V_D}{(\gamma V_G + V_D)^2}, \quad \textit{and} \quad \hat{x}_D = \frac{\gamma V_G V_D^2}{(\gamma V_G + V_D)^2}. \tag{10}$$

The proof is omitted because the uniqueness originates from the standard finding in the literature on asymmetric lottery contests (Baik, 1994; Gupta and Singh, 2018). Let $\hat{p}_i$ denote the winning probability of player i from the strategy profile $(\hat{x}_G, \hat{x}_D)$. Then, we have

$$\hat{p}_G = \frac{\gamma V_G}{(\gamma V_G + V_D)} \quad \text{and} \quad \hat{p}_D = \frac{V_D}{(\gamma V_G + V_D)}. \tag{11}$$

We need to check the psychological consistency condition (Condition (2) of Definition 1) to show that $(\hat{x}_G, \hat{x}_D)$ is a psychological Nash equilibrium strategy profile. The psychological consistency condition implies that

$$\mathcal{L}_G(b^*; \gamma) = \hat{p}_G \tag{12}$$

and

$$\mathcal{L}_G(b^*; \gamma = 1) = \mathcal{L}_D(b^*; \gamma = 1) = \frac{1}{2}.[9] \tag{13}$$

By equations (10), (12) and (13), equation (11) becomes

$$\hat{p}_G = \frac{\gamma(v + \theta|\hat{p}_G - \frac{1}{2}|)}{\gamma(v + \theta|\hat{p}_G - \frac{1}{2}|) + (v + k\theta|\hat{p}_G - \frac{1}{2}|)}. \tag{14}$$

Let p_G^* denote the solution of equation (14). The following proposition shows that p_G^* exists and is unique under a reasonably large v.

Proposition 2. *Suppose that $(\gamma + 1)v \geq k\theta$. Then, $p_G^* \in (\frac{1}{2}, 1)$ exists and is unique.*

[9] When $\gamma = 1$, players are ex-ante identical and there exists a unique symmetric Nash equilibrium in which each player has an equal chance to win.

Proof. To obtain a contradiction, suppose that $\hat{p}_G < 1/2$. After some rearrangement, equation (14) becomes

$$\theta(\gamma+k)\hat{p}_G^2 - \left((\gamma+1)v + \frac{(3\gamma+k)\theta}{2}\right)\hat{p}_G + \gamma(\frac{\theta}{2}+v) = 0. \tag{15}$$

Let $\mathcal{A}$ denote the expression on the left-hand side of equation (15). Due to strict convexity, the first-order condition guarantees that $\mathcal{A}$ achieves the unique minimum at $\hat{p}_G = \frac{\gamma\theta+(\gamma+1)v}{2(\gamma\theta+k\theta)} + \frac{1}{4} > \frac{1}{2}$ where the last inequality comes from the assumption that $(\gamma+1)v \geq k\theta$. We find that $\mathcal{A} = \gamma(v+\frac{\theta}{2}) > 0$ when $\hat{p}_G = 0$ and $\mathcal{A} = \frac{v(\gamma-1)}{2} > 0$ when $\hat{p}_G = 1/2$. Thus, equation (15) cannot have its solution in $[0, 1/2]$, which yields a contradiction. Thus, we have $\hat{p}_G \geq 1/2$. After some rearrangement, equation (14) becomes

$$\theta(\gamma+k)\hat{p}_G^2 + \left((\gamma+1)v - \frac{(3\gamma+k)\theta}{2}\right)\hat{p}_G + \gamma(\frac{\theta}{2}-v) = 0. \tag{16}$$

Let $\mathcal{B}$ denote the expression on the left-hand side of equation (16). Then, $\mathcal{B} = \frac{(1-\gamma)v}{2} < 0$ when $\hat{p}_G = 1/2$ and $\mathcal{B} = v + \frac{k\theta}{2} > 0$ when $\hat{p}_G = 1$. By the intermediate value theorem and the continuity and strict convexity of the expression $\mathcal{B}$ in $\hat{p}_G$, the solution of equation (16) $p_G^* \in (1/2, 1)$ exists and is unique. □

Proposition 2 demonstrates that unless David is drastically sensitive to fame relative to the size of the prize, $p_G^* \in (\frac{1}{2}, 1)$ exists and is unique. It further implies that the psychological Nash equilibrium of this game exists and is unique. Let (x_G^*, x_D^*) denote the unique strategy profile in the psychological Nash equilibrium. Then, we have

$$x_G^* = p_G^* p_D^* V_G = p_G^* p_D^* (v + \theta(p_G^* - \frac{1}{2})) \quad \text{and} \quad x_D^* = p_G^* p_D^* V_D = p_G^* p_D^* (v + k\theta(p_G^* - \frac{1}{2})). \tag{17}$$

Note that $\frac{x_G^*}{V_G} = \frac{x_D^*}{V_D} = \frac{\gamma V_G V_D}{(\gamma V_G + V_D)^2}$. Thus, we have $x_G^* > x_D^*$ if and only if $V_G > V_D$, or equivalently, $k < 1$.

Corollary 1. *Suppose that $v > \frac{k\theta}{\gamma+1}$. In the unique psychological Nash equilibrium, $x_G^* \substack{> \\ = \\ <} x_D^*$ if and only if $k \substack{< \\ = \\ >} 1$.*

Given that $p_G^* \geq 1/2$, we have $Y(\gamma) = s(\gamma) = f(\gamma) = p_G^* - \frac{1}{2}$. The following proposition characterizes the main properties of the shame and fame function $Y(\gamma)$ for a reasonably large v.

Proposition 3. *Suppose that* $v > \max\{\frac{k\theta}{\gamma+1}, \frac{\theta}{2}\}$. $Y(\cdot)$ *is continuous and differentiable, monotonically increasing and strictly concave in* γ *for any* $\gamma > 1$*, and becomes* 0 *when* $\gamma = 1$.

Proof. Let $\mathcal{B}$ denote the expression on the left-hand side of equation (16). As $\mathcal{B}$ is continuous and differentiable in γ, p_G^*, if exists, it is also continuous and differentiable in γ, and so is $Y(\gamma)$.

First, we show that p_G^* is increasing in γ. For any $\hat{p}_G \in (\frac{1}{2}, 1)$, $\frac{\partial \mathcal{B}}{\partial \hat{p}_G} > 0$ and $\frac{\partial^2 \mathcal{B}}{\partial \hat{p}_G^2} > 0$. By the chain rule, we have $\frac{\partial \mathcal{B}}{\partial \hat{p}_G} = \frac{\partial \mathcal{B}}{\partial \gamma} \cdot \frac{\partial \gamma}{\partial \hat{p}_G} > 0$, where $\frac{\partial \mathcal{B}}{\partial \gamma} = \big(\theta \hat{p}_G^2 + (v - \frac{3\theta}{2})\hat{p}_G + (\frac{\theta}{2} - v)\big) < 0$ for any $2v > \theta$. Thus, we have $\frac{\partial \hat{p}_G}{\partial \gamma} < 0$, which implies that $\frac{\partial p_G^*}{\partial \gamma} > 0$ and $\frac{\partial Y(\gamma)}{\partial \gamma} > 0$.

Second, we show that p_G^* is strictly concave in γ. By the chain rule, we have $\frac{\partial^2 \mathcal{B}}{\partial \hat{p}_G^2} = \frac{\partial^2 \mathcal{B}}{\partial \gamma^2} \cdot \left(\frac{\partial \gamma}{\partial \hat{p}_G}\right)^2 + \frac{\partial \mathcal{B}}{\partial \gamma} \cdot \frac{\partial^2 \gamma}{\partial \hat{p}_G^2} > 0$. Because $\frac{\partial^2 \mathcal{B}}{\partial \gamma^2} = 0$, we have $\frac{\partial^2 \mathcal{B}}{\partial \hat{p}_G^2} = \frac{\partial \mathcal{B}}{\partial \gamma} \cdot \frac{\partial^2 \gamma}{\partial \hat{p}_G^2} > 0$. From the fact that $\frac{\partial \mathcal{B}}{\partial \gamma} < 0$, we conclude that $\frac{\partial^2 \hat{p}_G}{\partial \gamma^2} < 0$, which implies that $\frac{\partial^2 p_G^*}{\partial \gamma^2} < 0$ and $\frac{\partial^2 Y(\gamma)}{\partial \gamma^2} < 0$.

Finally, it is straightforward to verify that equation (16) has a unique solution $p_G^* = 1/2$ when $\gamma = 1$. This completes the proof. □

3. Comparative Statics on Equilibrium Effort Levels

In this section, we conduct a comparative statics analysis and discuss how equilibrium effort levels respond to the variation in the degree of asymmetry γ, assuming that v is sufficiently large that $Y(\cdot)$ is uniquely determined and strictly increasing in γ. Our analysis starts from the following decomposition of the individual effort level for Goliath.

$$\begin{aligned} x_G^* &= [x_G^*]_{\gamma=1} + \left[[x_G^*]_{\substack{\gamma>1,\\ \theta=0}} - [x_G^*]_{\gamma=1}\right] + \left[[x_G^*]_{\substack{\gamma>1,\\ \theta>0}} - [x_G^*]_{\substack{\gamma>1,\\ \theta=0}}\right] \\ &= \underbrace{\frac{v}{4}}_{\substack{\text{effort level with}\\ \text{no asymmetry}}} + \underbrace{v\left[\frac{\gamma}{(\gamma+1)^2} - \frac{1}{4}\right]}_{\substack{\text{discouragement effect from}\\ \text{the asymmetry } \gamma>1}} + \underbrace{\gamma\left[\frac{V_G^2 V_D}{(\gamma V_G + V_D)^2} - \frac{v}{(\gamma+1)^2}\right]}_{\substack{\text{shame-fame effect from}\\ \text{the asymmetry } \gamma>1}} \end{aligned} \tag{18}$$

The first term of the right-hand side of equation (18) is obtained from x_G^* by setting $\gamma = 1$, which captures the effort level without asymmetry. The second term is obtained by setting $\gamma > 1$ and $\theta = 0$ to allow for the asymmetry in the contest but excluding the effect of shame and fame. This term captures the standard *discouragement effect* from the asymmetry in the contest, which is well identified in the literature (Baik, 1994). The third term is obtained by setting $\gamma > 1$ and $\theta > 0$ to allow for the asymmetry in contest and capture the *effect of shame and fame*.

Note that the second term of the right-hand side of equation (18) is always negative when $\gamma > 1$, monotonically decreasing in γ, and converges to $-\frac{v}{4}$ when γ goes to infinity. Thus, without considering the effect of shame and fame, the discouragement effect from the asymmetry substantially cancels out the effort level without asymmetry when the asymmetry is very large.

Next, we further rearrange the third, shame-fame term in equation (18) as follows:

$$\gamma\left[\frac{V_G^2 V_D}{(\gamma V_G + V_D)^2} - \frac{v}{(\gamma+1)^2}\right] = \frac{\gamma\theta Y(\gamma)\left[\gamma^2 V_G^2 k + V_D(2\gamma V_G + v\theta Y(\gamma)) + vV_D(2-k)\right]}{(\gamma V_G + V_D)^2(\gamma+1)^2} \tag{19}$$

This equation implies that the shame-fame effect *encourages* Goliath to increase his equilibrium effort level as long as $k \leq 2$. However, even when this condition is satisfied such that the shame-fame effect increases Goliath's equilibrium effort, the overall effect of asymmetry on the equilibrium effort will be determined jointly by the two competing effects: the discouragement effect and the shame-fame encouragement effect.

We now conduct the same decomposition exercise for David's equilibrium effort level.

$$\begin{aligned}
x_D^* &= [x_D^*]_{\gamma=1} + \left[[x_D^*]_{\substack{\gamma>1,\\ \theta=0}} - [x_D^*]_{\gamma=1}\right] + \left[[x_D^*]_{\substack{\gamma>1,\\ \theta>0}} - [x_D^*]_{\substack{\gamma>1,\\ \theta=0}}\right] \\
&= \underbrace{\frac{v}{4}}_{\substack{\text{effort level with}\\ \text{no asymmetry}}} + \underbrace{v\left[\frac{\gamma}{(\gamma+1)^2} - \frac{1}{4}\right]}_{\substack{\text{discouragement effect from}\\ \text{the asymmetry } \gamma>1}} + \underbrace{\gamma\left[\frac{V_G V_D^2}{(\gamma V_G + V_D)^2} - \frac{v}{(\gamma+1)^2}\right]}_{\substack{\text{shame-fame effect from}\\ \text{the asymmetry } \gamma>1}} \qquad (20)
\end{aligned}$$

The first two terms are the same as those in equation (18). The third term can be rearranged as follows:

(21)
$$\gamma\left[\frac{V_G V_D^2}{(\gamma V_G+V_D)^2}-\frac{v}{(\gamma+1)^2}\right]=\frac{\gamma\theta Y(\gamma)\left[2\gamma V_D V_G k+V_D^2+\gamma^2 V_G k\theta Y(\gamma)+v\gamma^2 V_G(2k-1)\right]}{(\gamma V_G+V_D)^2(\gamma+1)^2}$$

This equation means that the shame-fame effect *increases* David's equilibrium effort level as long as $k \geq 1/2$. Thus, we have the following proposition to summarize.

Proposition 4. *When $1/2 \leq k \leq 2$, the shame-fame effect due to the asymmetry encourages both contestants to exert more effort in equilibrium.*

It is worth mentioning that $1/2 \leq k \leq 2$ is only sufficient but not necessary for the shame-fame effect to encourage the contestants to exert more effort. This expression tells us that as long as Goliath and David are similarly sensitive to shame and fame, then shame and fame encourage both contestants to work harder.

Now, we are ready to investigate the overall effect of asymmetry on the equilibrium effort levels. It is clear that the asymmetry creates two opposing forces that compete with each other: the discouragement effect captured by the second terms in equations (18) and (20) and the shame-fame encouragement effect captured by the third terms in the two equations. From equation (10), we have

$$\frac{(\gamma V_G+V_D)^3}{V_G}\cdot\frac{\partial x_G^*}{\partial\gamma}=\underbrace{V_G}_{>0}\underbrace{(V_D-\gamma V_G)}_{(A)}\underbrace{(V_D-\gamma V_D')}_{(B)>0}+\underbrace{2\gamma V_G' V_D^2}_{>0},\tag{22}$$

and

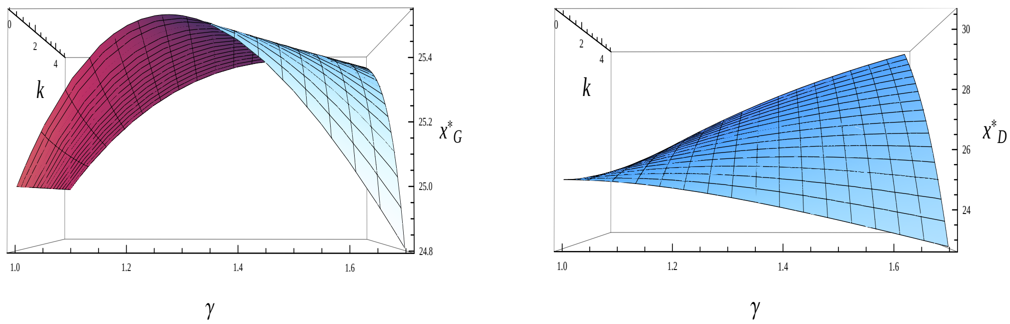
$$\frac{(\gamma V_G+V_D)^3}{V_D}\cdot\frac{\partial x_D^*}{\partial\gamma}=\underbrace{V_D}_{>0}\underbrace{(V_D-\gamma V_G)}_{(A)}\underbrace{(V_G+\gamma V_G')}_{(C)>0}+\underbrace{2\gamma^2 V_G^2 V_D'}_{>0},\tag{23}$$

where $V_i' > 0$ and $Y' > 0$ denote $\partial V_i(\gamma)/\partial\gamma$ and $\partial Y(\gamma)/\partial\gamma$, respectively. Note that term (A) and term (B) in equation (22) can be written respectively as

$$(A)=(1-\gamma)v+\theta(k-\gamma)Y(\gamma)\quad\text{and}\quad(B)=v+k\theta(Y(\gamma)-\gamma Y')>0.\tag{24}$$

where the last inequality comes from the fact that $Y' < Y(\gamma)/\gamma$ due to the strict concavity of $Y(\gamma)$.

Figures 1(a) and 1(b) illustrate how x_G^* and x_D^* change in response to the changes in γ and k under the parameter values $v = 100$ and $\theta = 60$. The strict concavity of $Y(\gamma)$



(a) x_G^* (b) x_D^*

FIGURE 1. Comparative Statics with $v = 100$ and $\theta = 60$

implies that the marginal effect of shame and fame is strongest at $\gamma = 1$. Consequently, the encouragement effect of shame and fame dominates the discouragement effect of asymmetry for both players at $\gamma = 1$, as term (A) is 0, meaning that 1) the right-hand side of (22) becomes $2\theta v^2 Y' > 0$ and 2) the right-hand side of (23) becomes $2k\theta v^2 Y' > 0$ at $\gamma = 1$. This observation, together with the continuity of equations (22) and (23), implies that both players' effort levels are strictly increasing in γ in the neighborhood of $\gamma = 1$ regardless of $k > 0$. It also implies that when $k < 1$ ($k > 1$), the marginal encouragement effect of shame for Goliath is larger (smaller) than that of fame for David. However, the encouragement effect of shame and fame is eventually dominated by the discouragement effect, as both the right-hand side of (22) and that of (23) become negative infinity when $\gamma = \infty$. As a result, players' equilibrium effort level is single peaked in the degree of asymmetry. Also we can see that two players' effort levels may bifurcate when k is less than one. That is, when players are more sensitive to shame than to fame, Goliath exerts more effort in the asymmetric contest than in the symmetric contest, while David exerts less effort in the asymmetric contest than in the symmetric contest.

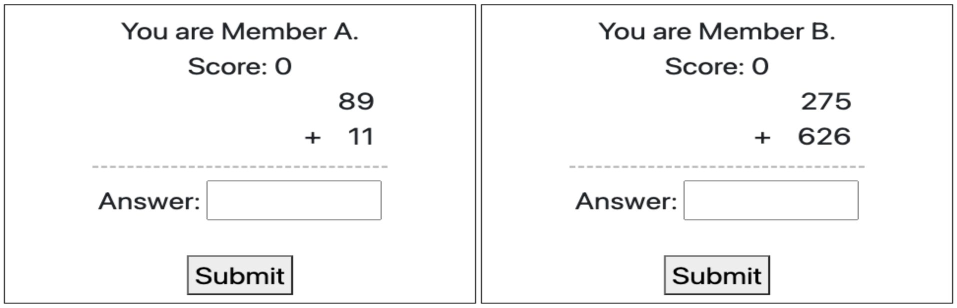
4. Experimental Design, Hypotheses, and Procedure

4.1. Experimental Design. In designing the experiments, our main focus was on creating two interfaces in which the exogenously introduced asymmetry between the two contestants *endogenously induces* different degrees of shame and fame and eventually affects individuals' effort choices differently. To achieve this goal, we implemented our experiments with two different real-effort games, each with two contestants (Members A and B) and an observer (Member C).[10] The first one is the "summation task" (Niederle and Vesterlund, 2007) in which two asymmetric/symmetric contestants compete by adding two numbers within two minutes (see Figure 2 for the screen shot). The second one is the "encryption task" (Erkal et al., 2011) in which two contestants compete by decoding an alphabet sequence to a number sequence according to a given decoding table within two minutes (see Figure 3 for the screen shot). In each round, three participants were randomly matched and roles were randomly assigned. At the beginning of each round, 60 experimental tokens were given to Member A and Member B, who competed against one another by independently and simultaneously solving a series of simple calculation/encryption questions within two minutes. The opportunity cost of solving one question was one experimental token, in addition to the time cost.[11] The type of tasks and difficulties each participant had may have differed depending on the role assigned to each participant and the treatment.

Table 1 presents our experimental design that features a 2×3 structure involving six main treatments, three based on the summation task (S) and three based on the encryption task (E). In Treatment SGG, both contestants (Goliath) are asked to solve a series of summation problems of adding two two-digit numbers. In Treatment SDD, both contestants (David) are asked to solve a series of calculation problems of adding

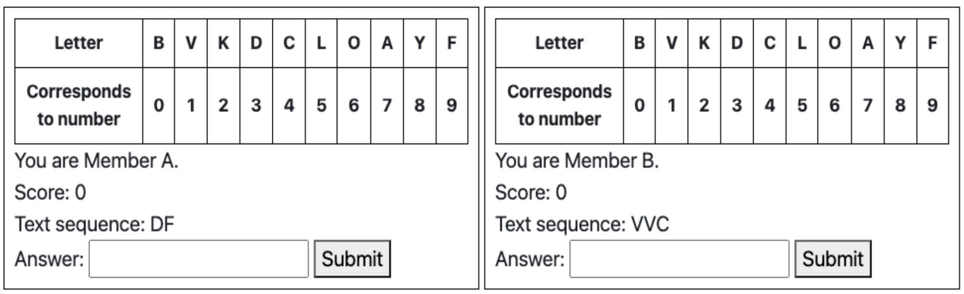
[10]We also employed a set of additional robustness check treatments in which there was no observer in the summation task. Our main hypothesis from these *No-Observer* treatments is that the absence of an observer does not change the shame-fame effect because the channel through which the shame and fame are formed is via the second-order belief of the active players about someone else's belief, where this someone else is not necessarily the observer. We will present the design and results of the *No-Observer* treatments in Appendix A.

[11]Thus, the maximum number of questions each player could solve was 60. In our data, no subject reached the maximum.



(a) Member A's Screen (b) Member B's Screen

FIGURE 2. Summation Task



(a) Member A's Screen (b) Member B's Screen

FIGURE 3. Encryption Task

two three-digit numbers. In Treatment SGD, which has a non-negligible degree of asymmetry between contestants, one contestant in the role of Goliath solves a series of calculation problems of adding two two-digit numbers, and the other contestant in the role of David solves a series of calculation problems of adding two three-digit numbers. In Treatment EGG, both contestants (Goliath) are asked to solve a series of encryption problems of decoding an alphabet sequence of a length of two letters into a number sequence according to a given decoding table. In Treatment EDD, both contestants (David) are asked to solve a series of encryption problems of decoding an alphabet sequence of a length of three letters. In Treatment EGD, which has a non-negligible degree of asymmetry between contestants, one contestant in the role of Goliath solves a series of encryption problems of decoding an alphabet sequence of a length of two letters, and the other contestant in the role of David solves a series of encryption problems of decoding an alphabet sequence of a length of three letters. It is important to emphasize that we induced the same degree of asymmetry ($\gamma = 1.5$)

across the two asymmetric environments, SGD and EGD, by tightly controlling the relative difficulty of each question for Goliath and David across the two tasks. We shall call Treatments SGD and EGD asymmetric treatments collectively, and the rest symmetric treatments collectively.

	Member B		
	Player	Goliath	David
Member A	Goliath	SGG	SGD
	David	N/A	SDD

Summation Task

	Member B		
	Player	Goliath	David
Member A	Goliath	EGG	EGD
	David	N/A	EDD

Encryption Task

Table 1. Experimental Treatments

The computer calculated how many questions each member solved within 2 minutes. Each question a player solved gave him/her one lottery ticket, and the computer randomly selected one lottery ticket out of all tickets Member A and Member B earned. The player who held the selected lottery ticket was declared the winner. The earnings in each round were 120 ECU (Experimental Currency Units) for the winner and 30 ECU for the loser, while both kept their unspent tokens.

The type of questions Member C was asked to solve varied depending on the environment. Member C in the summation task environment was always asked to solve a series of calculation problems of adding two numbers, one two-digit number and one three-digit number. Member C in the encryption task environment was always asked to solve a series of encryption problems of decoding an alphabet sequence of a length of two letters. At the beginning of each round, unlike Members A and B, Member C received no experimental token and did not need to pay any extra opportunity cost to solve questions. The computer calculated how many questions Member C solved within 2 minutes. Each question Member C solved gave him/her one experimental token. With the number of tokens he/she earned, Member C was asked to bet on who (between Member A and Member B) would win the competition. Member C was allowed to bet any non-negative integer amount of tokens on one player under his/her budget constraint. The number of tokens Member C bet was doubled if his/her guess was correct and halved otherwise. Thus, Member C's decision did not directly affect the payoffs of Members A and B.[12]

Having Member C solve questions and make a bet is a crucial feature of our experimental design. There are four reasons why we design our experiments in that way. First, by doing so, we give a serious role to Member C as an observer who cares about who will win the contest between Member A and Member B. Second, this inclusion is an incentivized mechanism for Member C to truthfully report his/her belief regarding who will win the contest. By examining the betting decision made by Member C, we can understand how much disappointment or letdown s/he could feel from the potential discrepancy between her expectation and the actual outcome of the contest. Third, as we shall soon discuss for our first hypothesis, we can compare the performances of Member C in different treatments to prove that the average problem-solving abilities of experimental subjects (randomly) assigned to different treatments are not different from each other. Fourth, and probably most importantly, we would like for Member A and Member B to both know that there exists a serious observer who cares about the contest outcome.[13]

4.2. Experimental Hypotheses. Our first hypothesis originates from the fact that we randomly assigned participants to different treatments. Given the fact that Member Cs in the three treatments under the same real-effort game environment were asked to solve the same type of questions, there is no reason to believe that the average numbers of questions the observers (Member C) solved vary across the treatments. Rejection of this random assignment hypothesis means that the average abilities of participants to perform the summation/encryption task are not the same across treatments.[14]

[12]However, it is possible that Members A and B may exhibit social preferences such as altruism. See Appendix A for further discussion.

[13]The absence of an observer may not change the shame-fame effect because the shame and fame are formulated as a second-order belief of an active player. Either the physical presence of the observer or what the observer actually thinks does not matter. We will present experimental results from the set of treatments without the observer in the summation task environment in Appendix A.

[14]As an alternative of Hypothesis 1, one could claim that Member C may have a greater incentive to work hard in asymmetric reatment than in two other symmetric treatments because the presence of asymmetry increases the accuracy of Member C's prediction. Whether this incentive could create a non-negligible difference in Member C's effort levels across treatments is an empirical question.

Hypothesis 1 (Random Assignment Hypothesis)**.** *In each real-effort game environment, the average numbers of questions solved by the observer (Member C) do not vary across treatments.*

To establish our next, key hypothesis, we compare the same player type (e.g., Goliath) in two different treatment conditions (an asymmetric contest vs. a symmetric contest). Our Proposition 4 shows that the shame-fame effect encourages both Goliath and David to exert more efforts under the reasonable range of k. And we hypothesize that **the shame-fame encouragement effect is stronger in the summation task environment than in the encryption task environment** based on the following reasons.[15] The first point is that tasks involving summation or other cognitive tasks are often seen as a measure of intelligence and thus success or failure in these tasks can have a significant impact on a person's self-esteem and sense of competence. In contrast, encryption tasks may not be viewed with the same level of importance or value. Secondly, summation tasks require more specific skills than encryption tasks, which may lead to a greater sense of pressure and potential embarrassment if a player performs poorly. Encryption tasks, however, may be seen more as a game or puzzle and may not generate the same level of pressure. Lastly, summation tasks are more commonly used in academic and professional settings, which may increase the level of expectation and pressure on players to perform well. In contrast, encryption tasks may not be as widely used in academic and professional settings, and therefore, may not have the same level of expectation or pressure attached to them.

Hypothesis 2 (Shame and Fame in Asymmetric Contests)**.** *a) The number of questions Goliath solves in the asymmetric treatment is different from that in the symmetric treatment in the summation task environment but not in the encryption task environment. b) The number of questions David solves in the asymmetric treatment is different from that in the symmetric treatment in the summation task environment but not in the encryption task environment.*

[15] We conducted all treatments with the summation task in the laboratory using the face-to-face mode while all treatments with the encryption task were conducted via Zoom using the real-time online mode. This difference is another reason to believe that a stronger shame-fame effect may exist in the summation task environment than in the encryption task environment.

Note that no shame and fame emerge without asymmetry in the contest, i.e., $\lim_{\gamma\downarrow 1} s(\gamma) = 0$ and $\lim_{\gamma\downarrow 1} f(\gamma) = 0$. This finding implies that the average number of questions Member A solved must be the same as the average number of questions Member B solved in each of the symmetric treatments.

Hypothesis 3 (No Shame / Fame Without Asymmetry)**.** *In each symmetric treatment, the average number of questions Member A solved is the same as that Member B solved.*

Our last hypothesis addresses how Member C's estimations regarding who would win the contest may differ across treatments. Given the asymmetry created between Member A and Member B in the asymmetric treatments, it is natural to expect that Member C would allocate more tokens to Member A (Goliath) than to Member B (David) for his/her betting decision. However, this difference may disappear in the symmetric treatments, where there is no asymmetry between Members A and B.

Hypothesis 4 (Member C's Estimations)**.** *In each real-effort game environment, the difference between the number of tokens Member C allocates to Member A and those she allocates to Member B in the asymmetric treatment is larger than the corresponding differences in the symmetric treatments.*

4.3. Experimental Procedure. Our experiment was conducted at the Hong Kong University of Science and Technology in English. All experiments with the summation tasks were conducted using z-Tree (Fischbacher, 2007) via the face-to-face mode in the behavioral laboratory and all experiments with the encryption tasks were conducted using oTree (Chen et al., 2016) and Zoom via the real-time online mode. A total of 261 subjects who had no prior experience with our experiment were recruited from the undergraduate and graduate population at the university. At the beginning of each session, participants in the face-to-face experiments were instructed to take a seat at their assigned computer terminals, while those in the real-time online experiments were required to join a designated Zoom meeting, turn on their videos, and find a quiet location with a strong internet connection. It was mandatory for all participants to keep their videos on throughout the entire experiment. Depending on the mode of the experiment, participants received either a hard copy or an electronic copy of the instructions, which were read aloud and accompanied by slide illustrations to aid comprehension. After the instructions, participants completed a comprehension quiz and a practice round to familiarize themselves with the task. In all sessions, subjects participated in 7 rounds of play under one treatment condition. All sessions except one had 18 participants, who were further divided into two matching groups of nine subjects. One session of Treatment EGD had nine subjects and, thus, one matching group.[16] At the beginning of each round, one-third of the participants were randomly assigned to the Member A group, another third to the Member B group and the remaining third to the Member C group. The role designation was random within a matching group in each round. We thus used the between-subjects design with the random-role, random-matching protocol. The experimental instructions for Treatment EGD are presented in Appendix C.

We randomly selected one round of the seven total rounds for each subject's payment. The amount a subject earned in the selected round was converted into Hong Kong dollars at a fixed and known exchange rate of HK$1 per 1 ECU. In addition to these earnings, subjects also received a payment of HK$50 ($\approx$ US$6.4) for participating. Subjects' total earnings averaged HK$153.7 ($\approx$ US$19.7). The average duration of a session was approximately 1 hour.

5. Experimental Results

5.1. Aggregate Outcome. Figure 4 presents the average effort levels, measured as the number of questions solved, aggregated over all seven rounds and all three sessions of each treatment.[17]

A few observations are immediately clear. First, the average numbers of questions Member C solved are 23.03, 24.35, and 23.83 in Treatments SGG, SDD, and SGD, respectively and 29.68, 31.12, and 29.57 in Treatments EGG, EDD, and EGD,

[16]The number of matching groups for each treatment is as follows: SGG (6), SGD (5), SDD(6), EGG (4), EGD (4), and EDD (4).

[17]Looking at the time trend reported in Figure 10 in Appendix B, there is at most a very mild degree of learning observed in the data. In the rest of the section, we will use the data aggregated over all rounds.

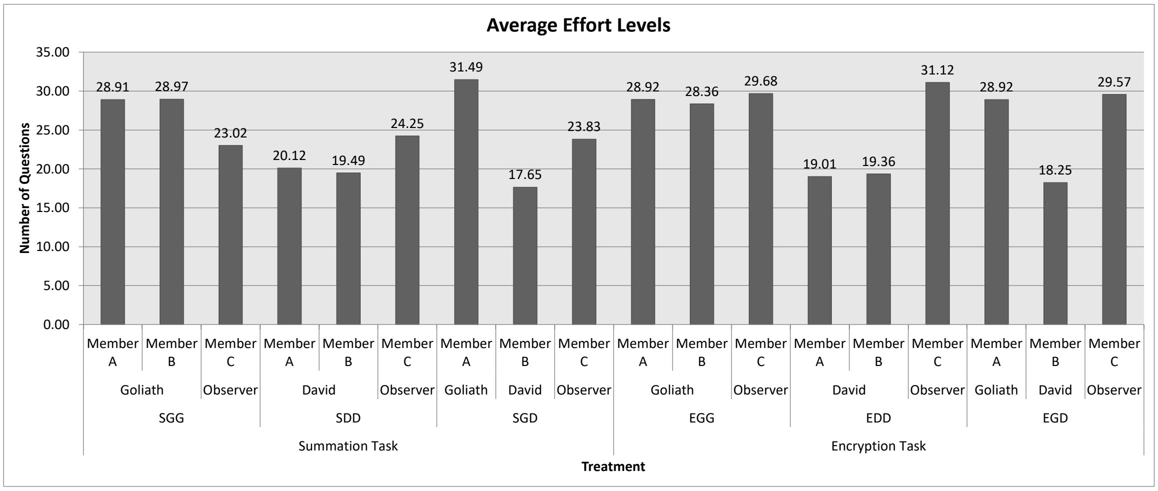


Figure 4. Average Effort Levels - Aggregated from All Rounds

respetively.[18] The non-parametric Mann-Whitney test (two-sided) with the individual average as an independent observation reveals that we cannot reject Hypothesis 1 (Random Assignment Hypothesis) that for a given real-effort game environment the number of questions Member C solved is statistically similar across the three treatments in any pairwise comparison (the lowest p-value is 0.3515 for the summation task and 0.4840 for the encryption task).[19] Second, the average number of questions Member A solved is 28.91 in Treatment SGG, which is not statistically different from 28.97, the average number of questions Member B solved in the same treatment (two-sided Mann-Whitney test, p-value $= 0.8768$). The average number of questions Member A solved is 28.92 in Treatment EGG, which is not statistically different from 28.36, the average number of questions Member B solved in the same treatment (two-sided Mann-Whitney test, p-value $= 0.6764$).Third, the average number of questions Member A solved is 20.12 in Treatment SDD, which is not statistically different from 19.49, the average number of questions Member B solved in the same treatment (two-sided

[18]In the summation task environment, Member C was solving a series of adding one two-digit number and one three-digit number. In the encryption task environment, Member C was solving a series of decoding problems with the sequence of alphabets with a length of two letters. Thus, the average performance of Member C was significantly higher in the encryption task environment than in the summation task environment.

[19]All non-parametric tests reported in this section are conducted with the individual average for each role as an independent observation. For example, if a subject played Member A three times, Member B two times, and Member C two times in a session, his/her average performance as Member A, Member B, and Member C each generates one independent observation.

Mann-Whitney test, p-value $= 0.6698$). The average number of questions Member A solved is 19.01 in Treatment EDD, which is not statistically different from 19.36, the average number of questions Member B solved in the same treatment (two-sided Mann-Whitney test, p-value $= 0.8014$). These three observations prove that participants' average problem-solving abilities in different treatments are essentially the same, and neither shame nor fame is induced in any of the symmetric contests. Confirming our Hypotheses 1 and 3, we have the following result.

Result 1. *For a given real-effort game environment, the average number of questions solved by Member C does not vary across treatments. The average number of questions Member A solved and Member B solved are the same in each symmetric treatment.*

We are now ready to present the main findings of the paper. Figure 4 reveals that the average number of questions Goliath (Member A) solved in SGD is 31.49, which is substantially larger than 28.94 ($= (28.91 + 28.97)/2$), the average number of questions Goliath (Members A and B) solved in Treatment SGG. The difference – an increase of almost 9% – is substantial in magnitude. We can reject the null hypothesis that the average number of questions Goliath solved in Treatments SGD and SGG are the same; thereby, the first part of Hypothesis 2(a) that Goliath solved more questions in Treatment SGD than in Treatment SGG is supported with a marginal significance (one-sided Mann-Whitney test, p-value $= 0.0803$). However, the average number of questions Goliath (Member A) solved in EGD is 28.92, which is not statistically and economically different from 28.64 ($= (28.92 + 28.36)/2$), the average number of questions Goliath (Members A and B) solved in Treatment EGG (two-sided Mann-Whitney test, p-value $= 0.7025$). Therefore, the second part of Hypothesis 2(a) that Goliath solved the same number of questions in Treatments EGG and EGD is also supported.

What about the performance of David across different treatments? Figure 4 also reveals that the average number of questions David (Member B) solved in Treatment SGD is 17.65, which is substantially lower than 20.03 ($= (20.12 + 29.94)/2$), the average number of questions David (Members A and B) solved in Treatment SDD. The difference – a decrease of almost 12% – is substantial in magnitude. We can reject the null hypothesis that the average numbers of questions David solved in Treatments SGD and SDD are the same and instead support the alternative that David solved fewer questions in Treatment SGD than in Treatment SDD (one-sided Mann-Whitney test, p-value $= 0.0518$). The average number of questions David (Member B) solved in Treatment EGD is 18.25, which is also significantly lower than 19.18 ($= (19.01 + 19.36)/2$), the average number of questions David (Members A and B) solved in Treatment EDD (one-sided Mann-Whitney test, p-value $= 0.0404$). The difference – a decrease of 4.85% – is less substantial in magnitude relative to that in the summation task environment.

Result 2. *In the summation task environment, the asymmetry between the two players encouraged Goliath to work harder while it discouraged David. In the encryption task environment, the asymmetry discouraged David from working harder while no evidence was found for the encouragement effect that affected Goliath.*

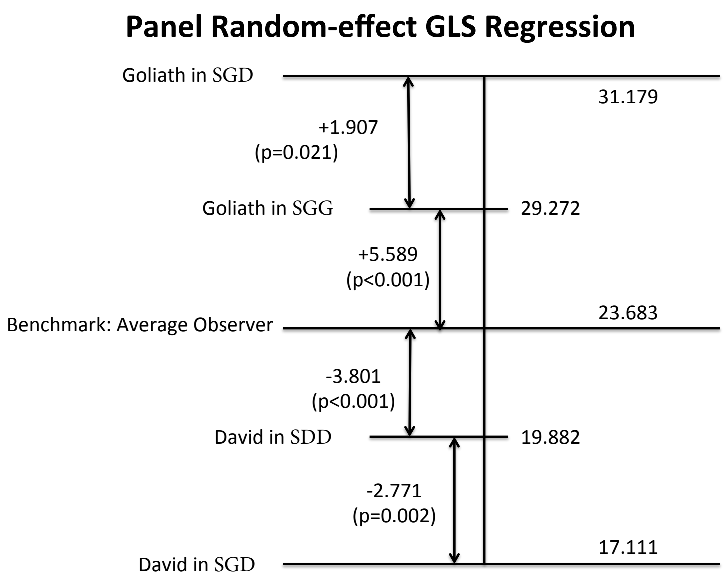
Result 2 indicates that the shame effect was strong while the fame effect was not substantial in the summation task environment. The fact that Goliath exerted more effort in the presence of asymmetry than in the absence of it in the summation task environment is in sharp contrast to the broad experimental support for the discouragement effect provided in the context of lottery contests (Fonseca (2009), Kimbrough et al. (2014)), rank-order tournaments (Weigelt et al. (1989), Schotter and Weigelt (1992)), and real-effort tournaments (Cason et al. (2010), Gill and Prowse (2012)). The observed difference comes from the fact that, unlike other studies, we employed the real-effort game design in which subjects are asked to solve simple "math" questions to compete with one another. Whether one can solve such simple math questions faster than others may be sensitive and private enough to induce additional psychological motives of shame into play. The result (discouragement effect from the asymmetry) we got from the encryption task which was meant to not bring much of the psychological motives is consistent with the findings in the literature.

To reinforce our findings obtained by the non-parametric tests, we focus on the summation task environment and conduct the following random effect GLS (Generalized

Least Squares) regression.[20] The dependent variable is NQ_{it}, the number of questions individual i solved in round t, and the four regressors are G_{it}, D_{it} and two interaction terms $ASYM_i \cdot G_{it}$ and $ASYM_i \cdot D_{it}$, where for individual i in round t, G_{it} takes value 1 if the role assigned to the individual is Goliath and 0 otherwise; D_{it} takes value 1 if the role assigned to the individual is David and 0 otherwise; and $ASYM_i$ takes value 1 if the individual is in Treatment SGD and 0 otherwise. We write ε_{it} for the idiosyncratic error. The coefficients of interest – those on the four regressors above – are given by β_1, β_2, β_3 and β_4, respectively.

$$(25) \quad NQ_{it} = \alpha_i + \beta_1 \cdot G_{it} + \beta_2 \cdot D_{it} + \beta_3 \cdot ASYM_i \cdot G_{it} + \beta_4 \cdot ASYM_i \cdot D_{it} + \varepsilon_{it}, \quad t = 1, ..., 7.$$

This regression specification implies that our benchmark is the average number of



Note: p-values are presented in parentheses.

FIGURE 5. Random Effect GLS Regression

questions solved by Member C (observer) in all three treatments. Thus, the constant term α_i measures the average performance of all Member Cs. Then, β_1 and β_2 have

[20]The random effect estimation is used because our experimental design ensures that individuals are randomly assigned to different treatments and that, in each treatment, the roles they play are randomly assigned in each round. As a result, the unobserved individual heterogeneity, α_i in equation (25), is not correlated with the observed explanatory variables.

a straightforward interpretation. Compared to the average performance of the observers, Goliath solved β_1 more questions on average in Treatment SGG, and David solved β_2 more questions on average in Treatment SDD. Additionally, interpretations for β_3 and β_4 are not difficult. Compared to the average performance of Goliath in Treatment SGG, Goliath in Treatment SGD solved β_3 more questions on average. Compared to the average performance of David in Treatment SDD, David in Treatment SGD solved β_4 more questions on average.

The results of the regression are summarized in Figure 5 above and Table 3 presented in Appendix B.[21] It reveals that observers (Member C) solved 23.683 questions on average. Goliath in Treatment SGG solved 5.589 more questions than the average observer, while Goliath in Treatment SGD solved 1.907 more questions than Goliath in Treatment SGG. Additionally, David in Treatment SDD solved 3.801 fewer questions than the average observer, while David in Treatment SGD solved 2.771 questions less than David in Treatment SDD. All differences are significant at the 1% confidence level, except for the difference between Goliath in Treatments SGG and SGD, which is significant at the 5% confidence level.

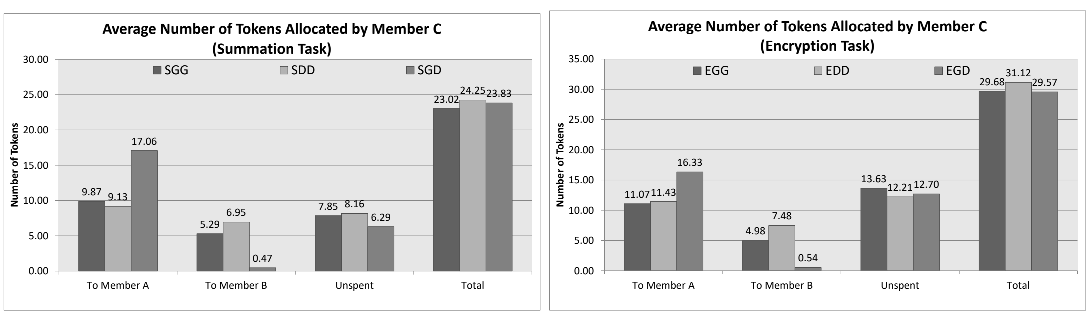


FIGURE 6. Average Number of Tokens Allocated by Member C

5.2. Member C's Token Allocation Decisions. Figure 6 illustrates Member C's token allocation decisions aggregated over all seven rounds and all sessions of each treatment. It is remarkable to observe that only 0.47 and 0.54 tokens were allocated

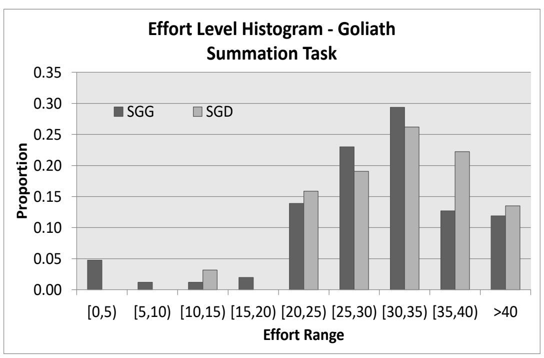
[21]Table 3 and Appendix B also present results from the linear regression. All qualitative results are robust to the specification.

to Member B (David) respectively in Treatments SGD and EGD, which are substantially smaller than the number of tokens allocated to Member B in any other treatments. Mann-Whitney tests reveal that the differences are statistically significant (all p-values < 0.0001). Similarly, the number of tokens allocated to Member A is 17.06 and 16.33 respectively in Treatments SGD and EGD, significantly more than the number of tokens allocated to Member A in any other treatments (Mann-Whitney tests, all p-values < 0.0022). These results are not from any difference in the total amount of tokens Member C earned because, as we discussed previously, the average numbers of tokens Member C earned are not different across the three treatments sharing the same real-effort game environment. Confirming our hypothesis 4, these observations provide very clear evidence that Member C's estimations of who will win differ between asymmetric and symmetric contests. It is interesting to see that the proportion of unspent tokens is substantially larger in the encryption task environment (42.6% on average) than in the summation task environment (31.4% on average) which indicates that Member Cs are on average more confident about their estimation in the summation task than in the encryption task.

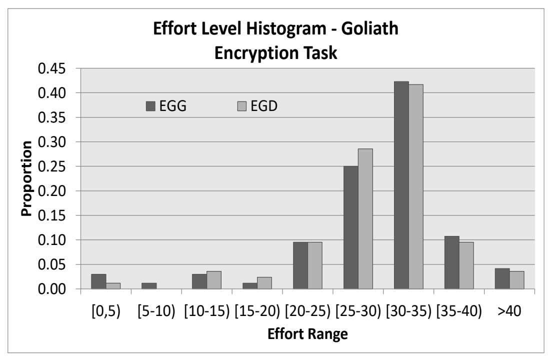
Result 3. *In each real-effort game environment, the difference between the number of tokens Member C allocates to Member A and those she allocates to Member B in the asymmetric treatment* (*16.59 and 15.73 in the summation task and the encryption task environment, respectively*) *was larger than the corresponding differences in the symmetric treatments* (*3.38 and 5.02 in the summation task and the encryption task environment, respectively*).

5.3. Source of performance difference. We now take a closer look at individual behavior to fully identify the main source of performance differences observed across treatments in our experiments. In their experimental investigation of asymmetric all-pay auctions, Müller and Schotter (2010) find that the actual efforts observed in the laboratory bifurcate. The David subjects in their experiments *drop out* and exert little or no effort, and the Goliath subjects try too hard. This bifurcation result was hidden in their aggregate-level data analysis but was revealed through the individual-level analysis.

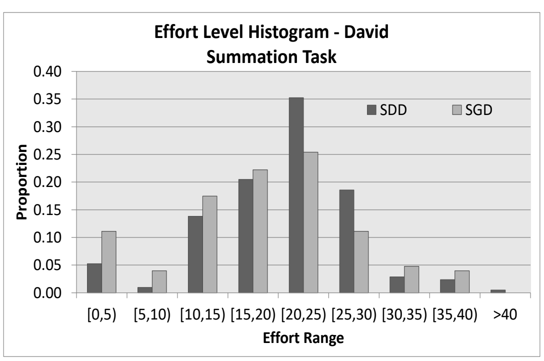
Could our main result also be driven by the same kind of dropout behavior? Figure 7 presents four histograms for individual effort levels, the two left panels for the summation task environment and the two right panels for the encryption task environment, and shows that this possibility is not the case. Figure 7(a) shows that Goliath's effort distribution in Treatment SGD first-order stochastically dominates that in Treatment SGG. In contrast, as our aggregate result indicated, Figure 7(b) shows that Goliath's effort distributions in Treatments EGD and EGG are almost identical. There are two main sources of Goliath's higher performance in Treatment SGD than in Treatment SGG. The first is the zero dropout rate in Treatment SGD as opposed to the 5% dropout rate observed in Treatment SGG. The second, and more important, source is the performance shift of mediocre performers (whose scores are between 25 and 35 in Treatment SGG) to the high performers (whose scores are larger than 35 in Treatment SGD).



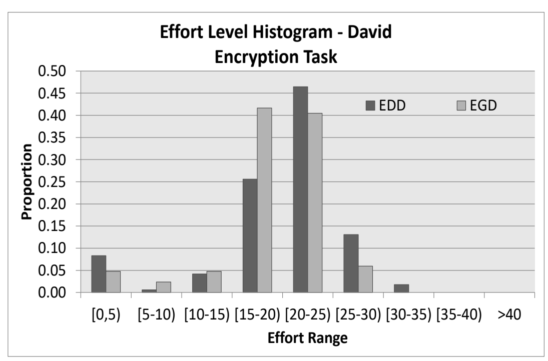
(a) Goliath: Summation Task



(b) Goliath: Encryption Task



(c) David: Summation Task



(d) David: Encryption Task

Figure 7. Individual Effort Levels – Histograms

Regarding David's effort distributions in the summation task environment, Figure 7(c) shows that there is no clear first-order stochastic dominance relationship. Instead, the distribution in Treatment SGD is almost a mean-preserving spread of that in Treatment SDD. There are two primary sources of David's lower performance in Treatment SGD than in Treatment SDD. The first is the higher dropout rate (approximately 11%) observed in Treatment SGD than the 5% observed in Treatment SDD. These dropout rates are not as substantial as the dropout rate observed in Müller and Schotter (2010). The second is the performance shift of high performers (whose scores are between 20 and 30 in Treatment SGD) to mediocre performers (whose scores are between 10 and 20 in Treatment SDD).

Figure 7(d) shows that David's effort distribution in Treatment EGD first-order stochastically dominates that in Treatment EDD. The main source of David's higher performance in Treatment EDD than in Treatment EGD is the performance shift of mediocre performers (whose scores are between 15 and 20 in Treatment EGD) to the high performers (whose scores are larger than 20 in Treatment EDD). This effect is large enough to compensate for the effect of the higher dropout rate in Treatment EDD (about 8%) than in Treatment EGD (about 5%).

6. Conclusion

In this study, we examined how the asymmetry in competitions induces shame and fame, which in turn affects individual players' equilibrium effort levels in two-player asymmetric contests. Our results showed that when players are relatively more (less) sensitive to shame than to fame, a player who is favored in the asymmetric contest exerts more (less) effort than in the symmetric contest and that a player who is handicapped in the asymmetric contest exerts less (more) effort than in the symmetric contest. Our experimental data from two types of real-effort games provided strong evidence for the shame encouragement effect in one of the environments, which was meant to implement a relatively high degree of shame. In this environment, we observed that participants who were favored in the asymmetric contest exerted more effort than they did in the symmetric contest, and participants who were handicapped in the asymmetric contest exerted less effort than they did in the symmetric contest.

While our study provides valuable insights into the role of social emotions in shaping competitive behavior, it also raises several important questions and avenues for future research. For example, one important direction for future research is to investigate the role of cultural factors in shaping the effects of shame and fame in competition. Since cultural norms and values can influence how individuals perceive and respond to social emotions, the effects of shame and fame may differ across cultures. Future research could explore whether our findings generalize to other cultures and whether there are cultural differences in how shame and fame influence competitive behavior.

Another important direction for future research is to examine the neural mechanisms underlying the effects of shame and fame in competition. While we provided evidence for the behavioral effects of shame and fame, it is unclear how these social emotions are processed in the brain and how they relate to decision-making processes. Future empirical studies could use neuroimaging techniques to investigate the neural correlates of shame and fame in competition and how they interact with other cognitive and affective processes.

Lastly, it would be useful to explore alternative mechanisms that could account for the effects of shame and fame in competition. While we suggest that these social emotions influence competitive behavior by affecting players' expectations of success and failure, other psychological processes may also be at play. For instance, social comparison, self-evaluation, and emotional regulation could all potentially influence how individuals respond to shame and fame in competition. By addressing these questions and exploring these research directions, future studies could deepen our understanding of the psychological processes underlying competitive behavior and inform interventions aimed at promoting healthy competition.

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Appendix Appendix A Role of the Observer

This section is devoted to investigating the causes of shame and fame. Our psychological game approach suggests that shame and fame are driven by the *second-order beliefs* of an individual contestant about *someone's* belief, and this someone need not be the observer. The introduction of an observer into our theoretical framework was to ease the formulation of the second-order belief and the derivation of the shame and fame motives. Therefore, it may not actually matter whether an observer is present or absent. Without an observer, it would be still possible for experimental subjects to feel some degree of shame and fame because experimenters are present in the laboratory. Shame and fame may be partly driven by the fact that one's opponent is always present. We design an additional set of treatments with *no observer* in the game and investigate whether the effect of shame and fame is via the second-order beliefs but not via the mere existence of an observer.

		Member B
	Question (Player) Type	2D (Goliath)
Member A	2D (Goliath)	SGG-N/O
	3D (David)	SGD-N/O

Table 2. Treatments with No Observer (N/O)

Our additional set of treatments consists of two treatments, as presented in Table 2. Treatment SGG-N/O is a version of Treatment SGG with no observer, and Treatment SGD-N/O is a version of Treatment SGD with no observer. We conducted two sessions for each of the two treatments. All sessions except one had 18 participants who were further divided into three matching groups of six subjects. One session of Treatment SGD-N/O had twelve subjects and therefore two matching groups. A total of 66 subjects who had no prior experience with our experiment were recruited from the undergraduate and graduate populations of the HKUST. All other steps are the same as those in the procedure presented in Section 4.3. Subjects' total earnings averaged HK\$169.6 ($\approx$ US\$21.74), and the average duration of a session was approximately 1 hour.

Our first hypothesis derived from the new set of treatments comes from the fact that the presence or absence of an observer does not affect equilibrium effort levels when the contest is symmetric. Testing this hypothesis also allows us to investigate whether our results presented in the previous sections are due to the other-regarding preferences of Members A and B.[22]

Hypothesis 5 (No Role of Observer in Symmetric Contests)**.** *The average number of questions Goliath solved in Treatment SGG-N/O is not different from the average number of questions Goliath solved in Treatment SGG.*

As argued earlier, the role of the observer may be minimal even in the asymmetric contest. Without having an observer, shame and fame may still emerge as long as an active player forms his/her second-order beliefs about someone else's beliefs. Thus, we have the following hypothesis.

Hypothesis 6 (No Role of Observer in Asymmetric Contests)**.**

(a) The average number of questions Goliath solved in Treatment SGD-N/O is not different from the average number of questions Goliath solved in Treatment SGD.

(b) The average number of questions David solved in Treatment SGD-N/O is not different from the average number of questions David solved in Treatment SGD.

We now report experimental findings from the new treatments. Figure 8 presents the average effort levels, measured by the number of questions solved, aggregated over all rounds and sessions for the two treatments with no observer and, for the sake of comparison, those for Treatments SGG and SGD.

A few observations emerge immediately. First, Goliath's average effort levels observed in Treatments SGG and SGG-N/O are literally the same – 28.94 vs. 28.84. The

[22]For example, in the presence of Member C, altruism provides Member A with an incentive to exert more effort and Member B with an incentive to exert less effort. In the absence of Member C, such motives originating from altruism must disappear, and thus, the average number of questions Goliath solved in Treatment *2D-SYM-N/O* should be different from that in Treatment SGG.

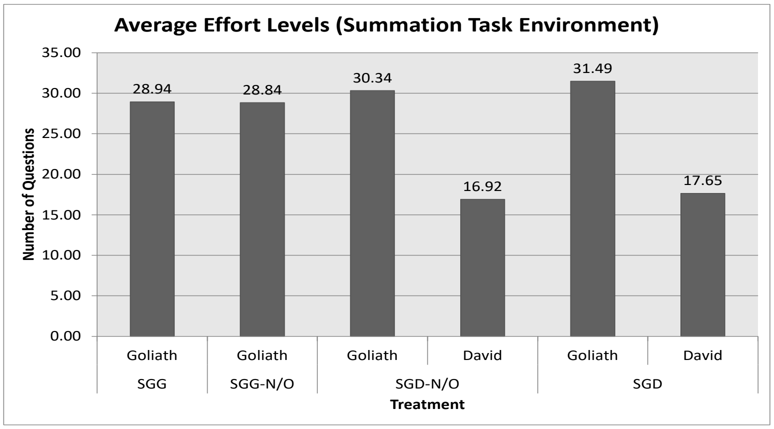
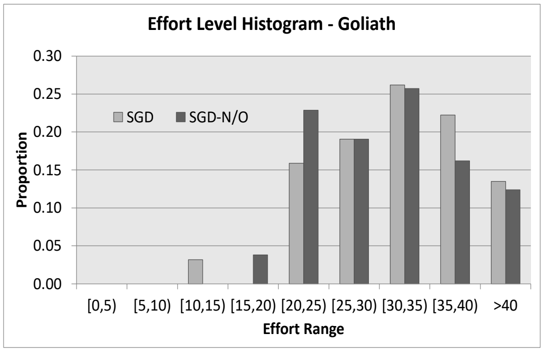


FIGURE 8. Average Effort Levels With and Without Observers

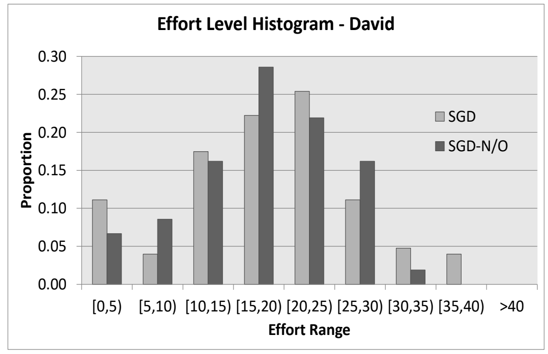
Mann-Whitney test reveals that we cannot reject the null hypothesis that the two values are statistically the same (p-value $= 0.9639$.) Thus, we confirm Hypothesis 5. This result indicates that our main results presented in the previous sections are not driven by social preferences Members A and B may have. Second, the average effort level observed from Goliath in Treatment SGD-N/O is 30.34, which is approximately 3.5% points lower than the 31.49 observed from Goliath in Treatment SGD. The fact that the average effort level is lower in the absence of an observer is not consistent with our Hypothesis 6(a), but the difference is not statistically significant (Mann-Whitney test, p-value $= 0.4689$). Third, the average effort level observed from David in Treatment SGD-N/O is 16.92, which is approximately 4.3% points lower than the 17.65 observed from David in Treatment SGD. The difference is not statistically significant (Mann-Whitney test, p-value $= 0.8392$), and thus, we accept Hypothesis 6(b).

Result 4. *The presence or absence of an observer does not create any statistically significant difference in David's and Goliath's performance in either symmetric contests or asymmetric contests.*

This result implies that the notion of shame and fame does not crucially depend on the mere presence of an observer, and it shows that the identified effect of minimal social cues in increasing altruistic giving behavior in the dictator game (Rigdon et al., 2009) does not extend to our setup. As Figure 9 indicates, however, the distributions of efforts across the two treatment conditions (with and without an observer) are



(a) Goliath



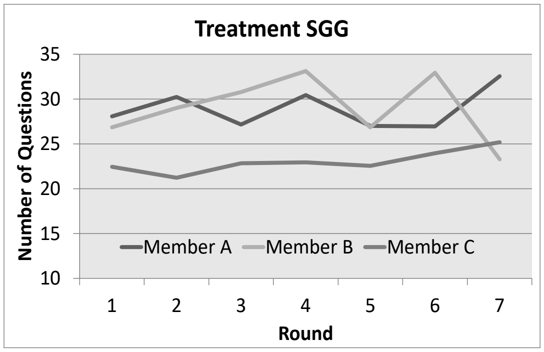
(b) David

FIGURE 9. Individual Effort Levels – Histograms

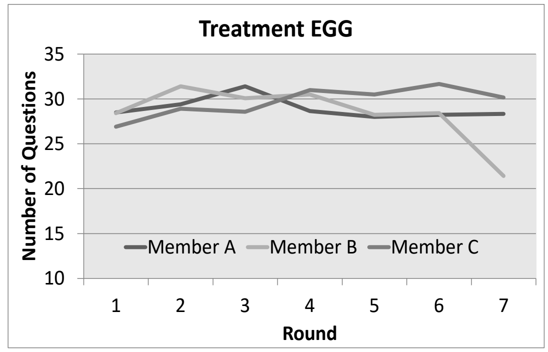
not the same. First, Figure 9(a) shows that Goliath's effort distribution in Treatment SGG-N/O is positioned slightly to the left of that in Treatment SGD. In particular, the proportion of effort in the range $[20, 25)$ in Treatment SGD-N/O is approximately 23%, substantially higher than the 16% observed in Treatment SGD. The proportion of effort in the range $[35, 40)$ in Treatment SGD-N/O is approximately 17%, substantially lower than the 22% observed in Treatment SGD. However, Goliath's higher performance in Treatment SGD is mitigated by the very low performer outliers in the effort range $[10, 15)$. Second, Figure 9(b) shows that David's effort distribution in Treatment SGD-N/O is more concentrated than that in Treatment SGD.

Our experimental finding suggests that subjects still feel substantial degrees of shame and fame in the experiments due to the common knowledge that some are favored and others are handicapped in the competitions. The fact that experimenters are always in the laboratory, even in the absence of an explicit observer, maybe another driving force of shame and fame.

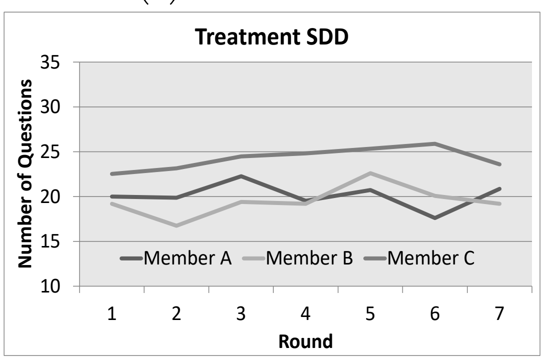
Appendix Appendix B Intended for Online Publication
Additional Tables and Figures



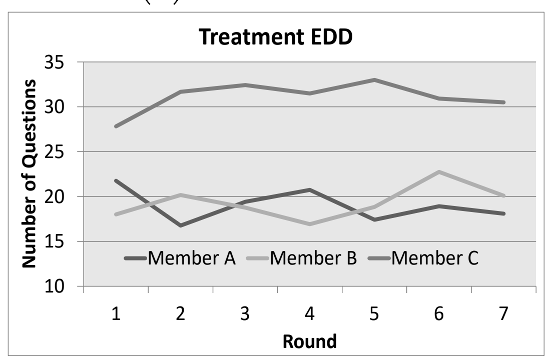
(a) Treatment SGG



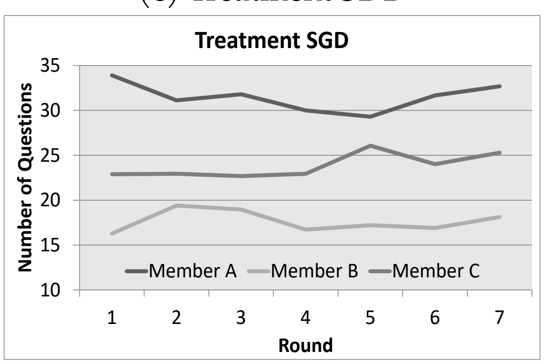
(b) Treatment EGG



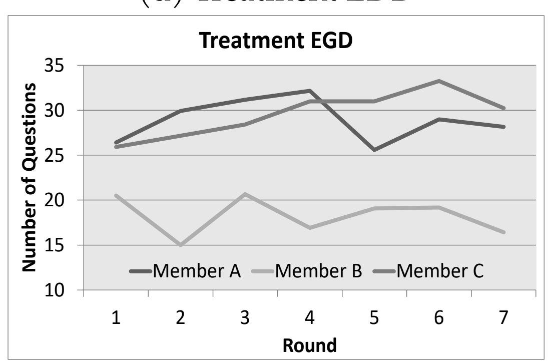
(c) Treatment SDD



(d) Treatment EDD



(e) Treatment SGD



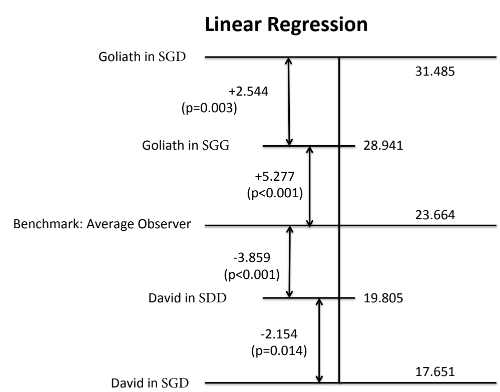
(f) Treatment EGD

FIGURE 10. Average Effort Levels - Time Trend

	Number of Questions	
	(1)	(2)
Regressor	Linear	Random Effect GLS
G_i	5.277***	5.588***
	(.642)	(.543)
D_i	-3.859***	-3.801***
	(.679)	(.629)
$A_i \cdot G_i$	2.544***	1.907**
	(.851)	(.826)
$A_i \cdot D_i$	-2.154**	-2.771***
	(.879)	(.876)
Constant	23.664***	23.683***
	(.413)	(.564)
Observations	1071	1071

Significant at ***1%, **5%, and *10%. Standard errors are corrected for clustering at the individual level in parentheses.

TABLE 3. Regression Results



Note: p-values are presented in parentheses.

FIGURE 11. Linear Regression

Appendix Appendix C Intended for Online Publication
Experimental Instructions - Treatments SGD

INSTRUCTION

Welcome to the experiment. This experiment studies decision-making among three individuals. Please read the instructions below carefully; the cash payment you will receive at the end of the experiment depends on how you make your decisions according to these instructions. Communication of any kind with any other participants in this room is not allowed.

Your Role and Decision Group

There are 18 participants in today's session. Prior to the first round, participants are equally and anonymously divided into 2 classes. Your class will remain fixed throughout the experiment.

In the following hour or so, you will participate in 7 rounds of decision-making. In each and every round, you will be randomly matched with two other participants in your class to form a group of three individuals. In each group, one participant is randomly assigned the role of **Member A**, one participant the role of **Member B**, and the other participant the role of **Member C**. Participants will be randomly re-matched after each round to form new groups, and each participant in your class has an equal chance to be matched with you. Your role will be randomly re-assigned to the new group after each round.

You will not learn the identity of the participants you are matched with, nor will they learn your identity—even after the end of the experiment.

Your Decisions and Earnings – Member A and Member B

Competition between Member A and Member B

In each round and in each group, Member A and Member B are asked to solve, simultaneously and independently, a series of simple calculation problems to compete for the prize of 120 Experimental Currency Units (ECU). At the beginning of each round, 60 tokens are given to you, and to solve each question you need to pay one token. The computer calculates how many questions you solve in 120 seconds.

- Member A is asked to solve a series of problems of adding 2 **TWO-digit** numbers.
- Member B is asked to solve a series of problems of adding 2 **THREE-digit** numbers.

(a) Member A's Screen (b) Member B's Screen

FIGURE 12. Screen Shots

Figures 12(a) and 12(b) show Member A's decision screen and Member B's decision screen, respectively. For each question, you have to

(1) use your mouse to put the cursor into the blank,
(2) use your keyboard to input your answer, and
(3) click the SUBMIT button.

You can proceed to the next question only if your answer is correct. If your answer is incorrect, you will see the message "Your answer is incorrect" and be asked to input your answer again. The computer will calculate how many questions each member solved within 120 seconds.

Lottery and Your Reward

Each question you solve gives you one lottery ticket with a ticket number on it. The computer randomly selects one lottery ticket out of all tickets Member A and Member B have, and the player who has the selected lottery ticket is declared the winner. Then,

$$\text{Your Winning Probability} = \frac{\text{\# of your lottery tickets}}{\text{\# of your lottery tickets} + \text{\# of your opponent's lottery tickets}}.$$

It implies 1) the more lottery tickets you have the higher the chance you win the competition and 2) the more lottery tickets your opponent has the lower the chance you win the competition. Your earning in a round is

$$\text{Your Earning} = \begin{cases} [120 + \text{\# of Tokens Remaining}]\ \text{ECU} & \text{if you are declared the winner} \\ [30 + \text{\# of Tokens Remaining}]\ \text{ECU} & \text{otherwise.} \end{cases}$$

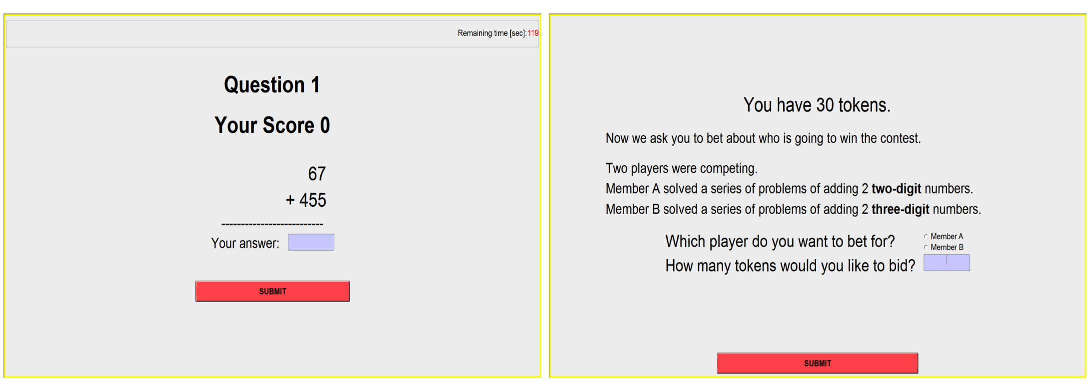
Your Decisions and Earnings – Member C

In each round, you are asked to solve a series of simple calculation problems (adding 2 two-/three-digit numbers) as presented in Figure 13(a). The computer calculates how many questions you solved within 120 seconds. Each question you solve gives you one token.

With the number of tokens you earned, you are asked to bet about who (between Member A and Member B) is going to win the competition. You are free to bet any amount of tokens between 0 and the total amount you earned, but you have to choose only one member to bet, as presented in Figure 13(b).

If the member you bet turns out to be the winner, then the number of tokens you bet becomes **DOUBLE**. Otherwise, the number of tokens you bet becomes **HALF**. Hence,

$$\text{Your Earning} = \begin{cases} [\text{\# of Tokens Remaining} + 2 \times (\text{\# of Tokens You Bet})]\ \text{ECU} & \text{if you have a winning bet} \\ [\text{\# of Tokens Remaining} + \frac{1}{2} \times (\text{\# of Tokens You Bet})]\ \text{ECU} & \text{if you have a losing bet.} \end{cases}$$



(a) Member C's Problems (b) Member C's Bet

FIGURE 13. Screen Shots

Information Feedback

At the end of a round, you will be informed about the winner and your earnings for the round.

Your Cash Payment

The experimenter will randomly select 1 round out of the 7 to calculate your cash payment. (So it is in your best interest to take each round equally seriously.) Your total cash payment at the end of the experiment will be the ECU you earned in the selected round, which will be translated into HKD with an exchange rate of 1 ECU = 1 HKD, plus a 50 HKD show-up fee.

Practice

To ensure your comprehension of the instructions, we will provide you with a practice round. Once the practice round is over, the computer will tell you "The official rounds begin now!"

Administration

Your decisions as well as your monetary payment will be kept confidential. Remember that you have to make your decisions entirely on your own; please do not discuss your decisions with any other participants.

Upon finishing the experiment, you will receive your cash payment. You will be asked to sign your name to acknowledge your receipt of the payment (which will not be used for tax purposes). You are then free to leave.

If you have any questions, please raise your hand now. We will answer your question individually. If there is no question, we will proceed to the practice round now.