Shame and Fame in Competition*

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Abstract

Ex ante asymmetry or unfairness between competitors may generate additional motives for them to work harder in competition. We identify psychological motives such as shame and fame and theoretically and experimentally investigate how asymmetry in competition induces shame and fame, which, in turn, affect individuals' equilibrium effort. Using the framework of two-player asymmetric contests, we show that interaction between the "shame-fame encouragement effect" and the standard discouragement effect of asymmetry generates a non-trivial comparative static - the individual effort level being single-peaked in the degree of asymmetry. Our data from laboratory real-effort game experiments provide strong supporting evidence.

Keywords: Shame and Fame, Lopsided Competition, Laboratory Experiments

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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.

The Bible (New International Version), Samuel 17, 4-42.

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 leapt 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 technological structures and developments. Conventional wisdom suggests that the ex ante asymmetry and

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

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 actions, 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.

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) and Battigalli and Dufwenberg (2009), 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, 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 a player is substantially less sensitive to shame or fame than his/her opponent, the discouragement effect dominates the "shame-fame encouragement effect" so that the equilibrium effort level is monotonically decreasing in the degree of asymmetry. However, when a player is substantially more sensitive to shame or fame relative to his/her opponent, the shame-fame encouragement effect dominates the discouragement effect for a low degree of asymmetry, but the discouragement effect catches up and eventually dominates the encouragement effect when the asymmetry increases. As a result, the equilibrium effort level is single peaked in the degree of asymmetry. That is, when players are relatively more (less) sensitive to shame than to fame, Goliath exerts more (less) effort in the asymmetric contest than in the symmetric contest, and in the asymmetric contest, David exerts less (more) effort than in the symmetric contest.

In our experimental implementation of the asymmetric contest, we focus mainly on creating an interface in which the exogenously given ex ante asymmetry between contestants endogenously induces the shame and fame and eventually affects contestants' effort choices. To induce shame and fame endogenously in the laboratory, we employ real-effort experiments in which two asymmetric contestants compete for a prize by solving a series of calculation questions independently and simultaneously. Our experimental design presents three main treatments. In Treatment *2D-SYM*, both contestants are asked to solve a series of calculation problems of adding two two-digit (2D) numbers. In Treatment *3D-SYM*, both contestants are asked to solve a series of calculation problems of adding two three-digit (3D) numbers. In Treatment *ASYM*, 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.

The real-effort tasks in our experiments were not intellectually demanding and onerous but rather basic and tedious so that our experimental implementation was more likely to induce a reasonably high shame sensitivity in the laboratory. It turns out that the data from the real-effort game experiments are consistent with the theoretical predictions based on high shame sensitivity; 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 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 a real-effort game. Several other behavioral motives have been considered in the literature, such as the joy of winning and loss aversion (e.g., Cornes et al. (2003), Baharad and Nitzan (2008), Dechenaux et al. (2015)), but the focus was almost exclusively on the symmetric contest with a single exception of Müller and Schotter (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. In Section 6, we establish the tight relationship between our shame-fame model and the loss aversion model in explaining our experimental data. Section 7 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 its laboratory investigations. There are several experimental studies in the literature providing supports for the theoretical models (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) and in field experiments on voter turnout (Gerber et al. (2010), Panagopoulos (2010)). 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 their laboratory investigation. 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 (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.

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 the perception of their winning probabilities by assuming 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 efforts 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 by Kahneman and Tversky (1979) can successfully organize their experimental data.

Last but not least, our study employs a real-effort experiment in which subjects are asked to solve a series of simple two-digit and/or three-digit calculation problems to compete for a prize, following a growing number of experimental studies (Bartling et al. (2009), Carpenter et al. (2010), Cason et al. (2010), Van Dijk et al. (2001), Freeman and Gelber (2010), Gill and Prowse (2012), Kuhnen and Tymula (2012), Vandegrift et al. (2007), Vandegrift et al. (2007), etc.).

2 Model and Equilibrium Analysis

We consider a lottery contest with two contestants, David (D) and Goliath (G), and an observer (O).[2] Each contestant $i = D, G$ independently and simultaneously exerts 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

$$P_G(x_G, x_D; \gamma) = \frac{\gamma x_G}{\gamma x_G + x_D} \quad \text{and} \quad P_D(x_G, x_D; \gamma) = \frac{x_D}{\gamma x_G + x_D} \tag{2.1}$$

[2] The observer is not an active player. It is a device to facilitate inducement of the psychological motives of shame and fame. We will further elaborate the role of the observer in Section 4.

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:

$$\Pi_G = v \cdot \Big(\frac{\gamma x_G}{\gamma x_G + x_D}\Big) - x_G - \theta_G \cdot s(\gamma) \cdot \Big(\frac{x_D}{\gamma x_G + x_D}\Big) \tag{2.2}$$

where $s(\gamma) \geq 0$ is the *shame* Goliath feels if he does not win the contest and $\theta_G > 0$ reflects the shame sensitivity of Goliath. We further assume that $s(\cdot)$ is continuous and differentiable, $s'(\gamma) > 0$ and $\lim_{\gamma \downarrow 1} s(\gamma) = 0$. That is, there is no shame without asymmetry, and shame is greater when asymmetry is greater.[3]

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

$$\Pi_D = v \cdot \Big(\frac{x_D}{\gamma x_G + x_D}\Big) - x_D + \theta_D \cdot f(\gamma) \cdot \Big(\frac{x_D}{\gamma x_G + x_D}\Big) \tag{2.3}$$

where $f(\gamma) \geq 0$ is the *fame* David enjoys when he wins the contest and $\theta_D > 0$ reflects the fame sensitivity of David. We further assume that $f(\cdot)$ is continuous and differentiable, $f'(\gamma) > 0$, and $\lim_{\gamma \downarrow 1} f(\gamma) = 0$. That is, there is no fame without asymmetry, and fame is greater when asymmetry is greater.

We now provide justifications for the main properties of the shame and fame functions using the belief-dependent utility *à la* the psychological game approach by Geanakoplos et al. (1989), Battigalli and Dufwenberg (2007) and Battigalli and Dufwenberg (2009). Let $X_i = [0, \infty)$ be the strategy space of player i and $\alpha_j^i(\cdot) \in \Delta(X_i)$ denote the first-order belief of the observer j about the strategy of player i, $i = G, D$. Assume that the observer's first-order beliefs are identical for the two players, i.e., $\alpha_j^G = \alpha_j^D$. Given the first-order belief (α_j^G, α_j^D), the observer j estimates the likelihood of winning for each player in the contest, L_j^G and $L_j^D = 1 - L_j^G$ as follows:

$$L_j^G = L_j^G(\alpha_j^G, \alpha_j^D; \gamma) = \int_{X_G} \int_{X_D} \alpha_j^G \alpha_j^D P_G(x_G, x_D; \gamma) dx_G dx_D. \tag{2.4}$$

Note that $L_j^G(\alpha_j^G, \alpha_j^D; \gamma = 1) = L_j^D(\alpha_j^G, \alpha_j^D; \gamma = 1) = \frac{1}{2}$. Also, $\frac{\partial L_j^G}{\partial \gamma} > 0$ and $\frac{\partial L_j^D}{\partial \gamma} < 0$. Let z^i denote the outcome of the contest where $z^G = 1$ and $z^D = 0$ if Goliath wins and $z^G = 0$ and $z^D = 1$ otherwise. Define

$$Y_j^G(z^G, L_j^G) = \begin{cases} |\frac{1}{2} - L_j^G| & \text{if } z^G = 0 \\ 0 & \text{otherwise.} \end{cases}$$

[3]As depicted in equations (2.2) and (2.3), we model shame (fame) as being realized conditional on losing (winning), which is a distinctive feature different from the "joy of winning".

and

$$Y_j^D(z^D, L_j^D) = \begin{cases} |\frac{1}{2} - L_j^D| & \text{if } z^D = 1 \\ 0 & \text{otherwise.} \end{cases}$$

The expression $Y_j^G(z^G, L_j^G)$ measures how much Goliath "lets down" the observer j when Goliath could not win. The expression $Y_j^D(z^D, L_j^D)$ measures how David "surprises" the observer j when David wins. Define $s(\gamma)$ and $f(\gamma)$ as monotonic transformations of $Y_j^G(z^G, L_j^G)$ and $Y_j^D(z^D, L_j^D)$, respectively. It is straightforward that $s(\cdot)$ is continuous and differentiable, $\frac{\partial s(\gamma)}{\partial \gamma} > 0$ and $\lim_{\gamma \downarrow 1} s(\gamma) = 0$. And the same applies to $f(\cdot)$.

In words, contestants who are averse to shame do not want to let the observer down. In the asymmetric contest with $\gamma > 1$, the observer may naturally estimate that Goliath has a significantly higher likelihood of winning the contest. The "letdown" is generated from the gap between the actual contest outcome and the outcome estimated by the observer. The observer's estimates become more skewed as the asymmetry parameter γ becomes more substantial, and as a result, the degree of letdown increases.

The first-order conditions for maximizing Π_G and Π_D are reduced to

$$v\gamma(\gamma x_G + x_D) - v\gamma^2 x_G + \gamma\theta_G s(\gamma) x_D = (\gamma x_G + x_D)^2 \tag{2.5}$$

and

$$(v + \theta_D f(\gamma))(\gamma x_G + x_D) - (v + \theta_D f(\gamma)) x_D = (\gamma x_G + x_D)^2 \tag{2.6}$$

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

$$V_G = V_G(\gamma) \equiv v + \theta_G s(\gamma) \text{ and } V_D = V_D(\gamma) \equiv v + \theta_D f(\gamma),$$

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 (2.5) and (2.6), the following reaction functions are obtained:

$$x_G = [-x_D + \sqrt{\gamma x_D V_G}]/\gamma \tag{2.7}$$

and

$$x_D = -\gamma x_G + \sqrt{\gamma x_G V_D}. \tag{2.8}$$

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. *Let (x_G^*, x_D^*) denote the unique Nash equilibrium of the lottery contest. Then,* *we have*

$$x_G^* = \frac{\gamma V_G^2 V_D}{(\gamma V_G + V_D)^2}, \quad \textit{and} \quad x_D^* = \frac{\gamma V_G V_D^2}{(\gamma V_G + V_D)^2}.$$

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). 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 $x_D^* > x_G^*$ if and only if $V_D > V_G$, which implies that the agent who cares more (less) about shame or fame exerts more (less) effort in equilibrium.

Let p_i^* and Π_i^* denote the equilibrium winning probability and the expected payoff of player i, $i = G, D$, respectively. Then, we have[4]

$$p_G^* = \frac{\gamma V_G}{(\gamma V_G + V_D)} \quad \text{and} \quad p_D^* = \frac{V_D}{(\gamma V_G + V_D)}$$

and

$$\Pi_G^* = \frac{v V_G^2 \gamma^2 - 2\theta_G s(\gamma) V_G V_D \gamma - \theta_G s(\gamma) V_D^2}{(\gamma V_G + V_D)^2} \quad \text{and} \quad \Pi_D^* = \frac{V_D^3}{(\gamma V_G + V_D)^2}.$$

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. Our analysis starts from the following decomposition of the individual effort level for Goliath.

$$\begin{aligned} x_G^* &= [x_G^*]_{\gamma=1} + \left[[x_G^*]_{\substack{\gamma>1,\\ \theta_G=0,\\ \theta_D=0}} - [x_G^*]_{\gamma=1} \right] + \left[[x_G^*]_{\substack{\gamma>1,\\ \theta_G>0,\\ \theta_D>0}} - [x_G^*]_{\substack{\gamma>1,\\ \theta_G=0,\\ \theta_D=0}} \right] \\ &= \underbrace{\frac{v}{4}}_{\substack{\text{effort level with}\\ \text{no asymmetry}}} + \underbrace{v\left[\frac{\gamma}{(\gamma+1)^2} - \frac{1}{4} \right]}_{\substack{\text{discouragement effect from}\\ \text{the asymmetry } \gamma>1}} + \underbrace{\gamma\left[\frac{V_G^2 V_D}{(\gamma V_G + V_D)^2} - \frac{v}{(\gamma+1)^2} \right]}_{\substack{\text{shame-fame effect from}\\ \text{the asymmetry } \gamma>1}} \end{aligned} \tag{3.1}$$

The first term of the right-hand side of equation (3.1) is obtained from x_G^* by setting $\gamma = 1$, which captures the effort level without asymmetry. The second term is obtained by setting $\gamma > 1$, $\theta_G = 0$, and $\theta_D = 0$ 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

[4]Note that the expected payoff of Goliath can be positive or negative depending on the realization of $s(\gamma)$ and $f(\gamma)$. If the model allows agents to freely exit the contest, we must consider an additional participation constraint for Goliath. However, here in our simple model, we ignore the possibility of free exit, and thus, our result remains valid regardless of the sign of the expected payoff of Goliath.

setting $\gamma > 1$, $\theta_G > 0$, and $\theta_D > 0$ 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 (3.1) 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 (3.1) as follows:

$$\gamma\left[\frac{V_G^2 V_D}{(\gamma V_G + V_D)^2} - \frac{v}{(\gamma+1)^2}\right] = \frac{\gamma\left[\gamma^2 V_G^2 \theta_D f(\gamma) + V_D s(\gamma)(2\gamma V_G \theta_G + v\theta_G^2 s(\gamma)) + vV_D(2\theta_G s(\gamma) - \theta_D f(\gamma))\right]}{(\gamma V_G + V_D)^2(\gamma+1)^2} \tag{3.2}$$

This equation implies that the shame-fame effect *increases* Goliath's equilibrium effort level as long as $\theta_G s(\gamma) \geq \theta_D f(\gamma)/2$. 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.

$$\begin{aligned} x_D^* &= [x_D^*]_{\gamma=1} + \left[[x_D^*]_{\substack{\gamma>1,\\ \theta_G=0,\\ \theta_D=0}} - [x_D^*]_{\gamma=1}\right] + \left[[x_D^*]_{\substack{\gamma>1,\\ \theta_G>0,\\ \theta_D>0}} - [x_D^*]_{\substack{\gamma>1,\\ \theta_G=0,\\ \theta_D=0}}\right] \\ &= \underbrace{\frac{v}{4}}_{\substack{\text{effort level with}\\ \text{no asymmetry}}} + \underbrace{v\left[\frac{\gamma}{(\gamma+1)^2} - \frac{1}{4}\right]}_{\substack{\text{discouragement effect from}\\ \text{the asymmetry } \gamma>1}} + \underbrace{\gamma\left[\frac{V_G V_D^2}{(\gamma V_G + V_D)^2} - \frac{v}{(\gamma+1)^2}\right]}_{\substack{\text{shame-fame effect from}\\ \text{the asymmetry } \gamma>1}} \end{aligned} \tag{3.3}$$

The first two terms are the same as those in equation (3.1). The third term can be rearranged as follows:

$$\gamma\left[\frac{V_G V_D^2}{(\gamma V_G + V_D)^2} - \frac{v}{(\gamma+1)^2}\right] = \frac{\gamma\left[2\gamma V_D V_G \theta_D f(\gamma) + V_D^2 \theta_G s(\gamma) + \gamma^2 V_G \theta_D^2 f(\gamma)^2 + v\gamma^2 V_G(2\theta_D f(\gamma) - \theta_G s(\gamma))\right]}{(\gamma V_G + V_D)^2(\gamma+1)^2} \tag{3.4}$$

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

Proposition 2. *When $2\theta_G s(\gamma) \geq \theta_D f(\gamma) \geq \theta_G s(\gamma)/2$, the presence of shame and fame encourages both contestants to exert more effort in equilibrium.*

It is worth mentioning that $2\theta_G s(\gamma) \geq \theta_D f(\gamma) \geq \theta_G s(\gamma)/2$ is only sufficient but not necessary for the presence of shame and fame to increase the equilibrium effort level. 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 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 (3.1) and (3.3) and the shame-fame encouragement effect captured by the third terms in the two equations. To closely examine how these two effects interact with one another, assume $f(\gamma) = s(\gamma)$ and focus on the subclass of the shame-fame function that satisfies the following condition:

Condition 1.

$$\frac{s(\gamma)}{\gamma} \leq s'(\gamma), \text{ for any } \gamma \geq 1.$$

Note that Condition 1 is milder than the weak-convexity. Any $s(\gamma) = a(\gamma - 1)^l$ with $a > 0$ and $l \geq 1 - \frac{1}{\gamma}$ satisfies this condition.

For notational convenience, define the relative fame-shame sensitivity as $k = \frac{\theta_D}{\theta_G} \in (0, \infty)$. Then, we have

$$V_G(V_D + \gamma V_G)^3 \cdot \frac{\partial x_G^*}{\partial \gamma} = \underbrace{V_G}_{>0} \underbrace{(V_D - \gamma V_G)}_{(A)} \underbrace{(V_D - \gamma k \theta_G s')}_{(B)} + \underbrace{2\gamma V_D^2 \theta_G s'}_{>0} \tag{3.5}$$

and

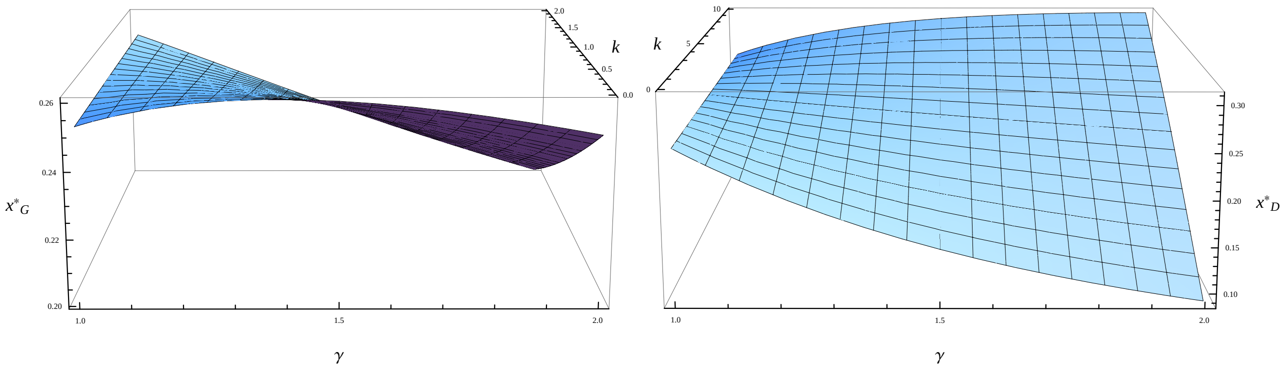
$$V_D(V_D + \gamma V_G)^3 \cdot \frac{\partial x_D^*}{\partial \gamma} = \underbrace{V_D}_{>0} \underbrace{(V_D - \gamma V_G)}_{(A)} \underbrace{(V_G + \gamma \theta_G s')}_{>0} + \underbrace{2\gamma^2 V_G^2 k \theta_G s'}_{>0}, \tag{3.6}$$

where s' denotes $ds(\gamma)/d\gamma$. Note that the term (B) in equation (3.5) can be written as

$$(V_D - \gamma k \theta_G s') \quad = \quad v + k \underbrace{(s - \gamma s')}_{<0} \theta_G, \tag{3.7}$$

which is positive when $k > 0$ is small and linearly decreasing in k to become negative when k is sufficiently large due to the fact that $(s - \gamma s') < 0$ under Condition 1.

Let us first consider $\frac{\partial x_G^*}{\partial \gamma}$ and take the extreme case in which $k \approx 0$ and $\gamma \approx 1$ in equation (3.5). In this case, the term (A) is approximately 0, while the last term $2\gamma V_D^2 \theta_G s'$ is strictly positive such that $\left[\frac{\partial x_G^*}{\partial \gamma}\right]_{k \approx 0, \gamma \approx 1} > 0$. When we keep $k \approx 0$ but increase $\gamma > 1$, the term (A) becomes strictly negative and monotonically decreasing in γ and the term (B) is strictly positive. If γ is small enough, the effect of the last positive term dominates the effect of the negative terms, but when γ is sufficiently large ($> \hat{\gamma}$), the joint effect of terms (A) and (B) dominates the last positive term such that $\left[\frac{\partial x_G^*}{\partial \gamma}\right]_{k \approx 0, \gamma > \hat{\gamma}} < 0$. Thus, when k is small enough, Goliath's equilibrium effort level x_G^* is single peaked in γ. However, when we keep γ but make $k > 0$ large enough, the term (A) becomes positive and the term (B) becomes negative regardless of $\gamma \geq 1$. For k sufficiently large ($> \hat{k}$),



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

Figure 1: Comparative Statics with $v = 100$, $\theta_G = 20$, and $f(\gamma) = g(\gamma) = (\gamma - 1)$

the joint effect of (A) and (B) dominates the effect from the last positive term for any $\gamma \geq 1$. Thus, for a large enough k, Goliath's equilibrium effort level x_G^* is monotonically decreasing, i.e., $\left[\frac{\partial x_G^*}{\partial \gamma}\right]_{k>\hat{k}} < 0$ for any $\gamma \geq 1$. Figure 1(a) illustrates how x_G^* changes in response to the changes in $\gamma \in [1, 2]$ and $k \in [0, 2]$ under the parameter values $v = 100$, $\theta_G = 20$, and $f(\gamma) = g(\gamma) = (\gamma - 1)$.

Next, consider $\frac{\partial x_D^*}{\partial \gamma}$ and take the extreme case in which $k \approx 0$ and $\gamma \approx 1$ in equation (3.6). In this case, both the term (A) and the last term $2\gamma^2 V_G^2 k \theta_G s'$ are approximately 0. When we keep $k \approx 0$ but increase $\gamma > 1$, the term (A) becomes strictly negative, while the last term is still approximately 0 such that $\left[\frac{\partial x_D^*}{\partial \gamma}\right]_{k\approx 0, \gamma>1} < 0$. Thus, when k is small enough, David's equilibrium effort level x_D^* is monotonically decreasing. When we keep $\gamma \approx 1$ but increase $k > 0$, the term (A) becomes strictly positive so that $\left[\frac{\partial x_D^*}{\partial \gamma}\right]_{k>\bar{k}, \gamma\approx 0} > 0$. When we further increase γ, the term (A) eventually becomes negative and dominates the effect of the last positive term in equation (3.6). That is, when k is large enough ($> \bar{k}$), David's equilibrium effort level x_D^* is single peaked in γ. Figure 1(b) illustrates how x_D^* changes in response to the changes in $\gamma \in [1, 2]$ and $k \in [0, 10]$ under the parameter values $v = 100$, $\theta_G = 20$, and $f(\gamma) = g(\gamma) = (\gamma - 1)$.

The following observations summarize our discussion:

Observation 1.

(a) When a player is substantially *less* sensitive to shame or fame relative to his/her opponent (i.e., high k for Goliath and low k for David), the discouragement effect dominates the shame-fame effect; therefore, the equilibrium effort level is monotonically decreasing in γ.

(b) When a player is substantially *more* sensitive to shame or fame relative to his/her opponent (i.e., low k for Goliath and high k for David), the shame-fame encouragement effect dominates the discouragement effect for a low γ, but eventually, the discouragement effect dominates when γ becomes larger. As a result, the equilibrium effort level is single peaked in γ.

(c) When k is low, x^*_G is single peaked, while x^*_D is monotonically decreasing in γ.

(d) When k is high, x^*_G is monotonically decreasing, while x^*_D is single peaked in γ.

4 Experimental Design, Hypotheses, and Procedure

4.1 Design and Hypotheses

In designing the experiments, our main focus was on creating an interface in which the exogenously introduced asymmetry between the two contestants *endogenously induces* shame and fame and eventually affects individuals' effort choices. To achieve this goal, we implemented our experiments as a real-effort game with two contestants (Members A and B) and an observer (Member C).[5] 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 questions within 120 seconds. The opportunity cost of solving one question was one experimental token, in addition to the time cost.[6] The type of calculation questions each participant had to solve may have differed depending on the role assigned to each participant and the treatment.

In Treatment *2D-SYM*, both Members A and B were asked to solve a series of calculation problems of adding two two-digit (2D) numbers. In Treatment *3D-SYM*, both Members A and B were asked to solve a series of calculation problems of adding two three-digit (3D) numbers. Hence, no asymmetry existed between Member A and Member B in these two treatments. In Treatment *ASYM*, however, we introduced a moderate degree of asymmetry between the two members; Member A was asked to solve a series of calculation problems of adding two two-digit (2D) numbers, while Member B was asked to solve a series of calculation problems of adding two three-digit (3D) numbers.[7] This experimental design is illustrated in Table 2 below. For notational convenience, in the rest of the paper, we call the player solving 2D questions Goliath and the player solving 3D questions David.

The computer calculated how many questions each member solved within 120 seconds. Each question a player solved gave him/her one lottery ticket, and the computer randomly selected

[5] We also employed a set of additional robustness check treatments in which there was no observer. Our main hypothesis from these *No-Observer* treatments is that the absence of an observer weakens the shame-fame effect. We will present the design and results of the *No-Observer* treatments in Section 5.3.

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

[7] Taking into account the fact that inputing an answer for each question takes a non-negligible amount of time, the γ we implemented should be bounded above by 1.5.

		Member B	
	Question (Player) Type	2D (Goliath)	3D (David)
Member A	2D (Goliath)	*2D-SYM*	*ASYM*
	3D (David)	N/A	*3D-SYM*

Table 1: Experimental Treatments

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 did not vary depending on the treatment. As an observer, Member C was always asked to solve a series of calculation problems of adding two numbers, one two-digit (2D) number and one three-digit (3D) number. 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 120 seconds. 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.[8]

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

[8] However, it is possible that Members A and B may exhibit social preferences such as altruism. See Section 5.3 for further discussion.

both know that there exists a serious observer who cares about the contest outcome.[9]

Our first hypothesis originates from the fact that we randomly assigned participants to different treatments. Given the fact that Member Cs in all treatments 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 treatments. Rejection of this random assignment hypothesis means that the average abilities of participants to add one two-digit number and one three-digit number are not the same across treatments.[10]

Hypothesis 1 (Random Assignment Hypothesis)**.** *The average numbers of questions solved by the observer (Member C) do not vary across treatments.*

Before we proceed to establish our next hypothesis, it is important to discuss whether our experimental interface induces a high relative (fame-shame) sensitivity $k = \theta_D/\theta_G$ or a low sensitivity, as our Observation 1 reveals that the theoretical predictions about the impact of the asymmetry on the equilibrium effort levels vary depending on the induced relative sensitivity. Our prior belief is that the experimental implementation based on the real-effort design is more likely to induce a lower k, i.e., $\theta_G \gg \theta_D$, because the real-effort tasks are not intellectually demanding and onerous but rather basic and tedious; therefore, experimental subjects may be more sensitive to the shame from losing than the fame from winning.[11]

Based on the prior that the induced k is small, our strategy to derive all other testable hypotheses is simple.[12] We will compare the same player type (e.g., Goliath) in two different treatment conditions (an asymmetric contest vs. a symmetric contest). We start with the effect of shame on individual contestants' effort choices. Observations 1(a) and 1(c) suggest that the average number of questions Goliath (Member A) solved in Treatment *ASYM* must be larger than the average number of questions Goliath (Members A and B) solved in Treatment *2D-SYM*. Note that in the absence of shame, the standard asymmetric contest (Baik, 1994) predicts that

[9]We thus believe that the absence of an observer may weaken the shame-fame effect unless the effect is completely eliminated. In fact, in the dictator game context, Rigdon et al. (2009) show that presenting the dictator with a minimal social cue of three dots in a watching-eyes configuration increases giving behavior. We will present experimental results from the set of treatments without the observer in Section 5.3.

[10]As an alternative of Hypothesis 1, one can claim that Member C may have a greater incentive to work hard in Treatment *ASYM* 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.

[11]In our experimental real-effort game, it is sensible to believe that the "letdown" the observer may feel from an unexpected loss by Goliath is more significant than the "surprise" she may feel from an unexpected win by David.

[12]Inducing a lower k may not be the first-best way to test the validity of our theory of shame and fame because, as we will discuss in Section 6, loss aversion might be a compounding factor. However, given the nature of the laboratory real-effort game with tedious and straightforward tasks, it is difficult to implement an environment in which subjects become more sensitive to fame than shame. Thus, we test our theory in the second-best environment in which subjects are more sensitive to shame than to fame.

the effort level chosen by the favored contestant in the asymmetric contest is lower than the effort level chosen by a contestant in the symmetric contest.

Hypothesis 2 (Shame in Asymmetric Contests)**.** *The average number of questions Goliath solved in Treatment ASYM is larger than the average number of questions Goliath solved in Treatment 2D-SYM.*

We move to the effect of fame on individual contestants' effort choices. Observations 1(b) and 1(d) suggest that the average number of questions David (Member B) solved in Treatment *ASYM* must be smaller than the average number of questions David (Members A and B) solved in Treatment *3D-SYM*. Given the assumption that the induced relative shame-fame sensitivity k is small, the discouragement effect of asymmetry dominates the shame-fame effect.

Hypothesis 3 (Fame in Asymmetric Contests)**.** *The average number of questions David solved in Treatment ASYM is smaller than the average number of questions David solved in Treatment 3D-SYM.*

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 Treatments *2D-SYM* and *3D-SYM*.

Hypothesis 4 (No Shame / Fame Without Asymmetry)**.**

(a) The average number of questions Member A solved is the same as the average number of questions Member B solved in Treatment *2D-SYM*.

(b) The average number of questions Member A solved is the same as the average number of questions Member B solved in Treatment *3D-SYM*.

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 Treatment *ASYM*, 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 other two treatments, where there is no asymmetry between Members A and B.

Hypothesis 5 (Member C's Estimations)**.** *The difference between the number of tokens Member C allocates to Member A and those she allocates to Member B in Treatment ASYM is larger than the corresponding differences in Treatment 2D-SYM and Treatment 3D-SYM.*

4.2 Experimental Procedure

Our experiment was conducted at the Hong Kong University of Science and Technology in English using z-Tree (Fischbacher, 2007). A total of 153 subjects who had no prior experience with our experiment were recruited from the undergraduate and graduate population at the university. Upon arrival at the laboratory, subjects were instructed to sit at separate computer terminals. Each received a copy of the experimental instructions. To ensure that the information contained in the instructions became public knowledge, the instructions were read aloud, aided by slide illustrations and a comprehension quiz. We conducted three sessions for each treatment. 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 *3D-SYM* had nine subjects and, thus, one matching group. 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 *ASYM* are presented in Appendix B.

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 (≈ US$6.4) for participating. Subjects' total earnings averaged HK$153.7 (≈ US$19.7). The average duration of a session was approximately 1 hour.

5 Experimental Results

5.1 Aggregate Outcome

Figure 2 presents the average effort levels, measured as the number of questions solved, aggregated over all seven rounds and all three sessions of each treatment.[13]

A few observations are immediately clear. First, the average numbers of questions Member C solved are 23.03 in Treatment *2D-SYM*, 24.25 in Treatment *3D-SYM*, and 23.83 in Treatment *ASYM*. 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

[13] Looking at the time trend reported in Figure 8 in Appendix A, there is at most a very mild degree of learning observed in the data. Figure 9 presents the average effort levels aggregated over the last two rounds only and shows that the results are qualitatively similar. Thus, in the rest of the section, we will use the data aggregated over all rounds. However, all results presented in this section are robust to the choice of rounds in aggregation.

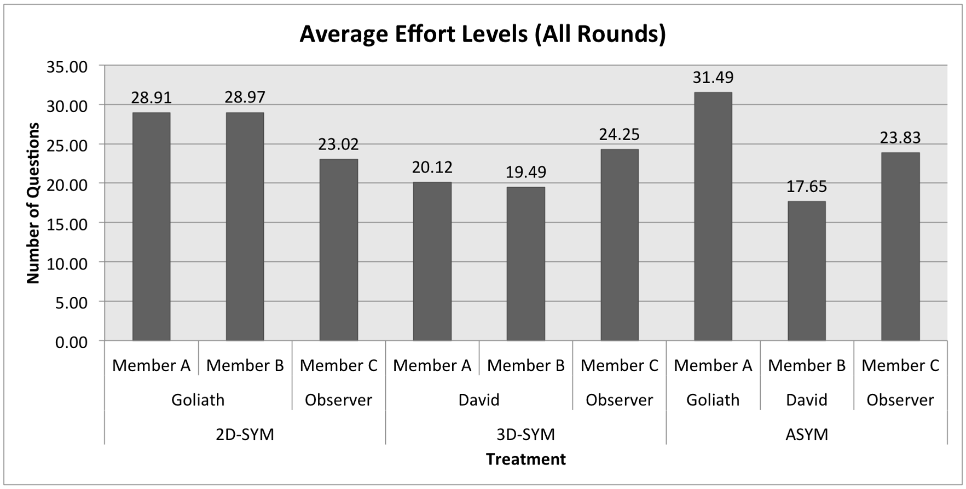


Figure 2: Average Effort Levels - Aggregated from All Rounds

Hypothesis) that the difference in the number of questions Member C solved is statistically similar in any pairwise comparison (the lowest p-value = 0.3515).[14] Second, the average number of questions Member A solved is 28.91 in Treatment *2D-SYM*, 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). Third, the average number of questions Member A solved is 20.12 in Treatment *3D-SYM*, which is not statistically different from 19.49, the average number of questions Member B solved in the same treatment (two-sided Mann-Whitney test, p-value = 0.6698). 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 4, we have the following result.

Result 1. *The average numbers of questions solved by Member C do not vary across treatments. The average numbers of questions Member A solved and Member B solved are the same in Treatments 2D-SYM and 3D-SYM.*

We are now ready to present the main finding of the paper. Figure 2 reveals that the average number of questions Goliath (Member A) solved in Treatment *ASYM* 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 *2D-SYM*. The difference – an increase of almost 9% – is substantial in magnitude. We can reject the null hypothesis that the average numbers of questions Goliath solved in Treatments *ASYM* and *2D-SYM* are the same; thereby, Hypothesis 2 that Goliath solved more questions in Treatment *ASYM* than in Treatment *2D-SYM* is supported with a marginal significance (one-sided Mann-Whitney test, p-value = 0.798). Consistent with our

[14] 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, as Member B, and as Member C each generates one independent observation.

Hypothesis 3, the average number of questions David (Member B) solved in Treatment *ASYM* 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 *3D-SYM*. Again, 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 *ASYM* and *3D-SYM* are the same and instead support the alternative that David solved fewer questions in Treatment *ASYM* than in Treatment *3D-SYM* (one-sided Mann-Whitney test, p-value = 0.0518). Confirming Hypotheses 2 and 3, we have the following result.

Result 2. *On average, Goliath solved a significantly greater number of questions in Treatment ASYM than in Treatment 2D-SYM, while David solved significantly fewer questions in Treatment ASYM than in Treatment 3D-SYM.*

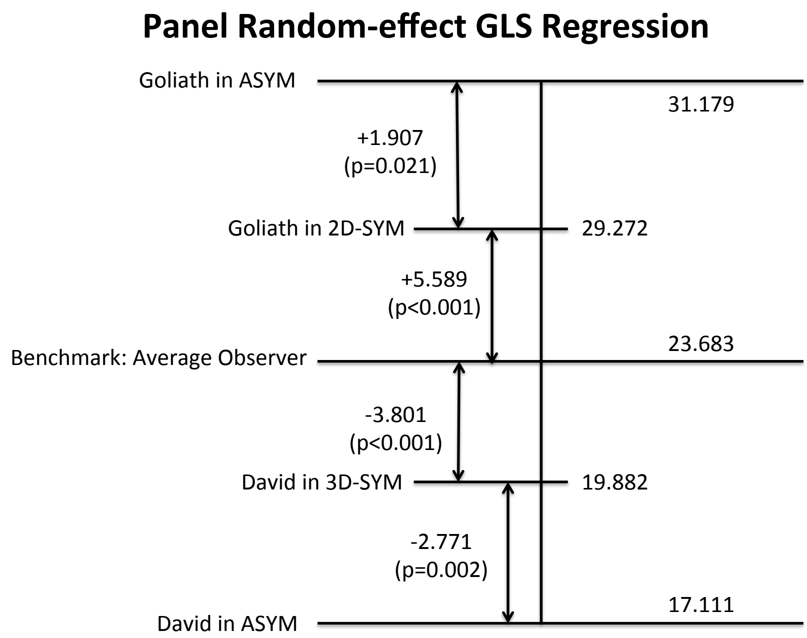
To reinforce our findings obtained by the non-parametric tests, we conduct the following random effect GLS (Generalized Least Squares) regression. The dependent variable is NQ_i, the number of questions individual i solved, and the four regressors are G_i , D_i and two interaction terms $ASYM_i \cdot G_i$ and $ASYM_i \cdot D_i$ where, for individual i, G_i takes the value 1 if the role assigned to the individual is Goliath and 0 otherwise; D_i takes the value 1 if the role assigned to the individual is David and 0 otherwise; $ASYM_i$ takes the value 1 if the individual is in Treatment *ASYM* and 0 otherwise. We write ε_i 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.

$$NQ_i = \alpha_i + \beta_1 \cdot G_i + \beta_2 \cdot D_i + \beta_3 \cdot ASYM_i \cdot G_i + \beta_4 \cdot ASYM_i \cdot D_i + \varepsilon_i \tag{5.1}$$

This regression specification implies that our benchmark is the average number of 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 a straightforward interpretation. Compared to the average performance of the observers, Goliath solved β_1 more questions on average in Treatment *2D-SYM*, and David solved β_2 more questions on average in Treatment *3D-SYM*. Additionally, interpretations for β_3 and β_4 are not difficult. Compared to the average performance of Goliath in Treatment *2D-SYM*, Goliath in Treatment *ASYM* solved β_3 more questions on average. Compared to the average performance of David in Treatment *3D-SYM*, David in Treatment *ASYM* solved β_4 more questions on average.

The results of the regression are summarized in Figure 3 above and Table 3 presented in Appendix A.[15] It reveals that observers (Member C) solved 23.683 questions on average. Goliath in Treatment *2D-SYM* solved 5.589 more questions than the average observer, while Goliath in

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



Note: p-values are presented in parentheses.

Figure 3: Random Effect GLS Regression

Treatment *ASYM* solved 1.907 more questions than Goliath in Treatment *2D-SYM*. Additionally, David in Treatment *3D-SYM* solved 3.801 fewer questions than the average observer, while David in Treatment *ASYM* solved 2.771 questions less than David in Treatment *3D-SYM*. All differences are significant at the 1% confidence level, except for the difference between Goliath in Treatments *2D-SYM* and *ASYM*, which is significant at the 5% confidence level.

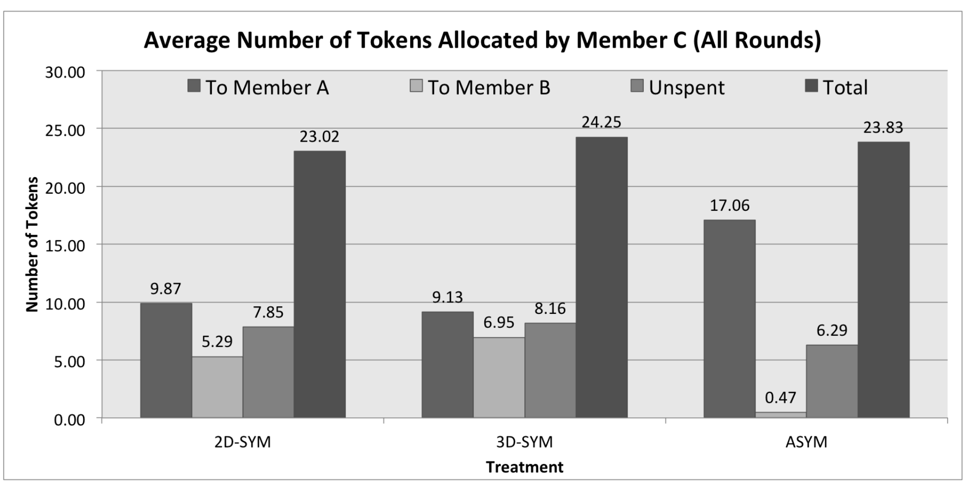


Figure 4: Average Number of Tokens Allocated by Member C – Aggregated from All Rounds

Figure 4 illustrates Member C's token allocation decisions aggregated over all seven rounds and all three sessions of each treatment. It is remarkable to observe that only 0.47 tokens were allocated to Member B (David) in Treatment *ASYM*, which is substantially smaller than 5.29 and 6.95, the number of tokens allocated to Member B in Treatments *2D-SYM* and *3D-SYM*, respectively. Mann-Whitney tests reveal that the differences are statistically significant (both p-values < 0.0001). Similarly, the number of tokens allocated to Member A is 17.06 in Treatment *ASYM*, significantly more than 9.98 in Treatment *2D-SYM* and 9.13 in Treatment *3D-SYM* (Mann-Whitney tests, both p-values < 0.0022). These results are not from any difference in the initial amount of tokens Member C has because, as we discussed previously, the average numbers of tokens Member C obtained from the problem-solving task are not different across treatments. The number of unspent tokens is 6.29 in Treatment *ASYM*, which is smaller than the corresponding figures of 7.85 in Treatment *2D-SYM* and 8.16 in Treatment *3D-SYM*, but the differences are not statistically significant (Mann-Whitney tests, p-values > 0.1360). These three observations provide very clear evidence that Member C's estimations of who will win differ between asymmetric and symmetric contests.[16]

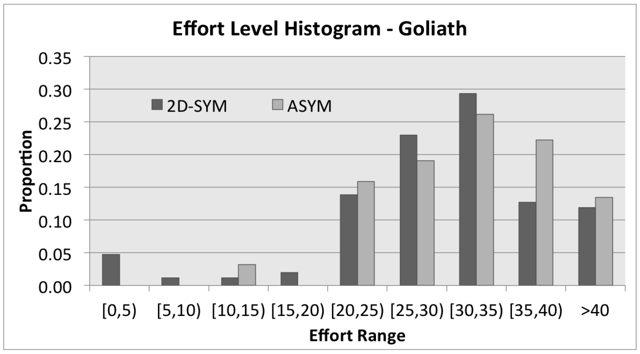
5.2 Individual Outcome – Source of Performance Difference

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.

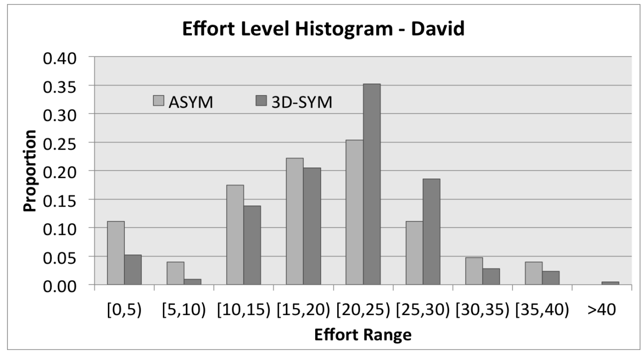
Could our main result also be driven by the same kind of dropout behavior? Figure 5 presents three histograms for individual effort levels and shows that this possibility is not the case. Figure 5(a) shows that Goliath's effort distribution in Treatment *ASYM* first-order stochastically dominates that in Treatment *2D-SYM*. Similarly, Figure 5(b) shows that David's effort distribution in Treatment *ASYM* is first-order stochastically dominated by that in Treatment *3D-SYM*. Even if some dropout behavior by David is observed in Treatment *ASYM*, this behavior is only approximately 15% or less, which is not as substantial as the dropout rate observed in Müller and Schotter (2010).

There are two main sources of Goliath's higher performance in Treatment *ASYM* than in Treatment *2D-SYM*. The first is the zero dropout rate in Treatment *ASYM* as opposed to the 5% dropout rate observed in Treatment *2D-SYM*. The second, and more important, source is

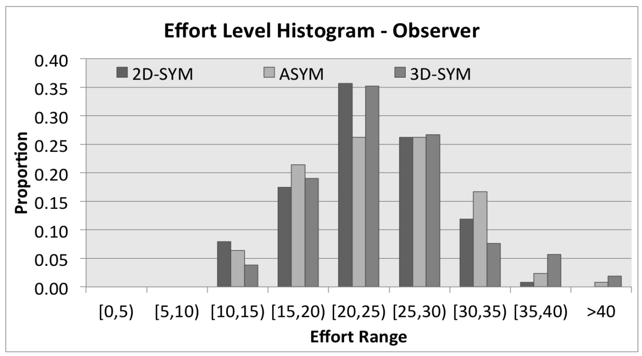
[16] Notice that Member C put substantially more tokens on Member A than on Member B in Treatment *2D-SYM* (9.87 vs. 5.29). The difference is still positive, despite the fact that the magnitude is smaller in Treatment *3D-SYM* (9.13 vs. 6.95). However, it is clear that the difference between the number of tokens allocated to Member A and the number allocated to Member B observed in Treatment *ASYM* is 16.59, which is significantly and substantially larger than the differences observed in the other two treatments.



(a) Goliath



(b) David



(c) Observer

Figure 5: Individual Effort Levels – Histograms

the performance shift of mediocre performers (whose scores are between 25 and 35 in Treatment *2D-SYM*) to the high performers (whose scores are larger than 35 in Treatment *ASYM*). Similarly, there are two primary sources of David's lower performance in Treatment *ASYM* than in Treatment *3D-SYM*. The first is the higher dropout rate (approximately 11%) observed in Treatment *ASYM* than the 5% observed in Treatment *3D-SYM*. The second is the performance shift of high performers (whose scores are between 20 and 30 in Treatment *ASYM*) to mediocre performers (whose scores are between 10 and 20 in Treatment *3D-SYM*).

5.3 Role of Observer – An Additional Set of Treatments

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. Therefore, is it crucial to have an observer to induce this second-order belief, or would shame and fame be self-contained notions in the mind of an individual? Without an observer, it would be still possible for experimental subjects to feel some degree of shame and fame due to the fact that experimenters are present in the laboratory. Shame and fame may be partly driven by the fact that one's opponent is always present. To answer these questions, we design an additional set of treatments with *no observer* in the game.

	Question (Player) Type	Member B 2D (Goliath)
Member A	2D (Goliath)	*2D-SYM-N/O*
	3D (David)	*ASYM-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 *2D-SYM-N/O* is a version of Treatment *2D-SYM* with no observer, and Treatment *ASYM-N/O* is a version of Treatment *ASYM* 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 *ASYM-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 4.2. Subjects' total earnings averaged HK$169.6 (≈ 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.[17]

Hypothesis 6 (No Role of the Observer in Symmetric Contests)**.** *The average number of questions Goliath solved in Treatment 2D-SYM-N/O is not different from the average number of questions Goliath solved in Treatment 2D-SYM.*

In the asymmetric contest, however, the role of the observer might be crucial. Without having an observer who watches the contest and estimates the contestants' likelihood of winning, shame and fame may emerge significantly less frequently than otherwise. This possibility implies that in the asymmetric contest with no observer, 1) Goliath exerts less effort than Goliath in the asymmetric contest with an observer and 2) David exerts more effort than David in the asymmetric contest with an observer. Thus, we have the following hypothesis.

Hypothesis 7 (Role of Observer in Asymmetric Contests)**.**

[17] 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 *2D-SYM*.

(a) The average number of questions Goliath solved in Treatment *ASYM-N/O* is lower than the average number of questions Goliath solved in Treatment *ASYM*.

(b) The average number of questions David solved in Treatment *ASYM-N/O* is greater than the average number of questions David solved in Treatment *ASYM*.

We now report experimental findings from the new treatments. Figure 6 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 *2D-SYM* and *ASYM*.

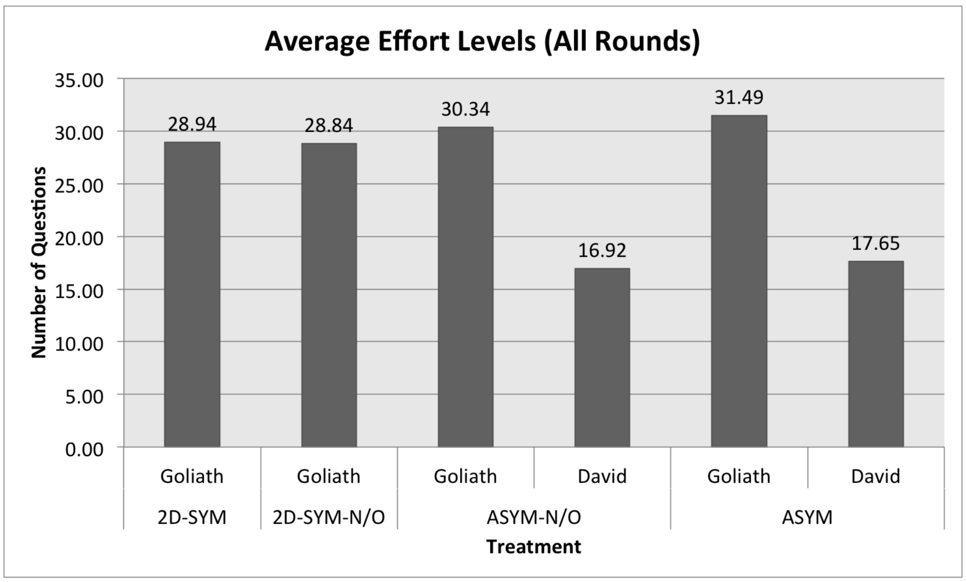
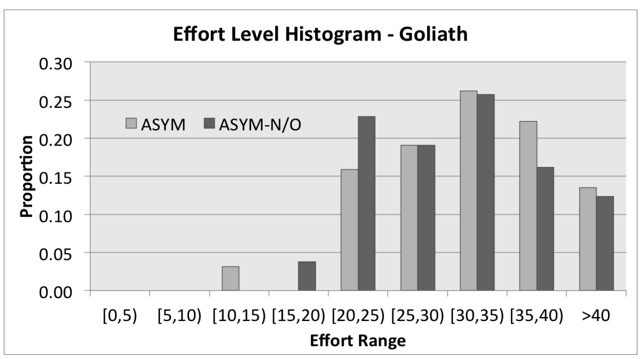


Figure 6: Average Effort Levels With and Without Observers

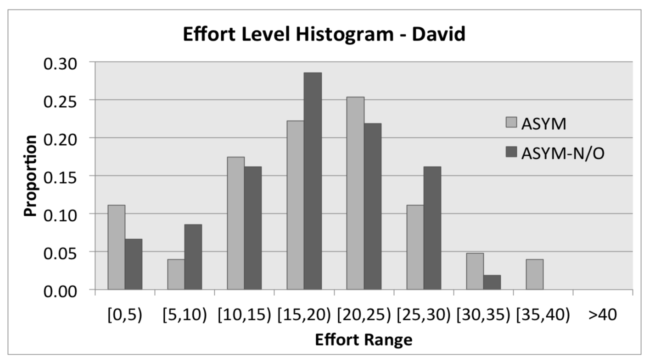
A few observations emerge immediately. First, Goliath's average effort levels observed in Treatments *2D-SYM* and *2D-SYM-N/O* are literally the same – 28.94 vs. 28.84. The Mann-Whitney test reveals that we cannot reject the null hypothesis that the two values are statistically the same (p-value = 0.9639.) Thus, we confirm Hypothesis 6. 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 *ASYM-N/O* is 30.34, which is approximately 3.5% points lower than the 31.49 observed from Goliath in Treatment *ASYM*. The fact that the average effort level is lower in the absence of an observer is consistent with our Hypothesis 7(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 *ASYM-N/O* is 16.92, which is approximately 4.3% points lower than the 17.65 observed from David in Treatment *ASYM*. The difference is not statistically significant (Mann-Whitney test, p-value = 0.8392), and thus, we reject Hypothesis 7(b).

Result 3. *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 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 7 indicates, however, the distributions of efforts across the two treatment conditions (with and without an observer) are not the same. First, Figure 7(a) shows that Goliath's effort distribution in Treatment *ASYM-N/O* is positioned slightly to the left of that in Treatment *ASYM*. In particular, the proportion of effort in the range $[20, 25)$ in Treatment *ASYM-N/O* is approximately 23%, substantially higher than the 16% observed in Treatment *ASYM*. The proportion of effort in the range $[35, 40)$ in Treatment *ASYM-N/O* is approximately 17%, substantially lower than the 22% observed in Treatment *ASYM*. However, Goliath's higher performance in Treatment *ASYM* is mitigated by the very low performer outliers in the effort range $[10, 15)$. Second, Figure 7(b) shows that David's effort distribution in Treatment *ASYM-N/O* is more concentrated than that in Treatment *ASYM*.



(a) Goliath in Asymmetric Contests



(b) David in Asymmetric Contests

Figure 7: Individual Effort Levels – Histograms

Our experimental finding suggests that subjects may 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, may be another driving force of shame and fame.

6 Discussion

An alternative explanation for our main result (Result 2) is the assumption that contestants are averse to loss (Kahneman and Tversky, 1979). For example, Müller and Schotter (2010) consider a three-player all-pay auction in which each contestant is privately informed about his/her ability, and show that their experimental results, which are qualitatively similar to ours, can be well explained by loss aversion. Could loss aversion also explain our data? To formally answer this question, we follow Kahneman and Tversky (1979) and assume that players' utility functions are

$$u(\omega) = \begin{cases} \omega^\alpha & \text{if } \omega \geq 0 \\ -\lambda(-\omega)^\alpha & \text{otherwise} \end{cases}$$

where $\alpha > 0$ and $\lambda > 1$, while we shut down the shame-fame channel, i.e., $\theta_G = \theta_D = 0$. Assuming $\alpha = 1$, the objective functions of Goliath and David become

$$\Pi_G^L = v \cdot \left(\frac{\gamma x_G}{\gamma x_G + x_D}\right) - x_G - (\lambda - 1) \cdot x_G \cdot \left(\frac{x_D}{\gamma x_G + x_D}\right). \tag{6.1}$$

and

$$\Pi_D^L = v \cdot \left(\frac{x_D}{\gamma x_G + x_D}\right) - \lambda x_D + (\lambda - 1) \cdot x_D \cdot \left(\frac{x_D}{\gamma x_G + x_D}\right) \tag{6.2}$$

The third term (highlighted in blue) on the right-hand side of equation (6.1) indicates that loss aversion discourages Goliath from exerting efforts. When the contest becomes more asymmetric (i.e., higher γ), the discouragement effect on Goliath becomes weaker because Goliath is more likely to win in equilibrium (as $\frac{x_D}{\gamma x_G + x_D}$ becomes smaller). Thus, loss aversion predicts that Goliath exerts *more* effort in the asymmetric contest than in the symmetric contest.

The effect of loss aversion on David's equilibrium effort level is more complicated. On one hand, the third term (highlighted in blue) on the right-hand side of equation (6.2) reveals that loss aversion encourages David to exert more effort. On the other hand, the second term (highlighted in red) indicates that David's opportunity cost for one unit of effort becomes $\lambda > 1$ so that loss aversion discourages David from exerting effort. When the contest becomes more asymmetric, the encouragement effect becomes weaker (as $\frac{x_D}{\gamma x_G + x_D}$ becomes smaller), while the discouragement effect does not depend on the degree of asymmetry in contests. Thus, loss aversion predicts that David exerts *less* effort in the asymmetric contest than in the symmetric contest.

Recall that the objective functions under our shame-fame utility (equations (2.2) and (2.3)) were very similar to those under the loss aversion utility:

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

and

$$\Pi_D = v \cdot \left(\frac{x_D}{\gamma x_G + x_D}\right) - x_D + \theta_D \cdot f(\gamma) \cdot \left(\frac{x_D}{\gamma x_G + x_D}\right).$$

Define $k^L = \frac{(\lambda-1)x_D}{(\lambda-1)x_G} = \frac{x_D}{x_G}$. Using the simplified specification of the shame-fame model with $s(\gamma) = f(\gamma)$, we can establish a tight parallel between the two models. The only differences are the following: 1) k^L is endogenously determined in the loss aversion model, while $k = \frac{\theta_D}{\theta_G}$ is a parameter exogenously given in our shame-fame model, and 2) David's opportunity cost for one unit of effort is greater in the loss aversion model (λ vs. 1).

To summarize, despite the conceptual difference between the notion of shame and fame and that of loss aversion, our experimental results can be explained well by loss aversion. In the meantime, these results imply that our shame-fame model can also explain some existing data (e.g., Müller and Schotter (2010)) previously explained by loss aversion. However, this implication does not mean that the two models are equivalent. For example, in an environment in which k is substantially large, i.e., contestants are more sensitive to fame than to shame, our theory of shame and fame predicts that David (Goliath) exerts more (less) effort in the asymmetric contest than in the symmetric contest, while loss aversion still predicts that David (Goliath) exerts less (more) effort in the asymmetric contest.

7 Conclusion

In this paper, we investigated how the asymmetry in competitions induces shame and fame, which in turn affect individual players' equilibrium effort levels. Using the simple framework of two-player asymmetric contests, we 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 a player who is handicapped in the asymmetric contest exerts less (more) effort than in the symmetric contest. Our experimental data from the real-effort game were consistent with the theoretical predictions; 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.

It would be possible to separate the shame-fame effects from loss aversion effects by considering an environment in which subjects are substantially more sensitive to fame than to shame such that the predictions from our shame-fame model and those from the loss aversion model are divergent. Creating such an environment in the laboratory may not be straightforward, and thus, we leave it for future research.

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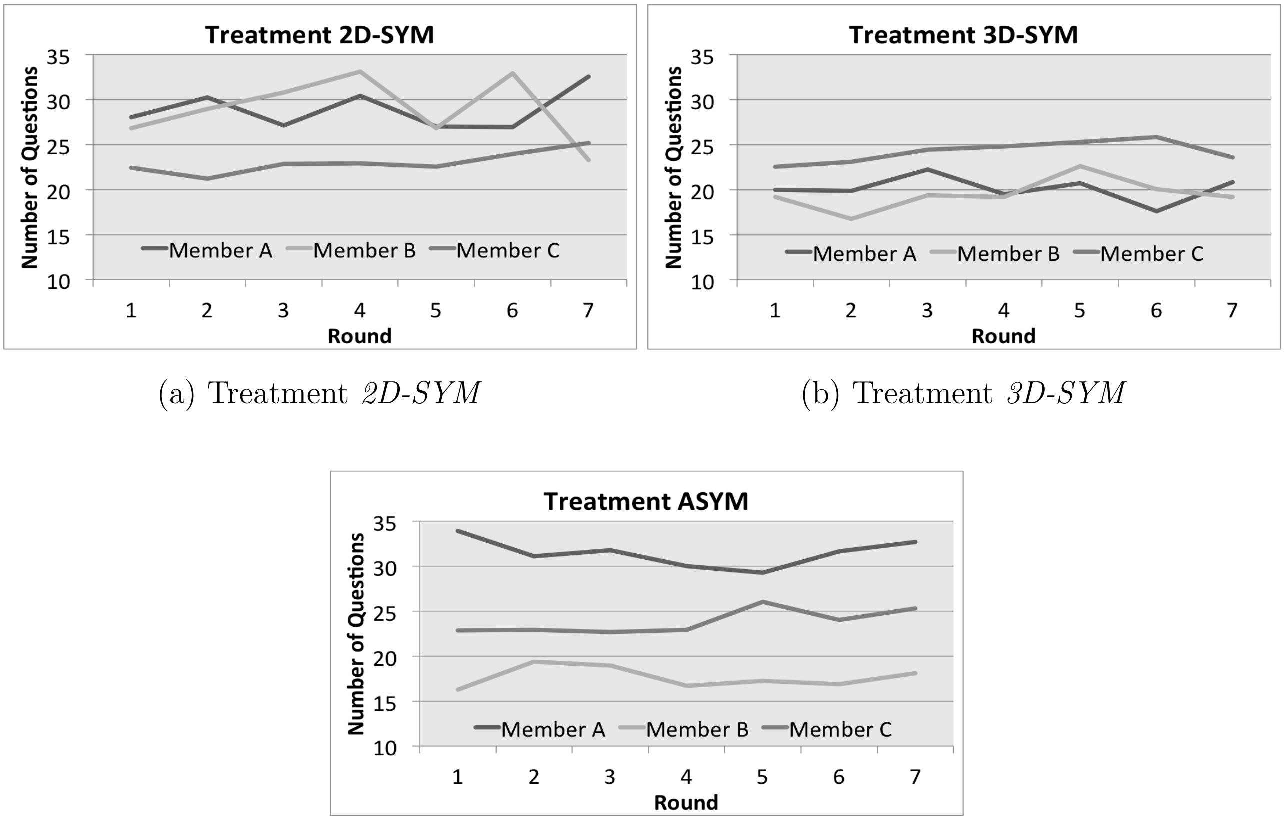
Appendix A Tables and Figures



(a) Treatment *2D-SYM*

(b) Treatment *3D-SYM*

(c) Treatment *ASYM*

Figure 8: Average Effort Levels - Time Trend

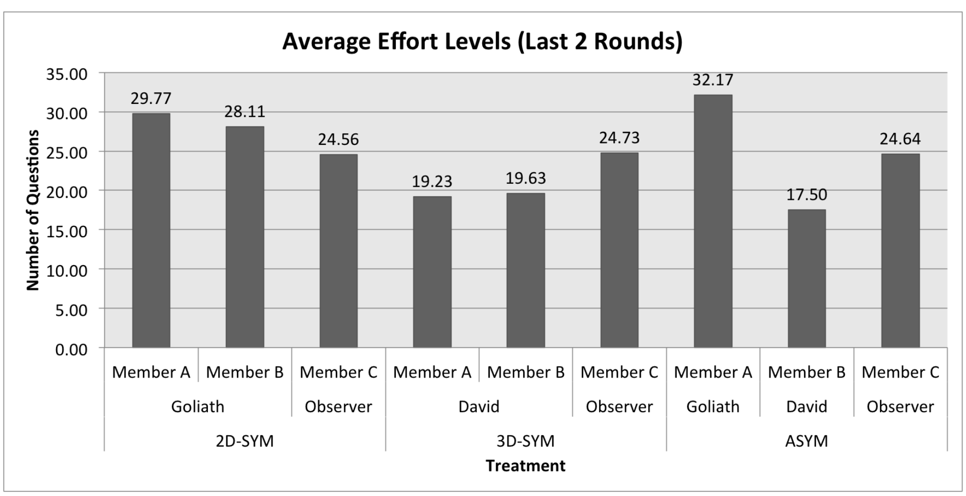
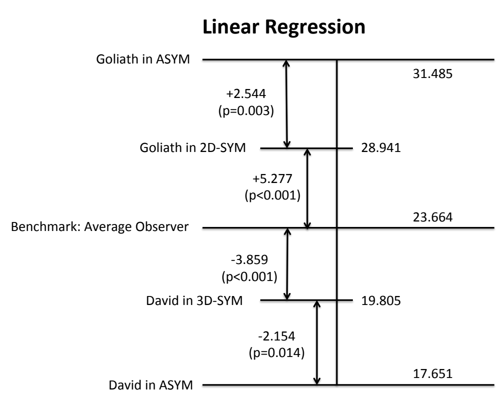


Figure 9: Average Effort Levels

	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 10: Linear Regression

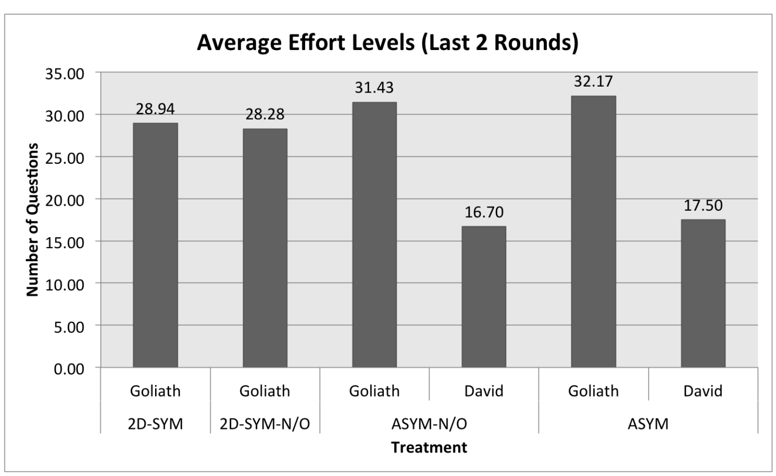


Figure 11: Average Effort Levels With and Without Observers - Last Two Rounds

Appendix B Experimental Instructions - Treatments ASYM

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 kinds 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 for 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.

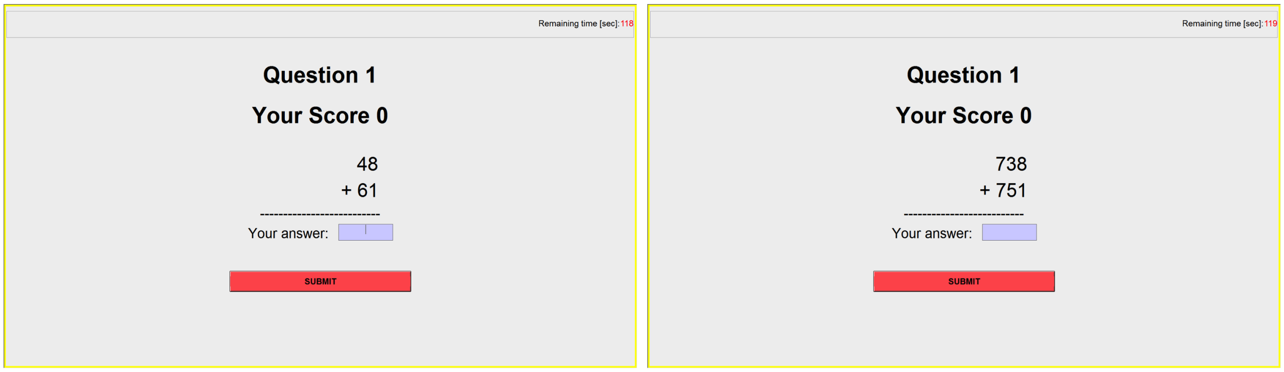
Your Decisions and Earnings – Member A and Member B

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.

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



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

Figure 12: Screen Shots

1. use your mouse to put the curser 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 solved 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

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

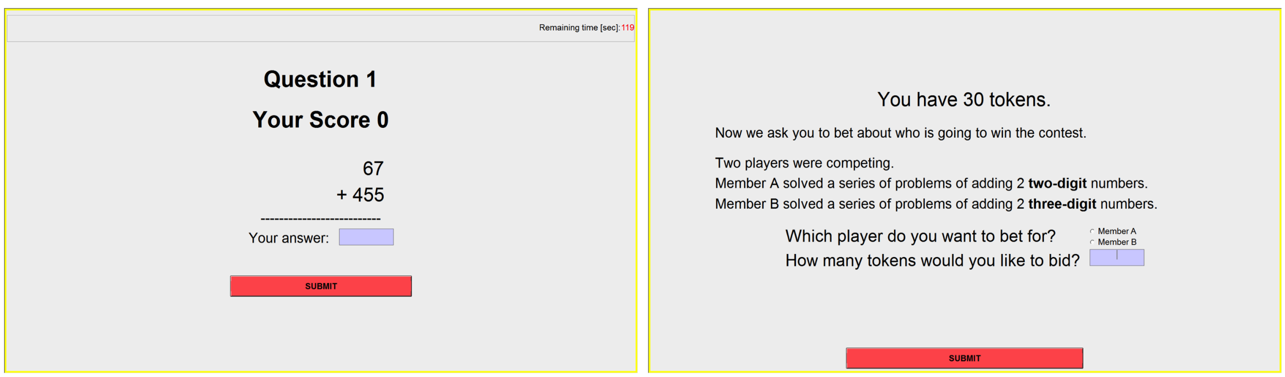
Your Decisions and Earnings – Member C

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 solved 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 earning 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 question, please raise your hand now. We will answer your question individually. If there is no question, we will proceed to the practice round now.