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ABSTRACT

Disappointment Aversion and Social Comparisons in a Real-Effort Competition*

We present an experiment to investigate the source of disappointment aversion in a sequential real-effort competition. Specifically, we study the contribution of social comparison effects to the disappointment aversion previously identified in a two-person real-effort competition (Gill and Prowse, 2012). To do this we compare "social" and "asocial" versions of the Gill and Prowse experiment, where the latter treatment removes the scope for social comparisons. If disappointment aversion simply reflects an asymmetric evaluation of losses and gains we would expect it to survive in our asocial treatment, while if losing to or winning against another person affects the evaluation of losses/gains we would expect treatment differences. We find behavior in social and asocial treatments to be similar, suggesting that social comparisons have little impact in this setting. Unlike in Gill and Prowse we do not find evidence of disappointment aversion.

JEL Classification: C91, D12, D81, D84

Keywords: real effort competition, social comparison effects, disappointment aversion, reference-dependent preferences

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I. INTRODUCTION

An important research program in behavioral economics has been the development of theories of reference-dependent preferences according to which people are loss averse – weighing losses more heavily than gains – around an expectations-based reference point. Such theories (e.g. Bell (1985); Loomes and Sugden (1986); Delquié and Cillo (2006); Köszegi and Rabin (2006)) were originally developed and tested in non-strategic settings (e.g. individual lottery choice experiments), but they have obvious relevance to contests, which quite naturally result in winners and losers, gains and losses.[1] In this paper we examine the behavioral consequences of competing against Nature or against another person. The reason this may matter is that competing against a person invites social comparisons that are not relevant in games against Nature.

Our framework for studying social comparison effects in a contest is the two-person sequential real effort competition studied in Gill and Prowse (2012). In their model they show that a disappointment averse second mover (i.e. a second mover who is loss averse around an expectations-based reference point) responds negatively to a first mover's effort, and in their experiment they find significant evidence for this discouragement effect.

We hypothesize, on the basis of existing evidence on the importance of social comparisons, that disappointment aversion is likely to be different when competing against another person compared to competing against Nature. To test this hypothesis we conduct an experiment with two treatments. The SOCIAL treatment features a game between two human subjects playing in the roles of first and second mover, exactly as in Gill and Prowse (2012). The ASOCIAL treatment removes the scope for social comparisons by removing the first mover. Instead the second mover plays against Nature in a decision problem that, absent social comparison effects, corresponds to the second mover's decision problem in the SOCIAL treatment. Thus, if social comparisons do not affect behavior we expect behavior in the two treatments to be similar, whereas social comparison effects may lead to differences.

Our main result is that, contrary to our hypothesis, behavior is very similar across our treatments. This is the case whether we compare average efforts or examine the data at a more disaggregated level using regression analysis. Two other unexpected findings of our

[1] See Gill and Stone (2010) for an analysis of endogenous expectations-based reference points to a competitive setting.

study are that we find much weaker prize effects than Gill and Prowse (2012) and, unlike them, we find no evidence for disappointment aversion.

The remainder of our paper is organized as follows. The next section introduces the Gill and Prowse (2012) framework. Section III discusses the literature that motivated our main hypothesis. Section IV presents the design of our study, and Section V the results. Section VI presents a discussion and conclusions.

II DISAPPOINTMENT AVERSION IN THE GILL AND PROWSE (2012) FRAMEWORK

Gill and Prowse (2012), (hereafter GP), applied an expectations-based version of a disappointment aversion model to a real-effort competition. In their setting, a *first mover* and a *second mover* compete for a single prize by sequentially exerting efforts, with each player's chance of winning the prize being a probabilistic function of both efforts. Specifically, the second mover wins a money prize, v, with probability $P = (e_2 - e_1 + 50)/100$, where e_1 and e_2 represent first mover and second mover effort, respectively.

In GP's model the second mover's utility is separable in the utility derived from monetary earnings and the disutility associated with effort. In their linearized model the second mover's utility from monetary earnings in the event that she wins the prize is assumed to be $v + g_2(v - vP)$, where v is the "material utility" of the prize, g_2 is a preference parameter and $g_2(v - vP)$ is the "gain-loss utility" associated with earning more than expected. Utility from monetary earnings in the event that the second mover fails to win the prize is given by $0 + l_2(0 - vP)$, where 0 is the material utility, l_2 is a preference parameter and $l_2(0 - vP)$ is the gain-loss utility associated with earning less than expected. A second mover is defined as being disappointment averse if $\lambda_2 \equiv l_2 - g_2$ is strictly positive, i.e. if she is loss averse around her expected monetary payoff. Letting $C(e_2)$ denote the second mover's effort cost, the second mover's expected utility is

$$\begin{aligned} EU_2(e_1, e_2) &= P(v + g_2(v - vP)) + (1 - P)(0 + l_2(0 - vP)) - C(e_2) \\ &= vP + \lambda_2 vP(1 - P) - C(e_2). \end{aligned} \tag{1}$$

GP assume that the second mover maximizes (1), taking e_1 as given. They show that if $\lambda_2 = 0$ the optimal e_2 is independent of e_1, but if the second mover is disappointment averse, $\lambda_2 > 0$, then the optimal e_2 is always (weakly) decreasing in e_1. Assuming a quadratic effort cost function and a strictly concave objective function, GP show that this discouragement effect becomes stronger if the second mover is more disappointment averse or if the value of the prize goes up.

The GP experiment, which we replicate and describe in more detail below, uses a real effort task in which subjects position sliders on a screen. Effort is measured by the number of correctly positioned sliders. GP find significant evidence for a discouragement effect (i.e., e_2 is decreasing in e_1), which is more pronounced the higher the prize. Using structural estimation to estimate the distribution of λ_2 they find significant heterogeneity across individuals and a significantly positive mean of λ_2.

The starting point for our study is based on the observation that the GP model is silent about the role of the first mover as a source of disappointment aversion. Suppose that the material utility of winning simply depends on the amount won, and the asymmetric weighting of gains and losses is akin to the loss aversion exhibited in many studies of individual decision making under uncertainty, where the gain-loss utility reflects the elation/disappointment of getting more/less money than expected. Under this interpretation it would not matter whether the second mover chooses e_2 to maximize (1) after observing the effort choice of a first mover, or whether there is no first mover and the second mover chooses e_2 to maximize (1) where e_1 is an exogenously given parameter of the probability of success function set by the experimenter.

However, we hypothesize that these two problems are behaviorally quite different. In the first case the second mover is involved in a game against another person, while in the second case the second mover plays a game against Nature. As we will argue in the next section, there is substantial evidence on social comparison effects that motivate our hypothesis.

III. THE IMPORTANCE OF SOCIAL COMPARISONS FOR EFFORT CHOICE

Our hypothesis is that the presence of rivals and the social comparisons they afford affect competitive behavior and hence also measured disappointment aversion. This hypothesis is based on a substantial literature in economics and psychology. Starting with the psychology literature, studies of social facilitation (Zajonc (1965)) have long investigated the importance of the awareness of being evaluated by others and its influence on performance (e.g., Markus (1978); Blascovich, et al. (1999)). In economics, evidence is accumulating that social comparisons matter for effort choice (see, for example, Falk and Ichino (2006); Mas and Moretti (2009); Gächter, Nosenzo and Sefton (2013); Thöni and Gächter (2015); Herbst and Mas (2015); Gill, et al. (2016)). Observing others also influences risk-taking behaviors (e.g., Cooper and Rege (2011); Linde and Sonnemans (2012); Bougheas, Nieboer and Sefton (2013); Dijk, Holmen and Kirchler (2014); Fafchamps, Kebede and Zizzo (2015); Schwerter (2016)).

Further support for the potential influence of social comparisons in competitive settings comes from Herrmann and Orzen (2008). They examine a sequential two-person rent-seeking contest to elicit one player's response to the rival's investment, and also examine the effect of removing the first mover and replacing their investment with a random number chosen by the computer. Herrmann and Orzen find second movers make higher investments when they play against another person compared with when they play against the computer. Similarly, Eisenkopf and Teyssier (2013) examine a simultaneous move game and find that average investment into a contest is higher in the presence of rivals.

There are other channels that can also lead to social comparison effects. More generally, the presence of the opponent might be behaviorally important because it might arouse emotions, such as *social* disappointment/elation from payoff comparisons and context-dependent joy of winning (e.g., Dohmen, et al. (2011)), in addition to the pecuniary reward.

To give a more formal example of how social comparisons may affect behavior in the context of GP's experiment, consider the effect of asymmetric inequality aversion. Let $y_i \in \{0, v\}$ be the monetary payoff to player *i*. Suppose that in a game against Nature the "material utility" from monetary earnings is $u_2(y_2) = y_2$, but in a game against another person the "material utility" from monetary payoffs depends not only on own payoff but also on the other person's payoff. Suppose the second mover is inequality averse, as in Fehr and Schmidt

(1999), so that "material utility" from monetary payoffs is $u_2(y_2, y_1) = y_2 - \alpha\max\{y_1 - y_2, 0\} - \beta\max\{y_2 - y_1, 0\}$, where α and β ($\alpha \geq \beta$; $\beta < 1$) are preference parameters measuring the marginal disutility from disadvantageous and advantageous inequality, respectively.[2] Then the effective prize spread, i.e., the difference between the material utility of winning the prize and not winning the prize, is simply v in the game against Nature and $v(1 + \alpha - \beta)$ in the game against another person. The upshot is that if a person is asymmetrically inequality averse (i.e. $\alpha > \beta$) then the effective prize spread in a contest against another person is greater than that in a contest against Nature. Thus, when winning in a competition means earning more than another person and losing means earning less, asymmetric inequality aversion leads to higher stakes, and in turn the higher stakes lead to a stronger discouragement effect.

In summary, there are theoretical and empirical arguments why decisions taken in a social environment (a contest against another person) might differ from decisions taken in an asocial but otherwise identical environment (a contest against Nature). In the next section we describe how our experiment is designed to test this hypothesis.

III. EXPERIMENTAL DESIGN AND PROCEDURES

Our design compares two treatments, SOCIAL and ASOCIAL, in three waves of sessions. In each wave there were six SOCIAL and three ASOCIAL sessions, with twenty subjects participating in each session. Thus, in each wave 120 subjects participated in our SOCIAL treatment (60 first movers and 60 second movers, as in GP) and 60 subjects participated in our ASOCIAL treatment. Across all three waves, 540 subjects participated in our experiment.

At the beginning of each session experimental instructions were handed out to participants in paper form and were read aloud by the experimenter. For the SOCIAL treatment we used exactly the same instructions as in GP. The instructions for our ASOCIAL treatment were adapted accordingly. All instructions are reproduced in the online appendix. Average earnings for participants were £14.14, including a £4 show-up fee, for a session lasting about ninety minutes. All sessions were conducted in the CeDEx lab at the University of Nottingham using z-Tree software (Fischbacher (2007)) and volunteer subjects recruited

[2] Note, the terminology is different from that usually used in discussion of the Fehr-Schmidt model. Usually, material utility would refer to the utility from own pecuniary earnings, and in addition the agent gets disutility stemming from inequality. Here "material utility" includes inequality aversion.

via ORSEE (Greiner (2015)) from the undergraduate student subject pool (excluding those who were then studying economics or psychology).

In sessions using our SOCIAL treatment ten subjects were designated as first movers and another ten as second movers. Roles were randomly determined and remained the same for the whole duration of the session. Each participant then took part in two practice rounds and ten paying rounds. A round consisted of a sequential two-player game between a first mover and a second mover. First movers were re-paired with second movers at the end of each round following a 'no contagion' matching so that no subject's behavior in a given round can directly or indirectly affect the behavior of other participants that the subject is paired with at a later round. In practice rounds, each participant was paired with an automaton so that these experiences would not contaminate the matching protocol in the paying rounds.

At the beginning of the game a monetary prize drawn from {£0.10, £0.20, …, £3.90} is announced to the players. The first mover then has 120 seconds to position sliders on a computer screen (see GP for a more detailed discussion of the slider task). The number of correctly positioned sliders is the first mover's points score, and is denoted e_1. The second mover is then informed of the value of e_1 and has 120 seconds to position sliders. The number of sliders correctly positioned by the second mover is denoted e_2. At the end of the game one of the players wins the prize and the other player gets nothing. The second mover wins with probability $(e_2 - e_1 + 50)/100$. At the end of each round, each participant learned her own and her pair member's points score, her probability of winning the prize and whether she was the winner or loser in that round.

The ASOCIAL treatment removes the scope for interpersonal comparisons by converting this two-player game into an individual decision-making task with as few changes as possible. At the beginning of the game a prize and a "given number", n, is announced. The player then has 120 seconds to position sliders. For convenience we refer to this player as the second mover and her number of correctly positioned sliders as e_2 (though of course, there is no first mover). At the end of the game the second mover wins the prize with probability $(e_2 - n + 50)/100$. We used the values of e_1 and the realized prize values from the SOCIAL treatment to provide the given numbers and prizes in the ASOCIAL treatment.

To see the difference between treatments as experimental participants saw it we reproduce the slider screen heading seen by second movers in Figure 1. Panel (a) presents the information displayed in the SOCIAL treatment and panel (b) shows the information

displayed to the subjects (who acted as if they were second movers) in the ASOCIAL treatment. The key differential information has been *italicized* (but not in the experiment).

FIGURE 1
Key Differential Information for Second Movers in the Two Treatments

(a) SOCIAL

The prize in pounds for this round is: …
The *first mover's points score* was: …
Currently, your points score is: …

(b) ASOCIAL

The prize in pounds for this round is: …
The *given number* for this round is: …
Currently, your points score is: …

Unlike in the SOCIAL treatment where the second movers knew that the first movers were real human participants who were participating in the same session, the participants in the ASOCIAL treatment were simply told that their probability of winning depended on their points score relative to a "given number". We did not tell subjects that this number was generated by the choice of a subject in an earlier session, as that might have introduced a social element into the ASOCIAL treatment. All references to other players were removed from the instructions. These procedures were adopted so that the second movers in the SOCIAL treatment and the subjects in the ASOCIAL treatment dealt with as similar a decision problem as possible *except for the presence of a rival*. Furthermore, in order to keep subjects' practical experiences with the slider task as similar as possible in both treatments, the participants in the ASOCIAL treatment were asked to wait two minutes before they started their tasks just as second movers had to wait two minutes for their paired first movers to finish the task before they started their own tasks in the SOCIAL treatment.

A. Differences between Waves

In the first wave we used the GP software to run our SOCIAL sessions.[3] However, after observing that average effort (i.e., correctly positioned sliders) was systematically lower than in GP we realized that the visual length of each slider was slightly shorter than in GP's experiment because of the smaller screen size of the computer monitors in the CeDEx lab. This made the task somewhat more difficult for our subjects. Therefore, in the second wave of sessions we modified the slider screen so that the visual length of each slider would be exactly the same as in GP's original experiment. The third wave was the same as the second with three exceptions. First, instead of allowing the in-built random number generator to

[3] Available for download at https://www.aeaweb.org/aer/data/feb2012/20100346_data.zip.

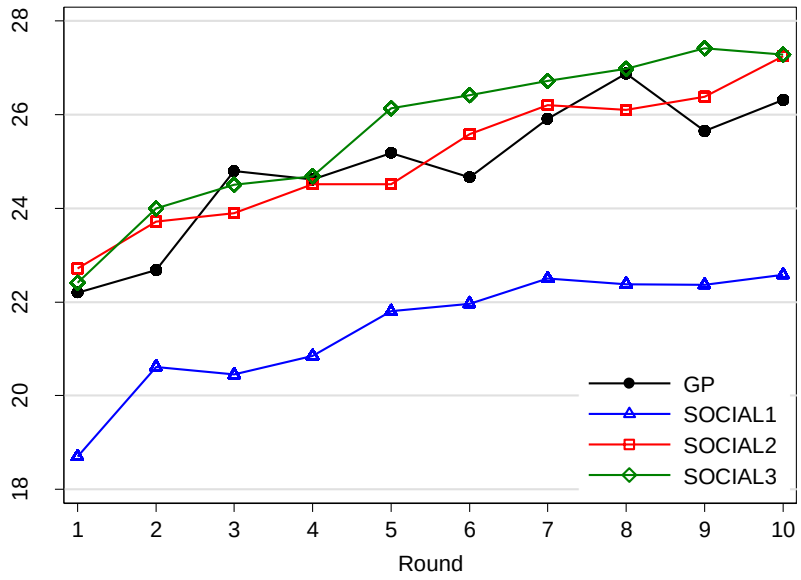
draw the prizes in the SOCIAL sessions, we used the realized prize values from GP.[4] Second, we only recruited inexperienced participants who had taken part in at most one other experiment. Third, we conducted all experimental sessions on weekdays at the same time of the day (14:00 ~ 15:30). These exceptions were made to enhance comparability with GP.

IV. RESULTS

A. First Mover Effort

There are strong round effects in the data. This is seen in Figure 2, which shows average first mover effort by round for each wave (and, for comparison, in GP).[5] In our first wave first mover effort was systematically lower than in GP. After modifying the slider screen for the second and third waves, average effort, and the development of effort across rounds, was much more in line with GP.

FIGURE 2
Development of First Mover Effort



[4] Although we used the prize realizations from the GP experiment we decided to retain the GP instructions. These stated "In each paying round, there will be a prize which you may win. Each prize will be chosen randomly at the beginning of the round and will be between £0.10 and £3.90." We might instead have explained that the prize draws were made in an earlier experiment, but we decided that explaining this to subjects would be potentially confusing. In either case the subjects would learn the outcome of the random draw at the beginning of the round.

[5] The GP data are available for download at https://www.aeaweb.org/articles?id=10.1257/aer.102.1.469.

Note that Figure 2 does not condition efforts on prize values. In order to do this we report random effect regressions, including round dummies to capture round effects. The results are reported in Table 1. Our estimates are very similar across all three waves and, as expected, first movers supply more effort when the prize is higher. Notice, however, that our estimate of the prize effect is somewhat lower than in GP.

TABLE 1
Random Effects Regressions for First Mover Effort

	GP	SOCIAL1	SOCIAL2	SOCIAL3
	(1)	(2)	(3)	(4)
Prize	0.670***	0.230**	0.243**	0.282**
	(0.153)	(0.110)	(0.102)	(0.126)
Intercept	20.896***	18.284***	22.240***	21.868***
	(0.908)	(0.588)	(0.630)	(0.639)
σ_ω	5.401	3.226	3.803	3.262
σ_ε	3.873	2.828	2.632	3.202
N × R	600	600	600	600
Hausman test for random versus fixed effects	$\chi^2(10)$ = 0.00 p = 1.000	$\chi^2(10)$ = 0.42 p = 1.000	$\chi^2(10)$ = 1.88 p = 0.997	$\chi^2(10)$ = 2.01 p = 0.996

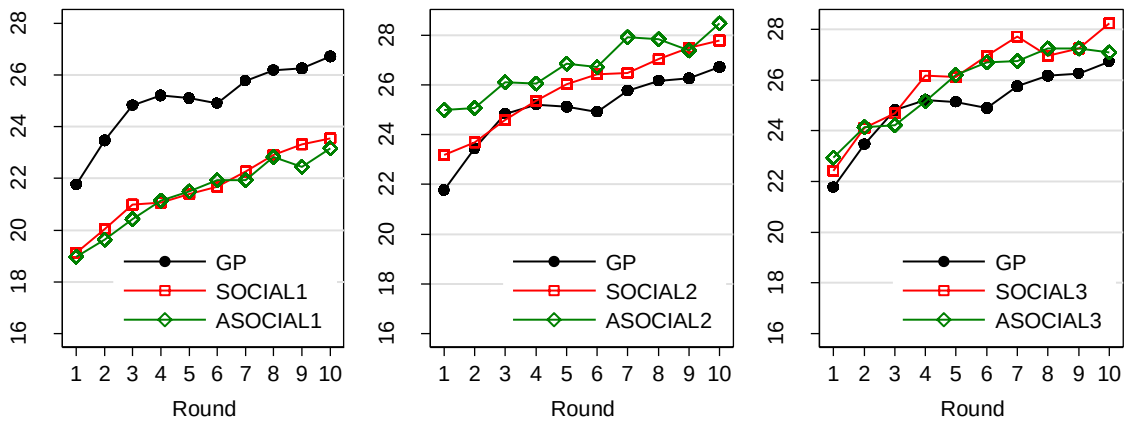
Notes: σ_ω denotes the standard deviation of the time invariant individual specific random effects and σ_ε denotes the standard deviation of the time varying idiosyncratic errors, which are i.i.d. over rounds and first movers. Standard errors are in parentheses. Asterisks denote p < 0.01 (***), p < 0.05 (**), and p < 0.10 (*). Round dummies (with the first round the omitted category) are included and are jointly significant at the 1% level in all cases.

B. Second Mover Effort

Figure 3 shows the development of average second mover effort over time in each of the three waves.[6] For the sake of easy comparison we include average GP second mover efforts in each panel. We find that second mover effort is very similar in SOCIAL and ASOCIAL in each of the three waves. With the exception of the first wave, average second mover efforts tend to be somewhat higher in our data than in GP.

[6] One participant from the first wave of the ASOCIAL treatment, one participant from the second wave of the ASOCIAL treatment and one second mover from the third wave of the SOCIAL treatment are dropped from our data analysis because they appear to have been unable to position any slider correctly. GP also found one second mover did not position any slider correctly in their experimental sample and drop this participant from their main data analysis. Neither our, nor their, main findings are affected by the inclusion or exclusion of these participants.

FIGURE 3
Development of Second Mover Effort in the Three Waves



Recall that disappointment aversion predicts that a second mover would respond to higher first mover effort by decreasing her effort and even more so when competing for a higher prize. To test this discouragement effect, we use the same random effects panel data regression as in GP. Table 2 reports the estimates for each wave in SOCIAL and ASOCIAL.

Contrary to GP's estimates, which are reproduced in Column (1), the coefficients on the regressors are generally insignificant: of 6x3 reported coefficients only two are significantly different from zero at the 10% level. To test whether second mover effort is neutral with respect to first mover effort, we test the joint significance of the coefficients on e_1 and Prize*e_1. In only one out of the six cases, ASOCIAL1, is there a significant effect at the 10% level, and here the effect differs from GP in that there is a stronger discouragement effect at *lower* prize levels. Thus, we find only very limited evidence that second mover behavior is influenced by first mover effort, and we do not find the discouragement effect predicted by disappointment aversion. Note, however, that we find weak incentive effects in general: we also tested whether second mover efforts were sensitive to prizes (i.e., we tested the joint significance of Prize and Prize*e_1) and found a significant effect at the 10% level in only two cases (ASOCIAL1 and SOCIAL3; see Table 2).

TABLE 2
Random Effects Regressions for Second Mover Effort

	GP	SOCIAL1	ASOCIAL1	SOCIAL2	ASOCIAL2	SOCIAL3	ASOCIAL3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
e_1	0.044	0.019	-0.096*	0.007	-0.006	-0.081	-0.008
	(0.049)	(0.045)	(0.051)	(0.051)	(0.042)	(0.057)	(0.049)
Prize	1.639***	0.408	-0.207	0.268	-0.176	-0.901	-0.286
	(0.602)	(0.452)	(0.510)	(0.577)	(0.470)	(0.626)	(0.537)
Prize * e_1	-0.049**	-0.016	0.020	-0.006	0.014	0.044*	0.018
	(0.023)	(0.021)	(0.023)	(0.023)	(0.019)	(0.024)	(0.021)
Intercept	19.777***	18.585***	20.454***	22.749***	24.849***	24.100***	22.915***
	(1.400)	(1.100)	(1.169)	(1.423)	(1.252)	(1.551)	(1.428)
σ_ω	4.288	3.760	2.768	3.759	4.688	3.285	4.847
σ_ε	3.852	2.473	2.777	3.003	2.429	3.173	2.753
H0: no e_1 effect	$\chi^2(2)$ = 7.09	$\chi^2(2)$ = 0.75	$\chi^2(2)$ = 5.28	$\chi^2(2)$ = 0.09	$\chi^2(2)$ = 1.48	$\chi^2(2)$ = 3.35	$\chi^2(2)$ = 1.97
	p = 0.029	p = 0.687	p = 0.071	p = 0.956	p = 0.477	p = 0.188	p = 0.374
H0: no prize effect	$\chi^2(2)$ = 12.08	$\chi^2(2)$ = 1.13	$\chi^2(2)$ = 4.84	$\chi^2(2)$ = 1.18	$\chi^2(2)$ = 4.24	$\chi^2(2)$ = 6.15	$\chi^2(2)$ = 3.49
	p = 0.002	p = 0.568	p = 0.089	p = 0.555	p = 0.120	p = 0.046	p = 0.175
N × R	590	600	590	600	590	590	600
Hausman test for random versus fixed effects	$\chi^2(12)$ = 2.60	$\chi^2(12)$ = 1.61	$\chi^2(12)$ = 0.08	$\chi^2(12)$ = 0.49	$\chi^2(12)$ = 0.05	-	$\chi^2(12)$ = 1.06
	p = 0.998	p = 1.000	p = 1.000	p = 1.000	p = 1.000	-	p = 1.000

Notes: σ_ω denotes the standard deviation of the time invariant individual specific random effects and σ_ε denotes the standard deviation of the time varying idiosyncratic errors, which are i.i.d. over rounds and second movers. Standard errors are in parentheses. Asterisks denote p < 0.01 (***), p < 0.05 (**), and p < 0.10 (*). Round dummies (with the first round the omitted category) are included and are jointly significant at the 1% level in all cases. The Hausman test statistic is missing in SOCIAL3 because the estimated covariance matrix of the difference between random and fixed effects estimators is not invertible.

C. Structural Estimation

We also repeated the structural estimation of disappointment aversion parameters following GP, using their preferred specification (GP, Table 3, p. 487). Our estimates (including a re-estimation using GP data) are reported in our Table 3 below. For our purposes the key parameter is λ_2, which measures the difference between the marginal utility of earnings in the loss and the gain domain (where expected earnings define the reference point) for second movers. Disappointment aversion is reflected in a positive λ_2. The GP model assumes a distribution of λ_2 in the population, with mean $\tilde{\lambda}_2$ and variance σ_λ. Whereas the estimate of $\tilde{\lambda}_2$ is positive and significant in GP, our estimates are much lower and generally insignificant. Indeed, in four of the six cases, the estimate is negative. In the second wave of ASOCIAL the negative estimate of $\tilde{\lambda}_2$ is significant. This is an unexpected finding and taken

at face value it would mean that subjects weight gains more heavily than losses. We are reluctant to put much weight on this finding, as it is clear from Table 3 that the estimates vary considerably across waves.

TABLE 3
Structural Estimates of Disappointment Aversion

	GP	SOCIAL1	ASOCIAL1	SOCIAL2	ASOCIAL2	SOCIAL3	ASOCIAL3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\tilde{\lambda}_2$	1.758***	0.458	0.856	-0.591	-1.929***	-0.124	-0.629
	(0.640)	(0.446)	(1.198)	(0.647)	(0.490)	(0.687)	(0.493)
σ_λ	1.868***	0.777*	0.780	0.794	1.408***	2.253	0.680
	(0.634)	(0.467)	(1.310)	(0.507)	(0.243)	(1.500)	(0.690)
$de_2/de_1(v = £0.10, low\ \lambda_2)$	-0.000	0.000	-0.000	0.000	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
$de_2/de_1(v = £2, average\ \lambda_2)$	-0.028**	-0.006	-0.015	-0.001	0.000	-0.003	-0.000
	(0.013)	(0.006)	(0.016)	(0.003)	(0.000)	(0.007)	(0.002)
$de_2/de_1(v = £3.90, high\ \lambda_2)$	-0.107***	-0.031*	-0.059	-0.024	-0.036***	-0.068	-0.019
	(0.034)	(0.018)	(0.064)	(0.018)	(0.011)	(0.051)	(0.017)
N × R	590	600	590	600	590	590	600
OI test	13.435	33.752	33.450	27.076	22.691	29.708	30.043
	[0.858]	[0.028]	[0.030]	[0.133]	[0.304]	[0.075]	[0.069]

Notes: The estimation method is Method of Simulated Moments and follows the preferred model in GP, Table 3. Reaction functions and gradients are produced by simulation methods with the gradients evaluated at $e_1 = 20$. Low, average, high λ_2 refer to the 20th, 50th, and 80th percentiles of the distribution of λ_2. Standard errors are in parentheses. Asterisks denote p < 0.01 (***), p < 0.05 (**), and p < 0.10 (*). Newey overidentification (OI) test statistics are reported with p-values shown in brackets.

D. Treatment Differences

Since our main focus is whether interpersonal comparisons affect behavior, we also compared second mover behavior across our SOCIAL and ASOCIAL treatments. To do this our first approach exploits the fact that in our design each SOCIAL second mover has a counterpart in the ASOCIAL treatment who had to complete the same slider task for the same prize and same monetary incentives. For each SOCIAL second mover we take the average number of sliders positioned across all ten paying rounds, and compare this average to that of their counterpart in the ASOCIAL treatment, using a Wilcoxon signed-ranks test. In none of the waves do we observe a significant treatment effect (first wave p = 0.497, second wave p = 0.280, third wave p = 0.979). Second, we re-ran random effects regressions of second mover efforts on prizes, e_1 and an interaction term for the pooled SOCIAL + ASOCIAL samples, adding treatment dummies and treatment interactions. The results are in Table 4. In

addition, we report the test of the joint significance of the treatment dummies and treatment interactions.

TABLE 4
Random Effects Regressions for Second Mover Effort (Pooling SOCIAL and ASOCIAL)

	Wave 1	Wave 2	Wave 3	All waves
	(1)	(2)	(3)	(4)
e_1	0.023	0.015	-0.080	-0.022
	(0.047)	(0.046)	(0.053)	(0.027)
Prize	0.454	0.231	-0.995*	-0.200
	(0.476)	(0.524)	(0.582)	(0.287)
Prize * e_1	-0.018	-0.004	0.048**	0.014
	(0.022)	(0.021)	(0.022)	(0.012)
ASOCIAL	2.068	1.642	-2.027	0.379
	(1.567)	(1.839)	(2.060)	(1.012)
ASOCIAL * e_1	-0.124*	-0.030	0.070	-0.015
	(0.067)	(0.066)	(0.074)	(0.038)
*ASOCIAL * Prize*	-0.729	-0.380	0.789	-0.010
	(0.673)	(0.741)	(0.816)	(0.406)
*ASOCIAL * Prize* * e_1	0.042	0.016	-0.032	0.003
	(0.031)	(0.029)	(0.032)	(0.017)
Wave 1				-4.578***
				(0.017)
Intercept	18.499***	22.983***	24.527***	23.677***
	(1.115)	(1.316)	(1.476)	(0.742)
σ_ω	3.307	4.245	4.147	3.897
σ_ε	2.622	2.739	2.971	2.784
H0: no *treatment* effect	$\chi^2(4) = 4.99$ $p = 0.288$	$\chi^2(4) = 1.70$ $p = 0.790$	$\chi^2(4) = 1.23$ $p = 0.873$	$\chi^2(4) = 0.69$ $p = 0.953$
N × R	1190	1190	1190	3570
Hausman test for random versus fixed effects	- -	$\chi^2(15) = 0.38$ $p = 1.000$	- -	$\chi^2(15) = 5.29$ $p = 0.989$

Notes: σ_ω denotes the standard deviation of the time invariant individual specific random effects and σ_ε denotes the standard deviation of the time varying idiosyncratic errors, which are i.i.d. over rounds and second movers. Standard errors are in parentheses. Asterisks denote $p < 0.01$ (***), $p < 0.05$ (**), and $p < 0.10$ (*). Round dummies (with the first round the omitted category) are included and are jointly significant at the 1% level in all cases. The Hausman test statistic is missing in Wave 1 and Wave 3 because the estimated covariance matrix of the difference between random and fixed effects estimators is not invertible

In none of the three waves is there a significant treatment effect. We also find neither a treatment effect nor a significant influence of e_1 and prizes when we pool all waves (including a dummy variable for the first wave to capture the level shift caused by modifying the slider screen (see Section 3A)).

V. DISCUSSION AND CONCLUSION

In this paper we have tested the hypothesis that competing against another person is not the same as competing against Nature. Our experiments reject this hypothesis for the environment in which we studied this question – GP's two-person sequential effort competition using the slider task as a real effort performance measurement. We conclude that social comparison effects do not influence estimates of disappointment aversion. Of course, this does not necessarily imply that our finding is generalizable to other environments or real effort tasks.

An unexpected finding of our experiment is that, in contrast to GP, we failed to find support for disappointment aversion in any wave of any treatment. Despite this being a "null result" it is nevertheless important to report. Our results, taken together with GP, suggest that evidence supporting models of expectation-based reference dependence (e.g. Kőszegi and Rabin (2007)) is mixed. These models assume individuals evaluate gains and losses asymmetrically around a reference point, where the reference point is expectations-based and depends on the action taken. The assumption that individuals, in making a choice, take into account that the choice will affect the reference point about which gains and losses are evaluated seems quite sophisticated, but whether actual behavior reflects such behavioral assumptions is an empirical question. Whereas GP find support, this is not echoed in our study. Similarly, Abeler, et al. (2011) and Ericson and Fuster (2011) find choices consistent with endogenous expectations-based reference points, whereas Holzmeister, et al. (2015) and Altmejd, et al. (2015) who replicated Abeler, et al. (2011), and Ericson and Fuster (2011), respectively, find no or only weakly significant support. Gneezy, et al. (forthcoming) also replicated the Abeler, et al. (2011) design, although in additional treatments they found important deviations from expectations-based reference dependence.

Another unexpected finding of our study was that in all three of our waves we observed much weaker prize effects in first movers than GP, and, contrary to GP, almost no prize effects in our second movers. These weaker prize effects may explain the absence of discouragement effects. If second movers are not responsive to monetary prizes, either because they place little value on the prize or because their marginal cost of effort is too high then it is perhaps not surprising that they are unresponsive to first mover efforts. It is worth noting, however, that our observed means and dynamics in effort over time are very similar to GP; if subjects have a positive marginal cost of effort and place no value on the prize they

should not be positioning sliders at all. Our result of a weak or no prize effect is consistent with Araujo, et al. (2016) who perform a between-subject comparison of slider task performance varying incentives and find only weak incentive effects; There are, however, other studies that do find that slider positioning efforts respond positively and significantly to increases in financial incentives (e.g. Neckermann, Warnke and Bradler (2014); Abeler and Jäger (2015); Lee (2015)). Note that non-monotonic responses to changes in piece rates are observed in between-subject studies of other real-effort tasks (e.g. Gneezy and Rustichini (2000); Ariely, et al. (2009)).

In conclusion, we believe our paper makes two contributions to the literature. Firstly, we have shown that social comparison effects do not matter in the contest we studied. Secondly, our study contributes to recent replication efforts in the experimental economics literature (Camerer, et al. (2016))[7] to establish a body of knowledge about results that are robust to replication. In particular, we show that in the contest we study, reference-point effects are surprisingly weak.

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ONLINE APPENDIX for

DISAPPOINTMENT AVERSION AND SOCIAL COMPARISONS IN A REAL-EFFORT COMPETITION

SIMON GÄCHTER, LINGBO HUANG, and MARTIN SEFTON

This online appendix documents the instructions for the experiments reported in this paper. For all SOCIAL treatments we used the original GP instructions.[8] We also used the original z-Tree code developed by GP in SOCIAL1.[9] In SOCIAL2 and SOCIAL3 we modified the slider task to make the task easier, and in SOCIAL3 we replaced the code using a random number generator to select prizes with the actual prizes realized in the GP experiment.

Instructions for the SOCIAL Treatments (GP)

Please open the brown envelope you have just collected. I am reading from the four page instructions sheet which you will find in your brown envelope. **[Open brown envelope]**

Thank you for participating in this session. There will be a number of pauses for you to ask questions. During such a pause, please raise your hand if you want to ask a question. Apart from asking questions in this way, you must not communicate with anybody in this room. Please now turn off mobile phones and any other electronic devices. These must remain turned off for the duration of this session. Are there any questions?

You have been allocated to a computer booth according to the number on the card you selected as you came in. You must not look into any of the other computer booths at any time during this session. As you came in you also selected a white sealed envelope. Please now open your white envelope. **[Open white envelope]**

Each white envelope contains a different four digit Participant ID number. To ensure anonymity, your actions in this session are linked to this Participant ID number and at the end of this session you will be paid by Participant ID number. You will be paid a show up fee of £4 together with any money you accumulate during this session. The amount of money you accumulate will depend partly on your actions, partly on the actions of others and partly on chance. All payments will be made in cash in another room. Neither I nor any of the other participants will see how much you have been paid. Please follow the instructions that will appear shortly on your computer screen to enter your four digit Participant ID number. **[Enter four digit Participant ID number]** Please now return your Participant ID number to its envelope, and keep this safe as your Participant ID number will be required for payment at the end.

This session consists of 2 practice rounds, for which you will not be paid, followed by 10 paying rounds with money prizes. In each round you will undertake an identical task lasting 120 seconds. The task will consist of a screen with 48 sliders. Each slider is initially positioned at 0 and can be moved as far as 100. Each slider has a number to its right showing its current position. You can use the mouse in any way you like to move each slider. You can readjust the position of each slider as many

[8] Available for download at https://www.aeaweb.org/aer/data/feb2012/20100346_app.pdf.
[9] Available for download at: https://www.aeaweb.org/aer/data/feb2012/20100346_data.zip.

times as you wish. Your "points score" in the task will be the number of sliders positioned at exactly 50 at the end of the 120 seconds. Are there any questions?

Before the first practice round, you will discover whether you are a "First Mover" or a "Second Mover". You will remain either a First Mover or a Second Mover for the entirety of this session.

In each round, you will be paired. One pair member will be a First Mover and the other will be a Second Mover. The First Mover will undertake the task first, and then the Second Mover will undertake the task. The Second Mover will see the First Mover's points score before starting the task.

In each paying round, there will be a prize which one pair member will win. Each pair's prize will be chosen randomly at the beginning of the round and will be between £0.10 and £3.90. The winner of the prize will depend on the difference between the First Mover's and the Second Mover's points scores and some element of chance. If the points scores are the same, each pair member will have a 50% chance of winning the prize. If the points scores are not the same, the chance of winning for the pair member with the higher points score increases by 1 percentage point for every increase of 1 in the difference between the points scores, while the chance of winning for the pair member with the lower points score correspondingly decreases by 1 percentage point. The table at the end of these instructions gives the chance of winning for any points score difference. Please look at this table now. **[Look at table]** Are there any questions?

During each task, a number of pieces of information will appear at the top of your screen, including the time remaining, the round number, whether you are a First Mover or a Second Mover, the prize for the round and your points score in the task so far. If you are a Second Mover, you will also see the points score of the First Mover you are paired with.

After both pair members have completed the task, each pair member will see a summary screen showing their own points score, the other pair member's points score, their probability of winning, the prize for the round and whether they were the winner or the loser of the round.

We will now start the first of the two practice rounds. In the practice rounds, you will be paired with an automaton who behaves randomly. Before we start, are there any questions?

Please look at your screen now. **[First practice round]** Before we start the second practice round, are there any questions? Please look at your screen now. **[Second practice round]** Are there any questions?

The practice rounds are finished. We will now move on to the 10 paying rounds. In every paying round, each First Mover will be paired with a Second Mover. The pairings will be changed after every round and pairings will not depend on your previous actions. You will not be paired with the same person twice. Furthermore, the pairings are done in such a way that the actions you take in one round cannot affect the actions of the people you will be paired with in later rounds. This also means that the actions of the person you are paired with in a given round cannot be affected by your actions in earlier rounds. (If you are interested, this is because you will not be paired with a person who was paired with someone who had been paired with you, and you will not be paired with a person who was paired with someone who had been paired with someone who had been paired with you, and so on.) Are there any questions?

We will now start the 10 paying rounds. There will be no pauses between the rounds. Before we start the paying rounds, are there any remaining questions? There will be no further opportunities to ask questions. Please look at your screen now. **[10 paying rounds]**

The session is now complete. Your total cash payment, including the show up fee, is displayed on your screen. Please leave the room one by one when asked to do so to receive your payment. Remember to bring the envelope containing your four digit Participant ID number with you but please leave all other materials on your desk. Thank you for participating.

Difference in points score	Chance of winning prize for Mover with higher score	Chance of winning prize for Mover with lower score
0	50%	50%
1	51%	49%
2	52%	48%
3	53%	47%
4	54%	46%
5	55%	45%
6	56%	44%
7	57%	43%
8	58%	42%
9	59%	41%
10	60%	40%
11	61%	39%
12	62%	38%
13	63%	37%
14	64%	36%
15	65%	35%
16	66%	34%
17	67%	33%
18	68%	32%
19	69%	31%
20	70%	30%
21	71%	29%
22	72%	28%
23	73%	27%
24	74%	26%
25	75%	25%
26	76%	24%
27	77%	23%
28	78%	22%
29	79%	21%
30	80%	20%
31	81%	19%
32	82%	18%
33	83%	17%
34	84%	16%
35	85%	15%
36	86%	14%
37	87%	13%
38	88%	12%
39	89%	11%
40	90%	10%
41	91%	9%
42	92%	8%
43	93%	7%
44	94%	6%
45	95%	5%
46	96%	4%
47	97%	3%
48	98%	2%
49	Not Possible as there are only 48 sliders	
50	Not possible as there are only 48 sliders	

Instructions for the ASOCIAL Treatments

Please open the brown envelope you have just collected. I am reading from the four page instructions sheet which you will find in your brown envelope. **[Open brown envelope]**

Thank you for participating in this session. There will be a number of pauses for you to ask questions. During such a pause, please raise your hand if you want to ask a question. Apart from asking questions in this way, you must not communicate with anybody in this room. Please now turn off mobile phones and any other electronic devices. These must remain turned off for the duration of this session. Are there any questions?

You have been allocated to a computer booth according to the number on the card you selected as you came in. You must not look into any of the other computer booths at any time during this session. As you came in you also selected a white sealed envelope. Please now open your white envelope. **[Open white envelope]**

Each white envelope contains a different four digit Participant ID number. To ensure anonymity, your actions in this session are linked to this Participant ID number and at the end of this session you will be paid by Participant ID number. You will be paid a show up fee of £4 together with any money you accumulate during this session. The amount of money you accumulate will depend partly on your actions and partly on chance. All payments will be made in cash in another room. Neither I nor any of the other participants will see how much you have been paid. Please follow the instructions that will appear shortly on your computer screen to enter your four digit Participant ID number. **[Enter four digit Participant ID number]** Please now return your Participant ID number to its envelope, and keep this safe as your Participant ID number will be required for payment at the end.

This session consists of 2 practice rounds, for which you will not be paid, followed by 10 paying rounds with money prizes. In each round you will undertake an identical task lasting 120 seconds. The task will consist of a screen with 48 sliders. Each slider is initially positioned at 0 and can be moved as far as 100. Each slider has a number to its right showing its current position. You can use the mouse in any way you like to move each slider. You can readjust the position of each slider as many times as you wish. Your "points score" in the task will be the number of sliders positioned at exactly 50 at the end of the 120 seconds. Are there any questions?

In each paying round, there will be a prize which you may win. Each prize will be chosen randomly at the beginning of the round and will be between £0.10 and £3.90. Whether you will win the prize depends on the difference between your points score and a given number, and some element of chance. The given number will change each round. If your points score is equal to this given number, you will have a 50% chance of winning the prize. If your points score differs from this given number, your chance of winning increases by 1 percentage point for every increase of 1 in the difference between your points scores and the given number, while your chance of winning correspondingly decreases by 1 percentage point for every decrease of 1 between your points score and the given number. The table at the end of these instructions gives the chance of winning for any difference between your points score and a given number. Please look at this table now. **[Look at table]** Are there any questions?

During each task, a number of pieces of information will appear at the top of your screen, including the time remaining, the round number, the prize for the round, the given number and your points score in the task so far.

After you have completed the task, you will see a summary screen showing your points score, the given number, your probability of winning, the prize for the round and whether you won the prize or not in the round.

We will now start the first of the two practice rounds. Before we start, are there any questions?

Please look at your screen now. **[First practice round]** Before we start the second practice round, are there any questions? Please look at your screen now. **[Second practice round]** Are there any questions?

The practice rounds are finished. We will now start the 10 paying rounds. There will be no pauses between the rounds. Before we start the paying rounds, are there any remaining questions? There will be no further opportunities to ask questions. Please look at your screen now. **[10 paying rounds]**

The session is now complete. Your total cash payment, including the show up fee, is displayed on your screen. Please leave the room one by one when asked to do so to receive your payment. Remember to bring the envelope containing your four digit Participant ID number with you but please leave all other materials on your desk. Thank you for participating.

Difference in your points score and the given number	Chance of winning prize if your points score is higher than the given number	Chance of winning prize if your points score is lower than the given number
0	50%	50%
1	51%	49%
2	52%	48%
3	53%	47%
4	54%	46%
5	55%	45%
6	56%	44%
7	57%	43%
8	58%	42%
9	59%	41%
10	60%	40%
11	61%	39%
12	62%	38%
13	63%	37%
14	64%	36%
15	65%	35%
16	66%	34%
17	67%	33%
18	68%	32%
19	69%	31%
20	70%	30%
21	71%	29%
22	72%	28%
23	73%	27%
24	74%	26%
25	75%	25%
26	76%	24%
27	77%	23%
28	78%	22%
29	79%	21%
30	80%	20%
31	81%	19%
32	82%	18%
33	83%	17%
34	84%	16%
35	85%	15%
36	86%	14%
37	87%	13%
38	88%	12%
39	89%	11%
40	90%	10%
41	91%	9%
42	92%	8%
43	93%	7%
44	94%	6%
45	95%	5%
46	96%	4%
47	97%	3%
48	98%	2%
49	Not Possible as there are only 48 sliders	
50	Not possible as there are only 48 sliders	