Salient Gender Identity and Power Imbalance in a Group Contest

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Abstract

The metaphor "glass ceiling" describes invisible barriers through which women can see elite positions, but cannot reach them. Often, this effect is associated with a lower degree of competitiveness on the part of women, which prevents them from filling high-ranking positions. We design a group contest experiment and manipulate the salience of social identity to investigate contest investments for male and female participants. Using a between-subjects design, we vary the degree of power for each gender identity group to investigate if being in a (dis)advantaged position to compete interacts with the gender identity and the salience thereof. We find that larger, dominant groups invest more into the contest. Male and female individuals react very differently to the salience of gender identity in our experiment. While female participants invest less into the contest when gender identities are salient, this is not true for male participants. We can rule out social identity or in-group bias as driving force for this effect.

Keywords— Group Contest; Social Identity; Gender Identity; Asymmetric Groups; Group Size Paradox

1 Introduction

Applications for group contests range from conflict related to language, religion or culture, to political competition and collective rent-seeking.[1] In these situations, a collection of individuals compete for a prize via irreversible and costly investments. In the underlying applications and the associated model, each member of the winning group enjoys a share of the spoils, often irrespective of or only weakly related to the individual effort. Within a group, this creates a trade-off: On the one hand, group members have the incentive to expend effort to win the prize, and on the other hand, each member has an incentive to keep resources to oneself. Importantly, investment has no productive value in group contests, but only influences the odds for winning the prize. Therefore, globally, higher efforts imply more inefficiency. For example, consider money spent on behalf of trade syndicates to lobby for government subsidies or to impose regulations on competitors to increase market share. The lobbying expenses do not add value to the economy in any way, directly or indirectly, except for the successful syndicate.

Group identity has been theorised to be one of the major components in initiating and escalating conflict (Sen, 2007). The associated social identity theory describes salient group identity to cause a blurring of the boundaries between personal and group welfare, leading to behaviour that bolsters group benefit at the expense of personal individualistic self interest (Tajfel, Turner, Austin, & Worchel, 1979). In intergroup relations, individuals place themselves and others in different categories based on perceived similarities and differences, and according to these categorisations identify others as either in-group or out-group members (Akerlof & Kranton, 2005; Basu, 2005; Akerlof & Kranton, 2010).[2] As a result of this identification, people discriminate in favour of the in-group and against the out-group. This has been a key concept to understand phenomena such as racial and political conflicts, as well as discrimination and many more (Abdelal, Herrera, Johnston, & McDermott, 2006). We study the effect of the salience of social identity on group conflict and how this interacts with competing groups' relative power.

Akerlof and Kranton (2000) have been among the first to introduce the concept of social identity into economic frameworks. By adopting a utility maximisation framework that incorporates an individual's self-identification, social identity helps understand the "microfoundation for earlier (discrimination) models."[3] To date there are only a few studies which incorporate social identity theory into contest games. Most prominently, Chowdhury, Jeon, and Ramalingam (2016) engage two homogenous groups – East Asians and Caucasians – in a group contest either with or without revealing the groups' racial composition. They find that revealing racial composition increases effort and decreases free riding significantly. This means that a salient real identity can escalate conflict, which is also predicted by social identity theory (Sen, 2007).[4]

[1] Dechenaux, Kovenock, and Sheremeta (2015) provide an extensive literature review, including applications and field studies on group contests.

[2] Such identification happens very early in life for some categories (Powlishta, Serbin, Doyle, & White, 1994).

[3] See Costa-Font and Cowell (2015); Li (2020) for a thorough review on social identity in economics.

[4] Similarly, Chakravarty, Fonseca, Ghosh, and Marjit (2016) report a small significant impact of social identity among Hindu villagers, yet none among Muslim villagers, in two-player group contest games. Sutter and Strassmair (2009) and Cason, Sheremeta, and Zhang (2012) use communication to trigger social identity in a group contest game. Both studies find that within, or between-group communication creates better coordination within and between the groups and less free riding within groups. An important point is

In our study we employ gender identity as social identity categorisation for three concrete reasons. *1)* Gender identity has been identified as an important group through which we define ourselves in daily life (Sen, 2007). *2)* Categorisation in terms of gender avoids identification problems. Observations of membership by gender are usually made without any error (Akerlof & Kranton, 2002). *3)* In many situations, males are found to be more aggressive and competitive (Croson & Gneezy, 2009; Gneezy, Niederle, & Rustichini, 2003), particularly when the conflict is physical and can sustain physical harm (Hay et al., 2011). Prior results from the contest game literature, by contrast, suggest that female participants invest more resources into the contest, i.e. compete more aggressively (Price & Sheremeta, 2015; Chowdhury et al., 2016; Heine & Sefton, 2018).[5] We investigate if this phenomenon of female competitiveness in this context of between group competition is triggered via group identity (as results from Cadsby, Servátka, & Song, 2013, suggest). This issue is of significant economic importance as group contests (e.g., for promotion decisions) are ubiquitous within firms, especially among top management.

Many related applications in the field, such as competition for promotion or tenure, are characterised by a (power) imbalance between social identity groups. Particularly considering gender identity, in many workplace settings, males are overrepresented both in numbers and in power (Shor, Van De Rijt, Miltsov, Kulkarni, & Skiena, 2015; Lang, 2010; Cotter, Hermsen, & Vanneman, 2000). In other areas like the service sector or social programme jobs, by contrast, women tend to be strongly overrepresented (Barone & Assirelli, 2020; Hurst, Gibbon, & Nurse, 2016). We study how the salience of social identity, in particular gender identity, influences the degree of engagement into a competition between groups and how being in an advantaged or disadvantaged position interacts with this.

We start by devising a theoretical model on social identity in a group contest in which a participant maximises individual utility as a weighted sum of own and others' utility (similar to Y. Chen & Li, 2009; Zaunbrecher & Riedl, 2016; Kolmar & Wagener, 2019). We hypothesise that when there is more weight placed on social identity, this leads to an increase in investment into the contest. We then conduct an experiment in which we vary the salience of social identity via the instructions, the positioning of a gender identity survey and the representation of participants by gendered or neutral emojis. Our results indicate that advantaged groups invest significantly more into the contest and that female groups invest less into the contest when gender identities are salient.

The remainder of this article is structured as follows. First, in Section 2 we explain the experimental design. Then, in Section 3, we discuss the theoretical framework by means of a social preferences model, from which we derive our hypotheses. We then present the results of our experiment in Section 4, before concluding in Section 5.

that this improved coordination happens even when it reduces, rather than enhances, efficiency i.e. higher over-spending in the within-group communication treatment. Drawing on social identity theory, Cason et al. (2012) interpret that "intra-group communication increases subjects' identification with their group and shifts their self-categorization from the individual to the group level, leading them to coordinate better with their group and compete more with the opponent group."

[5]For instance, in Chowdhury et al. (2016), the authors find that "the increase in conflict in a laboratory contest setting does not arise due to the behavior of a particular race, but due to the increase in efforts by females across racial groups." With the race treatment average efforts of the females increases from 11.718 to 18.265, compared to a slight increase from 11.523 to 12.407 in males.

2 Experimental Design

We model group competition using a repeated Tullock contest (Katz, Nitzan, & Rosenberg, 1990; Tullock, 1980) between two groups in partner matching. Figure 1 illustrates a round of the game for the Symmetric Control treatment, other treatment variations will be explained hereafter. Each player receives an individual endowment of $T_i = 60$ points per round, which they invest in the contest game to buy lottery tickets for their team for a price of one lottery ticket for one point. Endowment that is not invested will be added to the player's private account for that round. Players cannot accumulate funds for future rounds. The winning probability for a group is the sum of lottery tickets bought by the own group divided by the total amount of lottery tickets bought by both groups. If none of the players in both groups invest, one of the groups will win with equal chances. Once all investment decisions have been made, one ticket is drawn and the prize $z_i = 40$ goes to all players from the group with the winning ticket, the losing group receives nothing. Note that all players from the winning group receive the full prize, irrespective of their personal investment into the contest. The expected earnings of individual g from group A can be written as (equivalent for group B):

$$\pi_g\left(\sum_{i\in A} a_i, \sum_{j\in B} b_j\right) = T_i + \frac{\sum_{i\in A} a_i}{\sum_{i\in A} a_i + \sum_{j\in B} b_j} \cdot z_i - a_g \tag{1}$$

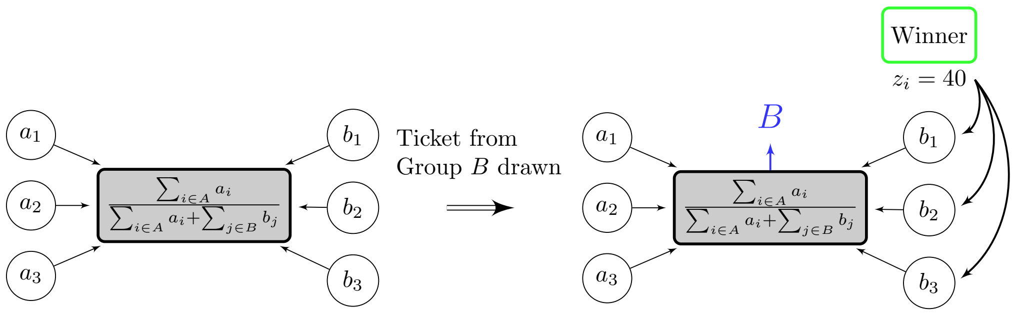


Figure 1: Groups of three ($a_{1,2,3}$ versus $b_{1,2,3}$) compete for a prize in a group contest. Suppose a winning ticket for Group B is drawn, then each player from that group receives the prize $z_i = 40$.

We explore the effect of social identity in a 3×2 experimental design. In all six treatments, participants were recruited such that each group consists of individuals from the same real social identity (as in Chowdhury et al., 2016). This means, each competing pair constitutes of one homogeneous group of participants with *female* gender identity competing against a group of participants with *male* gender identity.

Figure 2 provides an overview of our treatments. Between the treatments on the rows we vary the makeup of the groups. In the Symmetric treatments, groups of the same size – i.e. three female versus three male players – compete for the prize (as in Figure 1). In the Asymmetric Female treatments, five female participants compete against a group of three males. Equivalently, in the Asymmetric Male treatments, five male participants compete against a group of three females. As such, we vary whether groups are of equal size and power, or whether a certain social identity group is in an advantageous position and over-represented. This reflects phenomena in the field, in which certain (mostly male; sometimes female, for example in education) groups have more power or influence.

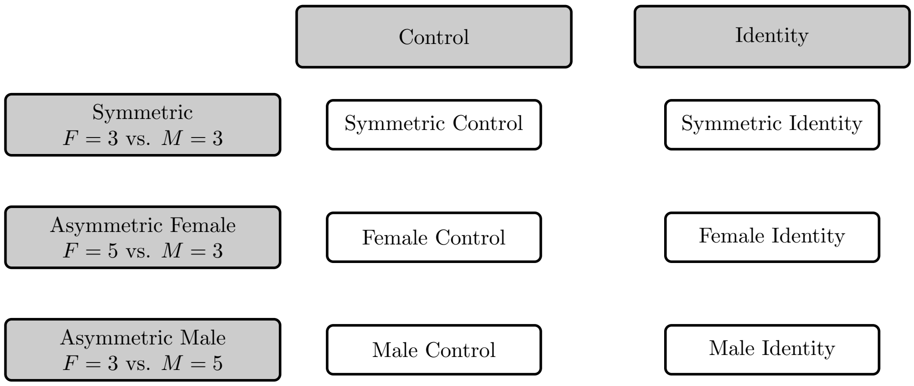


Figure 2: Overview of the Experimental Design. We apply a 3×2 design varying the salience of social identity on the one hand, and group size on the other hand.

Treatments in the two columns of Figure 2 differ in the salience of social identity. We vary salience in three ways, as visually summarised in Figure 3, where text in red font highlights the differences between the Control and Identity treatments. *First*, in the instructions for the Identity treatments we make explicit the social identity of group members, i.e. that this is a game of male versus female participants. *Second*, we vary the position of the Gender Identity Survey (Cameron, 2004) such that it comes either at the beginning of the experiment to prime gender identity, or at the end of the experiment.[6] The Gender Identity Survey serves another purpose: We are also interested in measuring the degree of identification with the own social identity, i.e. how much a participant's own identity overlaps with their gender identity. *Third*, we employ emojis that either reflect the gender identity group, or neutral ones, using emojis developed by OpenMoji (2020) (see Figure 4).[7]

As illustrated in Figure 3, the contest was repeated for 10 rounds, which allows us to observe if patterns are driven by behaviour from particular rounds only. Earnings from prior rounds cannot be saved for use in future rounds, instead participants receive a fixed endowment of 60 points in each round. At the end, one round will be selected for payment at random. This way, participants should treat each period as the payoff-relevant round, reducing potential hedging behaviour (Charness, Gneezy, & Halladay, 2016).

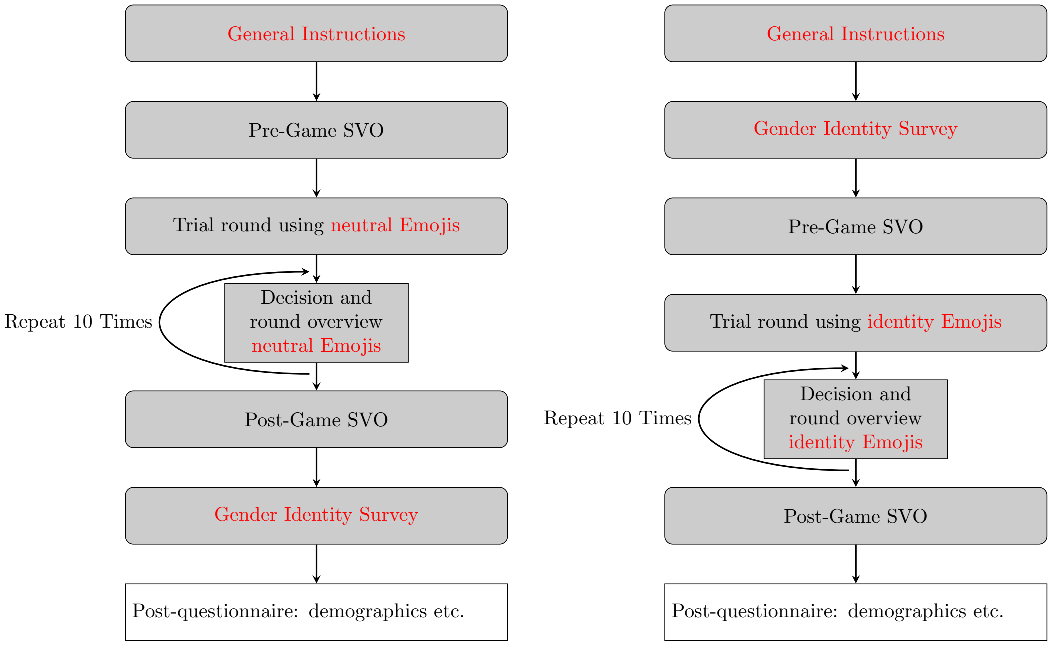
We programmed this computerised experiment in z-Tree by Fischbacher (2007) and conducted the sessions at CentERlab of Tilburg University, Netherlands, between November 2021 and September 2022.[8] A total of 350 individuals (average age 21.2 years, sd=3.47) participated in the study.[9] Participants sat in a cubicle, visually separated from each other. The experiment took about 60 minutes, including instructions and payment, average earnings were about €12.16. The following outlines the structure of the experiment in

[6] Cameron (2004) develops a three factor model representing social identity on three factors: centrality, ingroup affect, and ingroup ties. It is a twelve-item, partially reverse-scored Likert-type questionnaire including statements such as: *"I have a lot in common with other* men/women.*"* Please find a screen shot from this questionnaire in Figure 16.

[7] OpenMoji graphics are licensed under the Creative Commons Share Alike License 4.0 (CC BY-SA 4.0).

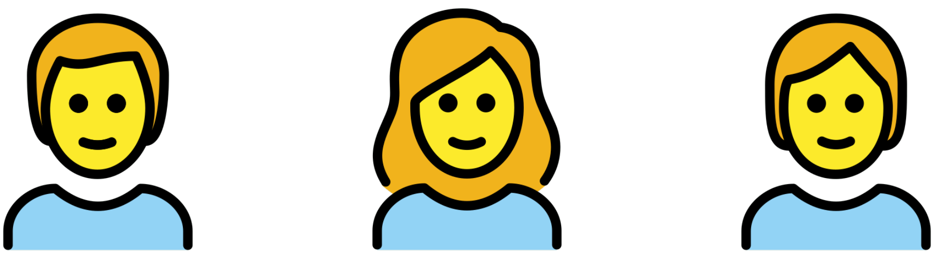
[8] Please find screen shots in Appendix A.

[9] Please find a detailed power analysis in Appendix C.



(a) Control Treatments **(b)** Identity Treatments

Figure 3: Experimental Setup. Control Treatments differ from Identity Treatments in elements highlighted with red font.



(a) Male Emoji **(b)** Female Emoji **(c)** Gender-neutral Emoji

Figure 4: Emojis used to prime gender social identity groups.

more detail (see also Figure 3). We adopted a recruitment strategy similar to the one in Chowdhury et al. (2016). Tilburg University's participant-database Sona allows us to use information on registered participants' gender identity for experiment invitations. As such, we used this information to recruit participants from each gender identity groups and applied the matching for each treatment.

2.1 The Structure of an Experimental Session

To make sure the gender identity matching was successful, participants started with a screen on demographics (gender identity, age, etc. See Figure 12). This allowed us to double check that the self-specified gender identity of participants when starting the experiment matches with what they have registered in the database. Next, participants received the instructions for the experiment, followed by a few questions about hypothetical game situations on screen to make sure participants completely understand the game. For the Identity treatments, the specific social identity of the group was made salient in the instructions and on the game screen. The emojis as in Figure 4 represented the players in the groups. While a neutral emoji, as in Sub-figure 4c represented participants in both Control treatments, players of the female and male gender identity groups were be represented by emojis as in Sub-figures 4b and 4a, respectively.

Before the contest, participants performed two social value orientation (SVO) tests, one with respect to someone from the *own* group and one with respect to someone from the *other* group. Each of the two tests consists of six different resource allocation decisions, based on Murphy, Ackermann, and Handgraaf (2011)'s slider measure.[10] The difference between giving to someone from the *own* group versus someone from the *other* group provides us with a measure for individual in-group bias. Figure 13 provides an example screen from this stage.

Then, participants played the group contest game for 10 rounds. In each round they decided how much to invest to buy lottery tickets for the contest, as illustrated in Figure 14. After each round, each player was informed about which group has won, how much their group has invested in total, how much the other group has invested in total and what the probability of winning the contest was for their group. To ensure no in-group reputation effect, we only provided information about aggregate investments at the group level instead of player level (see Figure 15).

Subsequent to the group contest, we conducted a second round of social value orientation test, again both with respect to the *own* group and the *other* group. We conducted the SVO test again to measure if the contest itself has had an effect on the level of in-group bias. In total, counting both the pre-game SVO and the post-game SVO, a player will be involved in four rounds of SVO tests as receiver and four rounds of SVO test as the dictator (each round consisting of six distinct allocation decisions, as in Figure 13). Two out of four rounds are with someone from their *own* group and the other two rounds are with someone from the *other* group. At the end of the experiment, one random resource allocation is selected from the SVO tests that the player was involved in. For this, our matching protocol avoids tacit gift exchange and ring matching situations. Furthermore, one random round from the group contest game is selected for payment. Players received the earnings from both the selected SVO payoff and the payoff from the group contest.

As last step, participants filled in a questionnaire about demographics, strategies used in the game, what the player thinks a social player should implement in this game and risk preferences.

3 Theory and Hypotheses

We begin by discussing the equilibrium predictions under standard (individualistic) preferences before presenting our social preferences model from which we derive our hypotheses. Under standard preferences, expected earnings for the group contest is the individual en-

[10] Murphy et al. (2011)'s slider measure is a parametric implementation of the SVO ring measure conceptualised by Griesinger and Livingston Jr (1973); Liebrand (1984).

dowment T_i less investment into the contest v_a plus the winning-probability weighted individual price z_i as in Equation 1. It is well-documented in the literature that for a group A, there exists a multiplicity of equilibria characterised by $\sum_{a \in A} = \frac{z_a}{4}$ (e.g., Konrad, 2009). In Appendix B we present a formal derivation of the equilibrium contribution. The calibrations of our experiment allow for a clean comparison between treatments, as group-level equilibrium predictions are equal across all treatments ($\sum_{a \in A} = 10$), as illustrated in Figure 5.

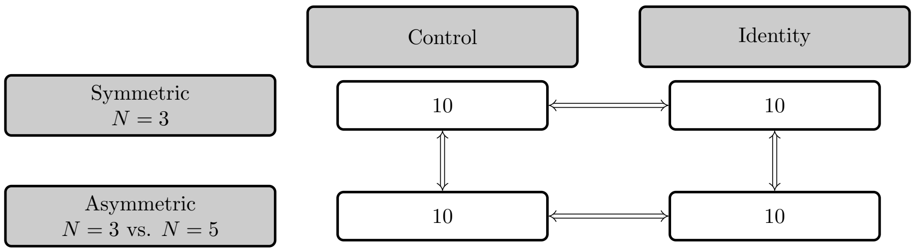


Figure 5: Group-Level Equilibrium Prediction under Individualistic Preferences.

3.1 Social Preferences Model

We use a social preferences model similar to Y. Chen and Li (2009); Kolmar and Wagener (2019), where an agent maximises a weighted sum of her own and others' payoffs. In particular, our model is strongly motivated by Zaunbrecher and Riedl (2016)'s model for the role of social identity in group contests.[11] Two groups A and B compete for a fixed individual prize $z_i > 0$. As such, the prize will be divided equally among all members of the winning group, irrespective of contest investment or other factors.

Agents maximise a weighted sum of own and other group members' payoffs. Let π_g be player g's payoff, $\overline{\pi}_{A \backslash g}$ the average payoff of player g's other group members and α the social-identity parameter, i.e. the weight that g puts on her group mates' payoff. As such, parameter α reflects the strength of g's social identity, where a higher α implies a stronger social identity.

$$u_g(i) = (1 - \alpha) \cdot \pi_g + \alpha \cdot \overline{\pi}_{A \backslash g} \tag{2}$$

The *material* payoff for each player is as in Equation (1), analogously for both groups. Players with individualistic preferences only care about their own material payoff, so $\alpha = 0$. Incorporating social preferences into the decision problem, a player g from group

[11] Both Zaunbrecher and Riedl (2016) and Kolmar and Wagener (2019) discuss a social identity model in group contest games. Both approaches differ in some crucial aspects. While Zaunbrecher and Riedl (2016) employ a weight $\alpha \in [0.1, 1]$, in Kolmar and Wagener (2019), this is only a binary measure of whether members of a group identify with the own group. Another difference between the two seminal approaches is that while Zaunbrecher and Riedl (2016) only consider social preferences towards members of the own group, Kolmar and Wagener (2019) model a preference for parochial disutility for the competing group. Third, Zaunbrecher and Riedl (2016) consider the *average* group payoff as reference, while Kolmar and Wagener (2019) refer to the *sum* of group payoffs. Our model combines elements from both approaches.

A maximises:

$$u_g\left(\sum_{i\in A}a_i,\sum_{j\in B}b_j\right)=(1-\alpha)\left[T_i+\frac{\sum\limits_{i\in A}a_i}{\sum\limits_{i\in A}a_i+\sum\limits_{j\in B}b_j}\cdot z_i-a_g\right]+ \\ \frac{\alpha}{N_A-1}\left[(N_A-1)\left(T_i+\frac{\sum\limits_{i\in A}a_i}{\sum\limits_{i\in A}a_i+\sum\limits_{j\in B}b_j}\cdot z_i\right)-\sum_{i\in A\setminus g}a_i\right] \tag{3}$$

In Appendix B we show that for group A the equilibrium for total investment equals to

$$\sum_{i\in A}a_i=\frac{z_i\,(1-\beta)}{(2-\alpha-\beta)^2}. \tag{4}$$

Similarly, the best response function for group B, where β is group B's social-identity parameter (group B's equivalent to what is α in group A), is

$$\sum_{j\in B}b_j=\frac{z_i\,(1-\alpha)}{(2-\alpha-\beta)^2} \tag{5}$$

In Appendix B.1 we show that group contribution depends positively on the social-identity parameter within the calibrations of the experiment, i.e. $\frac{\partial\sum_{i\in A}a_i}{\partial\alpha}\geq 0$. Intuitively, putting more weight on groupmates' earnings (meaning, increasing α) raises the attractiveness of the prize at stake as players (partially) internalise the positive within-group externalities from their contest-spendings.[12] As such, groups with a higher level of social identity would be willing to chip in more resources into the contest. We expect the salience of social identity to enhance the level of identification with the own group, i.e. increasing α. We hypothesise:

Hypothesis 1. *Total investment will be greater in the Social Identity Treatments.*

The second aspect we investigate is a power imbalance between the competing groups through the relative over-representation of one group. We model this by considering groups of unequal size.[13] Prior empirical results suggest that larger groups have a higher probability of winning against smaller groups (Sheremeta, 2018; Ahn, Isaac, & Salmon, 2011; Abbink, Brandts, Herrmann, & Orzen, 2010). Explaining this empirical finding with the social identity model with N_A and N_B representing the number of players in group A and B respectively, we note that

$$N_A>N_B\ \rightarrow\sum_{i\in A}a_i>\sum_{j\in B}b_j. \tag{6}$$

[12]While having positive externalities on other members from the *own* group, contest-spending implies negative externalities on members from the *other* group and a negative *total* effect on aggregate utility considering the set of all players involved.

[13]Modelling power imbalance through varying efficiency factors per group would be an alternative. We employ unequal group size as channel for a power imbalance between groups as this is more intuitive to explain to participants and because this makes the power imbalance more implicit. This tacit modelling of power imbalance mirrors phenomena in the field like "the unseen, yet unbreachable barrier that keeps (...) women from rising to the upper rugs of the corporate ladder" (US Federal Glass Ceiling Commission, 1995).

Plugging our results from Equations 4 and 5 delivers

$$\frac{z_i\,(1-\beta)}{(2-\alpha-\beta)^2} > \frac{z_i\,(1-\alpha)}{(2-\alpha-\beta)^2},$$

which simplifies into

$$\alpha > \beta.$$

This implies that the social-identity parameter is stronger in the large group, i.e. individuals in the larger groups value other member's utility more than individuals in the small group do. We postulate that the value of the social identity parameter depends on group size. As the social identity parameter increases with group size, our theory predicts total investment to increase with group size.

Hypothesis 2. *Total investment into the contest will be higher in the large group than in the small group.*

We expect the group contest to create an in-group bias measurable through the SVO test. Therefore:

Hypothesis 3. *The in-group bias measured by the SVO will be higher after the group contest (i.e. the post-game SVO measure) compared to before (i.e. the pre-game SVO measure).*

We expect that the high salience level of the shared social identity in the Identity treatments creates a higher in-group bias already at the start of the experiment, as compared to individuals in the Control treatments.

Hypothesis 4. *The in-group bias measured by the SVO before the group contest will be higher for the Identity treatments compared to the Control treatments.*

4 Results

First we present patterns in investments into the contest both in general and over time, and corresponding treatment differences. Individual observations per period are not independently distributed, as the actions of other players and previous rounds influence own behaviour. We start with the most conservative measure for decisions in this game by looking at average contest investment per pair of groups averaged over all rounds of the game.

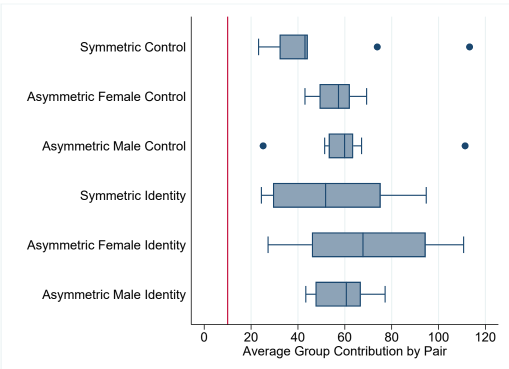
We apply non-parametric methods for hypotheses testing: Mann-Whitney U tests (MWU) (Mann & Whitney, 1947) for independent sample tests and Wilcoxon signed-rank test (Wilcoxon, 1945) for paired tests. Furthermore, we use the Kruskal-Wallis test (KW) (Kruskal & Wallis, 1952) and Dunn's test (Dunn, 1964) with a false discovery rate (FDR) adjustment by Benjamini and Hochberg (1995) for tests involving three or more groups. We use a non-parametric test for trend developed by Cuzick (1985). Unless specified differently, we use data on paired group level (six players in Symmetric treatments, eight players in Asymmetric treatments) as independent observation and apply two-sided tests.

When analysing dynamics in behaviour we will run panel regressions.[14] As the case may be, the dependent variable either is individual (with error terms clustered at group level) or group effort in period t, and the independent and control variables as described below.

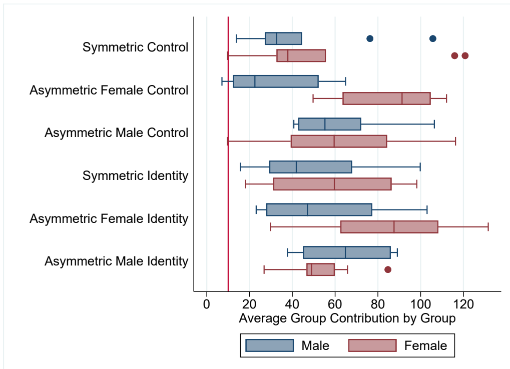
4.1 Results Overview

A recurring result in empirical research on contests is a robust and sizeable degree of over-investment, meaning that players invest more than the Nash equilibrium, and in turn a lot more than the social optimum. In specific, recent experimental studies on group contests find over-investment ranging from 10% to 256% (Sheremeta, 2011, 2018). Other-regarding preferences, and in specific, parochial altruism and social identity theory, have been identified as one of the main mechanisms leading to such escalation of conflict (Sen, 2007).[15]

We too find a drastic and robust over-contribution with respect to both the risk-neutral individualistic equilibrium prediction (Wilcoxon test. H0: group contr. $= 10$, $N = 48$, $z = 6.031$, $p < 0.0001$) and hence also the social optimal strategy, which is even lower. Sub-Figure 6a provides an overview of group contest investment per group pair averaged over all rounds separate for each treatment.[16] The vertical red line indicates the equilibrium prediction under individualistic preferences. The figure provides a couple of first visual cues, which we will investigate more thoroughly in the upcoming subsections. *First*, asymmetric groups appear to invest more into the contest. *Second*, Investment levels do not seem to be higher in the Identity treatments. *Third*, making identity salient does however increase the noise in the data as illustrated by the increased box and whisker size in the figure.



(a) Group contest investment per group *pair* averaged over all rounds.



(b) Group contest investment per *gender identity* group averaged over all rounds.

Figure 6: Box Plots showing the medians, quartiles, octiles and outliers per category. The vertical red line indicates the equilibrium prediction under individualistic preferences.

[14]We will execute a Hausman specification test Hausman (1978) to make an informed decision for a suitable GLS random effects or OLS fixed effects model.

[15]Alternative explanations include non-monetary utility from winning (Delgado, Schotter, Ozbay, & Phelps, 2008; Sheremeta, 2010; Mago, Samak, & Sheremeta, 2016) and bounded rationality (Chowdhury, Sheremeta, & Turocy, 2014; Lim, Matros, & Turocy, 2014; Masiliunas, Mengel, & Reiss, 2014).

[16]Appendix D provides tables with more quantitative evidence, such as the mean and standard deviation, complementing the graphs provided in this Section.

Sub-Figure 6b illustrates investment levels separate for participants with male and female gender identity. While there again is no obvious difference in investment levels between the Control and Identity treatments, we can see some first suggestive evidence that female individuals invest more if they are in a larger group. We will zoom in on this in Subsection 4.2.

For all treatments, overall contest investment decreases over time (Cuzick Test at group level: all treatments pooled ($N = 96$) and separate ($16 \leq N \leq 18$), $z \leq -10.928$, $p < 0.0001$), as illustrated in Figure 7. The figure depicts average group investment per period for each treatment and the equilibrium prediction under individualistic preferences ($\sum_{a \in A} = 10$). The downward trend notwithstanding, contest investment exceeds the equilibrium prediction at all times. The figure also adds to the earlier observation that contest investment appears higher in the Asymmetric treatments, compared to the Symmetric treatments.

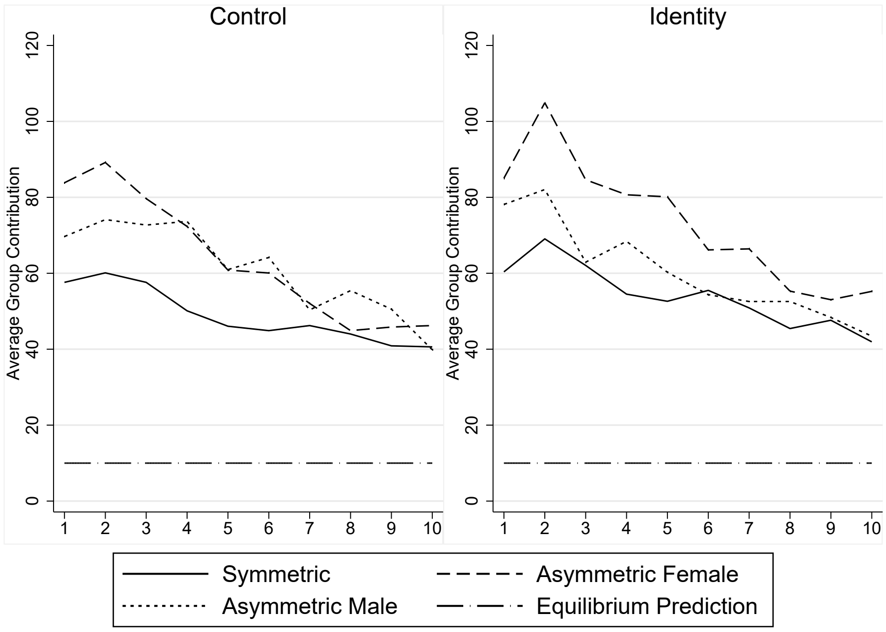


Figure 7: Average Group Contribution per Round.

4.2 Salience of Gender Identity

Using our social preferences model, we hypothesised that salience of social identity increases investment into the contest (Hypothesis 1). Analysing average contest investment aggregated at the Pair level, however, delivers no evidence that across the board, making gender identity salient would increase engagement into the contest (Wilcoxon test at Pair level. H0: group investment Control treatments = group investment Identity treatments, $N = 48$, $z = -0.804$, $p = 0.4277$). We further analyse this hypothesis using a random effects model with error terms clustered at pair-level to regress group investment in round t on treatment dummies and controls. The regression output in Table 1 shows that there is in fact no significant treatment effect, echoing the observation from Sub-Figure 6a.

Table 1: Random effects model regressing group contest investment in round t on treatment dummies and controls.

	(1)	(2)
	Group Contribution in t	
Asymmetric Female Control	-0.394	
	(2.88)	
Asymmetric Male Control	1.100	
	(3.23)	
Symmetric Identity	0.732	
	(3.02)	
Asymmetric Female Identity	2.292	
	(3.57)	
Asymmetric Male Identity	-0.085	
	(2.85)	
Female	3.270^{**}	4.462^{*}
	(1.64)	(2.50)
Identity		1.851
		(1.96)
Female $\times$ Identity		-2.300
		(2.90)
Lagged Group Contribution	0.787^{***}	0.788^{***}
	(0.02)	(0.02)
Lagged Other Group Contribution	0.054^{*}	0.058^{**}
	(0.03)	(0.03)
Round	-0.893^{***}	-0.875^{***}
	(0.26)	(0.26)
Constant	9.729^{***}	8.999^{***}
	(2.63)	(2.47)
Number of observations	864	864
Number of panels	96	96
Within model R-squared	0.265	0.265
Between model R-squared	0.978	0.978
Overall R-squared	0.693	0.693

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Clustered standard errors in parentheses.

Result 1 Making gender identity salient does not induce higher contest engagement overall.

Some of the control variables display significant effects. In particular, we find that female participants invest more points into the contest, which confirms results from prior literature on group contest games (e.g., Price & Sheremeta, 2015; Chowdhury et al., 2016; Heine & Sefton, 2018). Further, contest investment displays a robust degree of stationarity both in terms of what a given group has invested into the contest in $t-1$, as well as controlling for what the competing group has invested into the contest in $t-1$. Lastly, we replicate the negative trend over the duration of the experiment. Participants spend less points for the contest in later rounds than they do towards the beginning of the game.

We next zoom in on the observation from Sub-Figure 6b, which suggests a gender gap in contest investment levels between female and male groups. Figure 8 illustrates the difference between contest investment in female and male groups in a given round for each treatment. It shows that female groups invest more into the contest than their male counterparts, particularly when they are in an advantaged position, i.e. when they are in the larger group in the Asymmetric Female treatments (Wilcoxon test. H0: aggregate group investment male group = aggregate group investment female group, $N = 30,\ z = -3.215,\ p = 0.0013$). This effect appears as more pronounced if the gender identity is not salient, which suggests that female players are discouraged from competing when the male vs. female character of the game is salient. Over the course of the experiment, this gender gap decreases (Cuzick Test at group level: $N = 15,\ z \leq -7.391,\ p < 0.0001$).

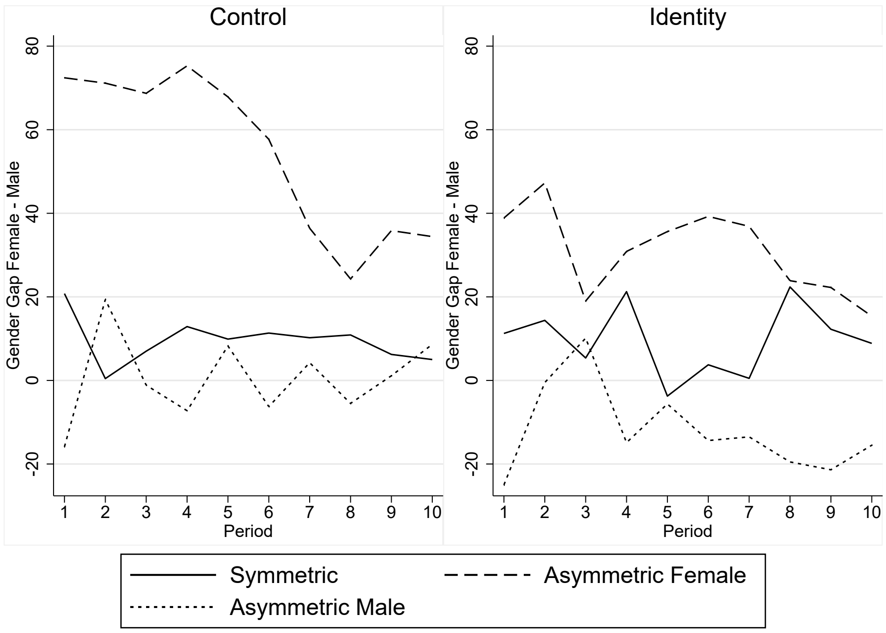


Figure 8: Gender gap in average group contribution levels between female and male groups per round.

For the Asymmetric Male treatments, by contrast, Figure 8 suggests a negative gender gap when identity is salient (Asymmetric Male Identity treatment), but not without salient gender identity (Asymmetric Male Control). This suggests that advantaged groups with male participants invest more than female groups do only if gender identity is salient. Non-parametric tests fail to confirm this relationship though (Wilcoxon test. H0: aggregate group investment male group = aggregate group investment female group, $N = 32,\ z = 0.603,\ p = 0.5641$). In contrast to the gender gap in the Asymmetric Female treatments, the gap in the Asymmetric Male treatments is persistent and does not decrease over time (Cuzick Test at group level: $N = 16,\ z \leq -0.495,\ p = 0.6207$). In the Symmetric treatments, there exists a small, yet not statistically significant difference in contest investment levels between female and male groups (Wilcoxon test. H0: aggregate group investment male group = aggregate group investment female group, $N = 34,\ z = -0.827,\ p = 0.4084$), which displays a small negative trend (Cuzick Test at group level: $N = 17,\ z \leq -2.025,\ p = 0.0428$) yet no difference between salient or non-salient treatments.

Result 2 Female participants display higher engagement into the contest when in an advantaged position, which is even more pronounced when gender identity *is not* salient. For male participants, by contrast, engagement into the contest is higher particularly when gender identity *is* salient.

4.3 Group Asymmetry

We further the analysis by zooming in on the effect of group competition between asymmetric groups. The analyses discussed so far indicate that large groups are more successful in mustering contest investments than small groups are, which is in line with evidence from the literature (Sheremeta, 2018). Our social preferences model from Subsection 3.1 suggests this may be because social identity is stronger in the advantaged group, which then causes the larger group to invest more into the contest. Our design allows to test this hypothesis. For the following analyses in this subsection, we only use data from the Asymmetric treatments, allowing for a direct comparison of behaviour when small and large groups interact. As such, we exclude data from the two Symmetric treatments from the analyses in this subsection.

Table 2 presents results of random effects regressions with error terms clustered at group-pair level using data from the Asymmetric treatments only.[17] The regressions show some evidence that large groups invest about 4-8 points more into the contest each round. Despite the factor not being significantly different from zero in Regression (3), it has the same directionality throughout.

Further, groups with female participants appear to invest more into the contest. This variable is not significantly different from zero in Regression (2), yet shares the same directionality with the other regressions, substantiating strong suggestive evidence that participants with female gender identity invest more into the contest. Salient social identity only displays a significant effect in Regression (4), which appears to be a corollary of the heterogeneous gender effect salient social identity has on the participants. While male participants invest about 6 tokens *more* into the contest when gender identity is salient, female participant group investment actually *drops* by about 10 points in a given round when gender identity is salient. This means that male and female participants display a very different reaction to the salience of gender identity. While salient gender identity impels male participants to engage more actively in the contest, female participants appear discouraged from competing when gender identity is salient.

Result 3 We find some evidence that large groups invest more into the contest.

4.4 Social Preferences

In Subsection 3.1 we discussed our social preferences model which describes agents maximising a weighted sum of their own and others' payoffs. We show that our model predicts a positive relationship between the social-identity parameter α and group investment into

[17] We reproduce the aforementioned stationarity with respect to lagged group contribution from the own and the other group, as well as the negative trend over the rounds.

Table 2: Random effects model regressing group contest investment in round t on groups size and controls.

	(1)	(2)	(3)	(4)
	Group Contribution in t			
Large	5.132^{**}	4.499^{*}	5.211	7.584^{*}
	(2.08)	(2.58)	(3.50)	(4.14)
Female	5.159^{**}	4.526	5.164^{**}	10.198^{*}
	(2.24)	(3.14)	(2.28)	(5.24)
Identity	0.908	0.890	0.981	6.441
	(2.03)	(2.01)	(3.08)	(4.01)
Large × Female		1.266		−3.510
		(4.00)		(5.11)
Large × Identity			−0.147	−5.089
			(3.97)	(4.96)
Identity × Female				-10.443^{*}
				(5.80)
Large × Identity × Female				9.311
				(7.51)
Lagged Group Contribution	0.743^{***}	0.743^{***}	0.743^{***}	0.732^{***}
	(0.04)	(0.04)	(0.04)	(0.03)
Lagged Other Group Contribution	0.055^{*}	0.054^{*}	0.055^{*}	0.059^{*}
	(0.03)	(0.03)	(0.03)	(0.03)
Round	-1.256^{***}	-1.259^{***}	-1.256^{***}	-1.290^{***}
	(0.36)	(0.37)	(0.37)	(0.37)
Constant	11.426^{***}	11.825^{***}	11.384^{**}	9.171^{*}
	(3.96)	(3.97)	(4.51)	(4.97)
Number of observations	558	558	558	558
Number of panels	62	62	62	62
Within model R-squared	0.327	0.327	0.327	0.329
Between model R-squared	0.966	0.966	0.966	0.963
Overall R-squared	0.686	0.686	0.686	0.689

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Clustered standard errors in parentheses.

the contest. In Appendix B.1 we analyse the sensitivity of group contribution towards α and β, which can visually be represented by a surface in the $\sum_{i \in A} a_i \times \alpha \times \beta$-space as depicted in Figure 17. We normalise the average ingroup Pre-Game SVO angle to a 0-1 scale for each group to determine a group's social-identity parameter α. Consequently, β is the competing group's social-identity parameter.

An important argument in formulating Hypothesis 1 is that making social identity salient increases the social-identity parameter, reflecting a higher level of identification with the own group's identity through the shared social identity. Formal tests confirm that we indeed find this relationship when comparing group-level social-identity parameter between Control and Identity treatments (MWU test. H0: alpha in Control treatments = alpha in Identity treatments, $N = 96,\ z = -3.715,\ p = 0.0002$). Similarly, Hypothesis 2 may be driven by an increase in social identity within larger groups. Non-parametric tests deliver no evidence, however, that the social-identity parameter is different for large groups (MWU test using data from Asymmetric treatments only. H0: alpha in small groups = alpha in large groups, $N = 62,\ z = -0.148,\ p = 0.8888$). As such, the effects we find for large groups is likely not driven by social identity, but must be driven by other motivations like the power imbalance between groups. As discussed in Subsections 4.2 and 4.3, male and female participants react very differently to the power imbalance in the contest. We find no evidence that the social-identity differs between male or female groups (MWU test. H0: alpha for female groups = alpha for male groups, $N = 96,\ z = -1.4,\ p = 0.1634$), which strongly suggests that any gender-related results we present are in fact not driven by a potential innate difference in social identity with the own group between male or female participants.

Using these parameters for α and β, we can test the relationship between the actual group investment level on the one hand, and the equilibrium predictions from the social preferences model on the other hand. As first step, pairwise tests indicate that group investment is significantly higher than what would be predicted given the imputed social-identity parameters (Wilcoxon test. H0: group contr. $= \frac{40(1-\beta)}{(2-\alpha-\beta)^2}$, $N = 96,\ z = 7.908,\ p < 0.0001$). Figure 9 depicts the relationship between the observed group investment level in our experiment as a function of average ingroup bias for a given group (α) on the x-axis and the competing group's ingroup bias (β) on the y-axis. The figure illustrates that our empirical data is close to yet mostly above the equilibrium prediction.

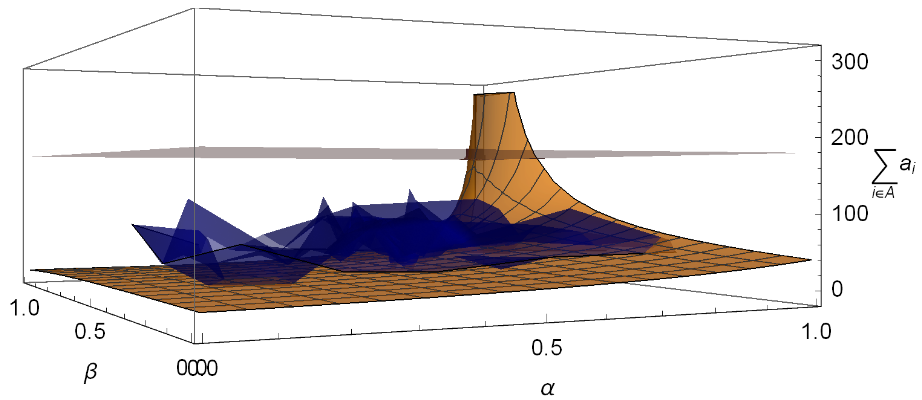


Figure 9: The *orange* surface depicts average group contest investment as a function of ingroup bias in the own group (α) and ingroup bias in the other group (β). The *blue* surface illustrates actual group contest investment as a function of α and β. The *grey* surface indicates the upper bound for small groups with an endowment of $3 \cdot 60 = 180$ points.

We expand on this by regressing group investment levels in a given round on α, β and a set of controls using a random effects model with error terms clustered at group-pair level. The associated regression output in Table 3 shows a significant positive effect for the social-identity parameter α on group investment levels. In Regression (2) we interact α with an indicator variable for Identity treatments, finding no evidence for the effect of α to differ if social identity is salient. In Regression (3) we assess whether participants' gender identity interacts with the social-identity parameter. While the Pearson's correlation coefficient between α and Female is at 0.136, we find no evidence for a different effect from α between participants with male or female gender identity. Including this interaction effect, however, renders the positive effect from female participants not significantly different from zero.

As before, we find a robust stationarity in contribution levels and a negative trend over the rounds of the game.

Table 3: Random effects model regressing group contest investment in round t on social preferences and controls.

	(1)	(2)	(3)
	Group Contribution in t		
Alpha	8.413^{**}	10.195^{*}	7.354^{*}
	(3.29)	(5.38)	(3.95)
Identity × Alpha		−2.968	
		(6.82)	
Female × Alpha			4.228
			(9.99)
Identity	−0.966	0.355	−1.040
	(1.66)	(3.28)	(1.64)
Beta	5.328	5.353	5.311
	(4.42)	(4.50)	(4.45)
Female	3.135^{*}	3.095^{*}	1.184
	(1.68)	(1.71)	(5.53)
Lagged Group Contribution	0.787^{***}	0.786^{***}	0.786^{***}
	(0.02)	(0.02)	(0.02)
Lagged Other Group Contribution	0.055^{*}	0.055^{*}	0.057^{**}
	(0.03)	(0.03)	(0.03)
Round	-0.887^{***}	-0.891^{***}	-0.886^{***}
	(0.26)	(0.26)	(0.26)
Constant	4.502	3.877	4.963
	(3.25)	(3.25)	(3.63)
Number of observations	864	864	864
Number of panels	96	96	96
Within model R-squared	0.265	0.265	0.265
Between model R-squared	0.980	0.979	0.980
Overall R-squared	0.695	0.695	0.695

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Clustered standard errors in parentheses.

4.5 Social Value Orientation

In Subsection 3 we hypothesise that the group contest increases the in-group bias (Hypothesis 3), i.e. the difference between in-group and out-group SVO. If this is true, we should be able to measure a higher in-group bias in the Post-Game SVO when compared to the in-group bias in the Pre-Game SVO. Figure 10 shows that ingroup bias does not systematically change via the contest. For all treatments and gender identity groups, the median is very close to zero, which we confirm via non-parametric testing (Wilcoxon test. H0: Difference Pre-Game-Post-Game in-group bias $= 0,\ N = 350,\ z = -1.574,\ p = 0.1155$).

Result 4 There is no evidence that the contest changes the ingroup bias.

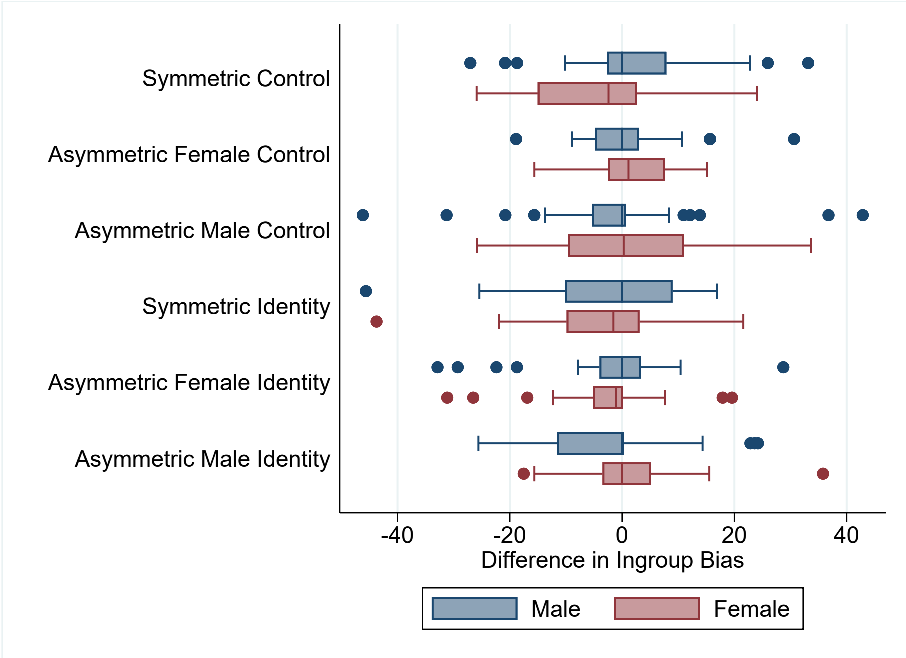


Figure 10: Difference between Post-Game and Pre-Game ingroup bias. Ingroup bias is the difference between SVO towards someone from your own group and someone from the competing group.

We also hypothesise that the salience of social identity creates a higher ingroup bias already at the start of the experiment. As can be seen in Figure 11, we find no evidence for this. While there is individual variation in terms of ingroup biases, we observe no systematic difference between treatments or between ingroup bias measured before or after the experiment. Figure 11 further illustrates that most ingroup biases are distributed around the positive domain, which means that in the SVO allocation decisions participants tend to distribute more to players from the own group than to the competing group, which we confirm through Wilcoxon tests (Wilcoxon test. H0: ingroup SVO angle = outgroup SVO angle, $N = 350,\ z > 8.574,\ p < 0.0001$).

Result 5 There is no evidence that salience of gender identity affects ingroup bias.

4.6 Gender Identity

We employ the Gender Identity Survey by Cameron (2004) to measure the degree to which a participant identifies with his or her stated gender identity. While all participants self-identified with either male or female gender identity, we observe some heterogeneity in the degree to which they identify with this social dimension (average score 4.14 on a 0-6 Likert scale, sd ≈ 0.827). We observe no significant difference in the gender identity score between treatments (KW Test. $N = 350,\ \chi^2 = 4.290,\ p = 0.5085$) or between Control and Identity treatments (MWU test. $N = 350,\ z = -0.669,\ p = 0.5034$). Given the different timing of the Gender Identity Survey between the Control and Identity treatments (see Figure 3), the fact that the gender identity score is not affected by the treatment manipulation speaks to its stability. Note that female participants display a

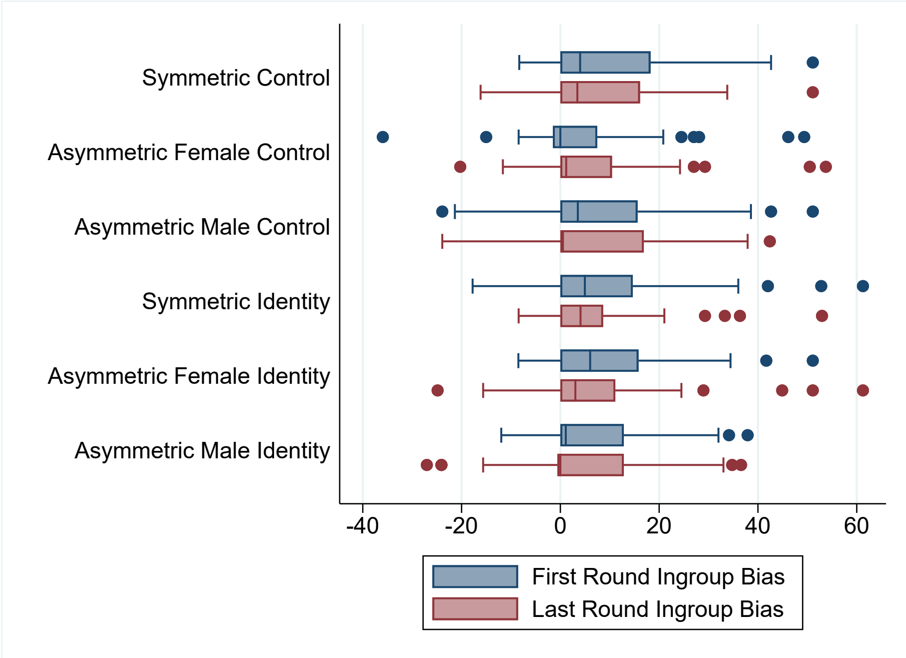


Figure 11: Levels of ingroup bias per treatment at the start (blue) and towards the end (red) of the experiment.

significantly higher level of identification with their gender identity than male participants do (MWU test. $N = 350,\ z = -3.556,\ p = 0.0004$). In Appendix D we explore whether the level of identification with the own gender identity impacts investment decisions into the contest, for which we find no evidence.

We check if the gender identity scores differ between various demographic characteristics. For some characteristics, such as programme of study (KW Test. $N = 350,\ \chi^2 = 16.998,\ p = 0.1994$), faculty of study (KW Test. $N = 350,\ \chi^2 = 5.749,\ p = 0.2187$) or country/region of origin (KW Test. $N = 350,\ \chi^2 = 2.773,\ p = 0.7349$), there is no difference between the categories. For other demographics, we do find an effect. Bachelor's students, for example, identify significantly stronger with their gender identity than master's student do (Wilcoxon test. H0: gender identity score Bachelor's students = gender identity score Master's students, $N = 342,\ z = -2.807,\ p = 0.005$). Similarly, the gender identity score was stronger for younger participants (Cuzick Test at individual level: $N = 350,\ z \leq -4.445,\ p < 0.0001$).

5 Conclusion

The "glass ceiling" is a popular metaphor describing the phenomenon of female under-representation in executive positions, providing an allegory to the invisible barrier that prevents women from rising beyond a certain hierarchy level (US Federal Glass Ceiling Commission, 1995). Often, this gender difference in promotion is attributed to a tendency to shy away from competition on the part of females (Lawless & Fox, 2008; Davies-Netzley, 1998). Our study contributes to this conversation by presenting a controlled study investigating the degree to which male and female individuals engage in a between-group contest against players from the opposite gender identity. By varying the salience of gender identity we can analyse if being reminded of and nudged towards gender identity influences the level of investment into the contest and how this interacts with participants' own gender identity.

We study a contest between groups involving irreversible and costly investments. We start by modelling individuals who maximise utility as a weighted sum of own and others' earnings as a function of their investment into the contest. For this, we define the social-identity parameter α as the weight a player puts on their group mates' payoff.

Our results describe how being in a position of power can drive competitiveness such that advantaged groups tend to invest more into the contest. Throughout, larger, more powerful groups invest more into the contest. Curiously though, male and female participants react very differently to the salience of gender identity in this context. While salient gender identity *decreases* the gender gap in contest engagement, salient gender identity in male-dominated contests leads to an *increase* in the gender gap. As such, salience of gender identity does not generally increase contest investment, but affects male and female contribution decisions very differently.

Importantly, this result is not driven via social identity or in-group cohesion. Both our measure for the social-identity parameter α and the Pre-Game and Post-Game SVO measures do not differ by gender identity, and remain stable after the contest.

The design of our study implies a few limitations, some of which may be followed-up by future research. While establishing a solid baseline and maximising the likelihood of triggering in-group bias, our design of a group contest between homogenous social identity groups will probably be an imperfect representation of rent-seeking contests in the field.

The induced effort character of our study design in which participants invest abstract points for a contest may represent an imperfect match with many contest situations in the field. Particularly when competition implies the chance for physical harm, prior research suggests that male participants may be more inclined to compete (Hay et al., 2011). Future work may investigate the underlying research question using data from the field. In particular, data on any type of (sports) competition in which male and female groups compete may constitute a valuable extension. Equestrian sports may present a promising application, in which male and female riders compete against each other in various fields (see, e.g., McKenzie, 2013). Other examples are Olympic shooting, in which men and women competed together between 1968-1980, or dog sled racing.

Appendix A Screen Shots

In this section we provide some of the key screen shots for our study. For brevity, we omit minor transition screens, like e.g. a welcome screen and waiting screens.

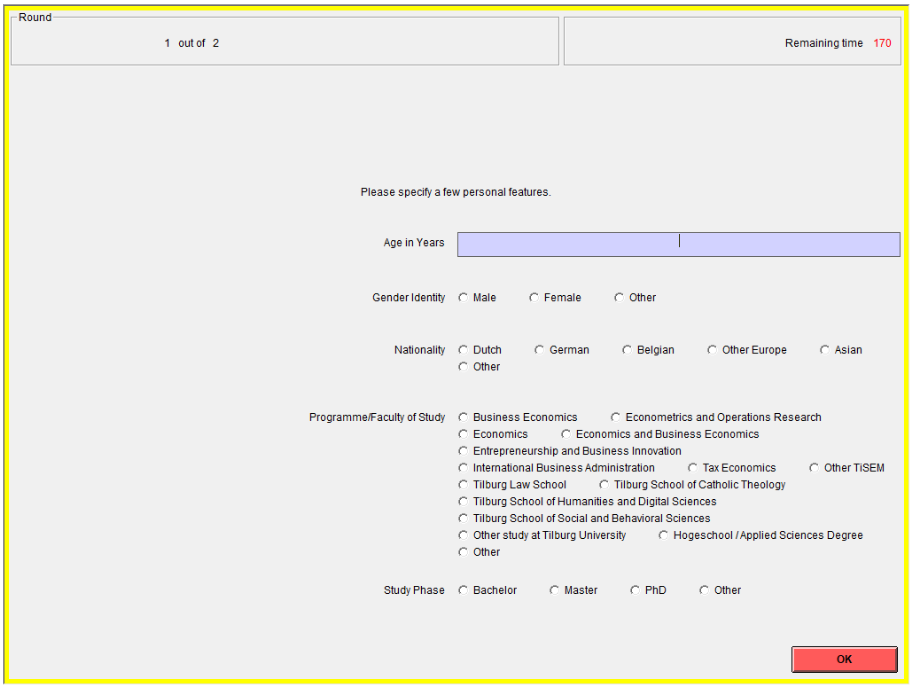


Figure 12: Demographics questionnaire at the start of the experiment. The purpose of this stage was also to check the success of the induced gender identity balance.

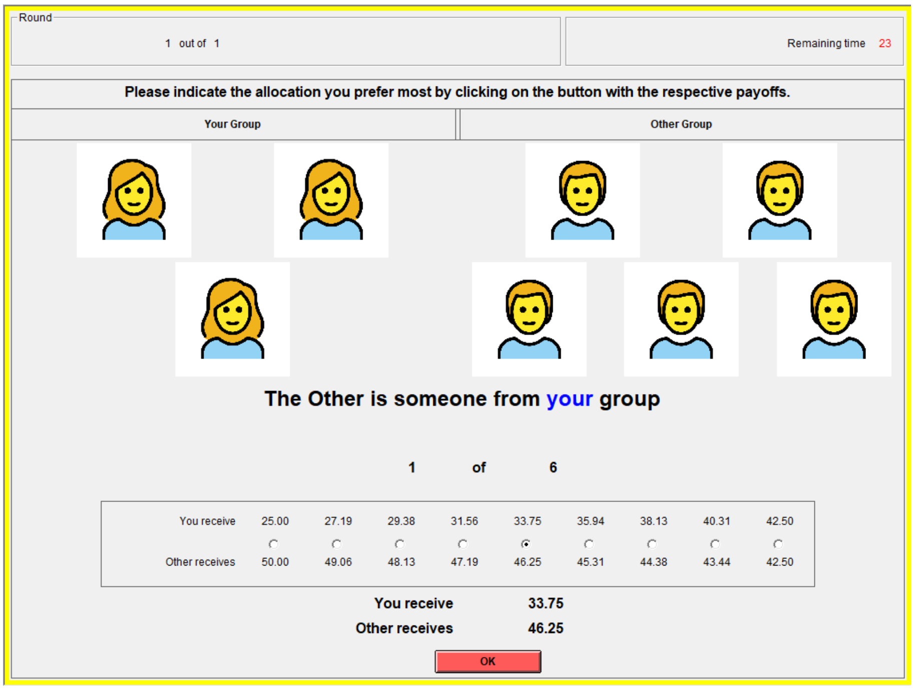


Figure 13: SVO test towards someone from the player's *own* group in the Asymmetric Male Identity treatment. Each player made six allocation decisions towards another player from the *own* group and six comparable decisions towards someone from the *other* group. After the group contest, each player again encountered the same number of decisions towards the *own* and the *other* group.

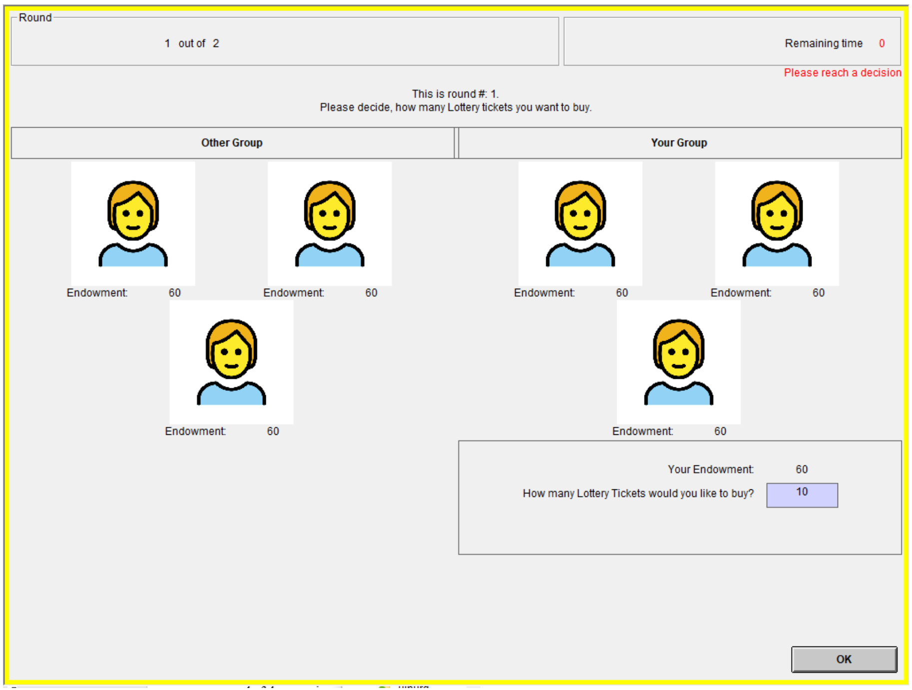


Figure 14: Decision Stage in the Symmetric Control treatment. In this phase, each player decides, how many lottery tickets to buy for the group contest.

Figure 15: Results Stage of a winning group in the Asymmetric Male Identity treatment.

Appendix B Equilibrium Strategies

This section presents theoretical predictions and equilibrium strategies for the group contest game building upon methods described in Konrad (2009); Zaunbrecher and Riedl (2016).

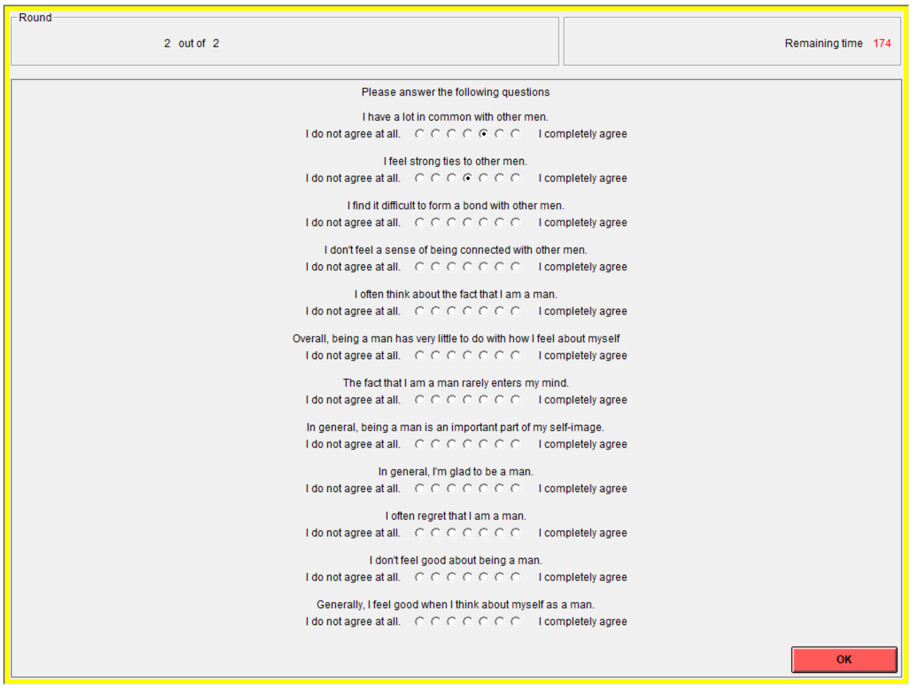


Figure 16: Gender Identity Survey, displayed either at the start or end of the experiment.

Similar to Charness and Rabin (2002); Y. Chen and Li (2009); R. Chen and Chen (2011) we model individual utility as a weighted average of own and others' payoff. In particular, we consider the utility function of the form $u_g(i) = (1-\alpha)\cdot\pi_g + \alpha\cdot\overline{\pi}_{A\backslash g}$, with π_g as payoff for player g, $\overline{\pi}_{A\backslash g}$ the average payoff of player g's other group members and $\alpha \in [0,1]$ the strength of g's social identity, where a higher α implies a stronger social identity. Without loss of generality, the following analysis holds true both with or without social preferences. Under individualistic preferences, let $\alpha = 0$. A player maximises the following utility function:

$$\begin{aligned} u_g\left(\sum_{i\in A} a_i, \sum_{j\in B} b_j\right) =&(1-\alpha)\left[T_i + \frac{\sum_{i\in A} a_i}{\sum_{i\in A} a_i + \sum_{j\in B} b_j}\cdot z_i - a_g\right] + \\ &\frac{\alpha}{N_A - 1}\left[(N_A-1)\left(T_i + \frac{\sum_{i\in A} a_i}{\sum_{i\in A} a_i + \sum_{j\in B} b_j}\cdot z_i\right) - \sum_{i\in A\backslash g} a_i\right] \end{aligned} \tag{7}$$

Taking the derivative with respect to a_g delivers the first order condition:

$$
\begin{aligned}
& \frac{\partial u_g\left(\sum_{i\in A} a_i, \sum_{j\in B} b_j\right)}{\partial a_g} = 0 \\
\Leftrightarrow \quad & \frac{\sum_{j\in B} b_j}{\left(\sum_{i\in A} a_i + \sum_{j\in B} b_j\right)^2} = \frac{1-\alpha}{z_i} \qquad (8)\\
\Leftrightarrow \quad & \frac{\sum_{j\in B} b_j}{1-\alpha} = \frac{\left(\sum_{i\in A} a_i + \sum_{j\in B} b_j\right)^2}{z_i} \qquad (9)
\end{aligned}
$$

Consider the second derivative to assess if u_g is concave, i.e. whether the first order condition delivers a maximum.

$$
\frac{\partial^2 u_g\left(\sum_{i\in A} a_i, \sum_{j\in B} b_j\right)}{\partial a_g^2} = \frac{-2z_i \sum_{i\in A} a_i}{(1-\alpha)\left(\sum_{i\in A} a_i + \sum_{j\in B} b_j\right)^3} < 0 \; \forall \sum_{i\in A} a_i + \sum_{j\in B} b_j > 0
$$

The function is concave and the extreme point will be a maximum, except for the case when both groups invest zero. $\sum_{i\in A} a_i + \sum_{j\in B} b_j = 0$ cannot be a maximum, though, as it would be individually optimal to deviate from this point, invest one point into the contest and win the prize with certainty. We solve the first order condition (Equation 9) for group contributions in group A:

$$
\sum_{i\in A} a_i = \sqrt{\frac{z_i \cdot \sum_{j\in B} b_j}{1-\alpha}} - \sum_{j\in B} b_j \qquad (10)
$$

Similarly, we derive the best response for an individual b_j from group B with $\beta \in [0,1]$ as measure for social identity, equivalent to α for group A:

$$
\frac{\sum_{i\in A} a_i}{1-\beta} = \frac{\left(\sum_{i\in A} a_i + \sum_{j\in B} b_j\right)^2}{z_i} \qquad (11)
$$

Equating the left-hand sides of Equations 9 and 11 we find that in equilibrium $\sum_{j\in B} b_j = \frac{(1-\alpha)\sum_{i\in A} a_i}{1-\beta}$. Using this, we can solve Equation 10 for

$$
\sum_{i\in A} a_i = \frac{z_i\,(1-\beta)}{(2-\alpha-\beta)^2} \qquad (4)
$$

and

$$
\sum_{j\in B} b_j = \frac{z_i\,(1-\alpha)}{(2-\alpha-\beta)^2} \qquad (5)
$$

For individualistic players, let $\alpha = 0$ to see that the equilibrium prediction will be $\sum_{i\in A} a_i = \frac{z_i}{4}$. Our model assumes constant marginal costs of investment and a homogeneous social-identity parameter for a given group. The model does allow, though, for different social-identity parameter between the two competing groups, i.e. α may or may not be equal to β. For our result, no further symmetry assumptions are required (Abbink et al., 2010; Konrad, 2009). However, this does not deliver a unique solution for individual contributions as all combinations of $\sum_{i\in A} a_i$ that sum up to $\frac{z_i}{4(1-\alpha)}$ constitute an equilibrium.

Note that equilibrium group contribution α is contingent on the *individual* prize for winning the contest z_i despite being an equilibrium prediction at the group level. As the individual prize remains unchanged between the symmetric and asymmetric treatments, (standard) equilibrium predictions remain the same, irrespective of group size.

B.1 Sensitivity for Social Identity

We next analyse how the social-identity parameter towards the own group α influences contribution decisions, before turning to how the level of social identity β in the competing group B influences investment decisions in group A. Deriving Equation 4 with respect to α delivers

$$\frac{\partial \sum_{i\in A} a_i}{\partial \alpha} = \frac{2}{(2-\alpha-\beta)^3} \geq 0 \quad \forall \quad 0 \leq \alpha \leq 1, 0 \leq \beta \leq 1. \tag{12}$$

As $\frac{\partial \sum_{i\in A} a_i}{\partial \alpha} \geq 0$ for the levels of α and β considered here, a higher level of social identity towards the own group increases the amount of contest spending. Similarly, we derive Equation 4 with respect to β to get

$$\frac{\partial \sum_{i\in A} a_i}{\partial \beta} = \frac{-z_i\,(2-\alpha-\beta)+2}{(2-\alpha-\beta)^3}. \tag{13}$$

This is not a monotonous function for large z_i as in our experiment, as illustrated in Figure 17. The graph depicts the equilibrium group contribution $\sum_{i\in A} a_i$ (Equation 4) on the z-axis as a function of own-group (α) on the x-axis and other-group (β) social identity on the y-axis within the range defined by the experiment. In particular, the range is $0 \leq \sum_{i\in A} a_i \leq 300$ for large groups. The upper boundary for small groups at $\sum_{i\in A} a_i = 180$ for small groups is represented by the grey coloured surface. The graph visualises the strictly positive relationship between $\sum_{i\in A} a_i$ and α along the x-axis and the non-monotonous relationship between $\sum_{i\in A} a_i$ and β along the y-axis. Note that for very high levels of α and β, the equilibrium is in a corner solution at $\sum_{i\in A} a_i = 180$ for small groups and $\sum_{i\in A} a_i = 300$ for large groups, respectively, as depicted in the graph.

Appendix C Power Analysis

We follow guidelines formulated by Athey and Imbens (2017); Vasilaky and Brock (2019). In specific, we assume there exists a null hypothesis μ_0 when there is no treatment effect (i.e.

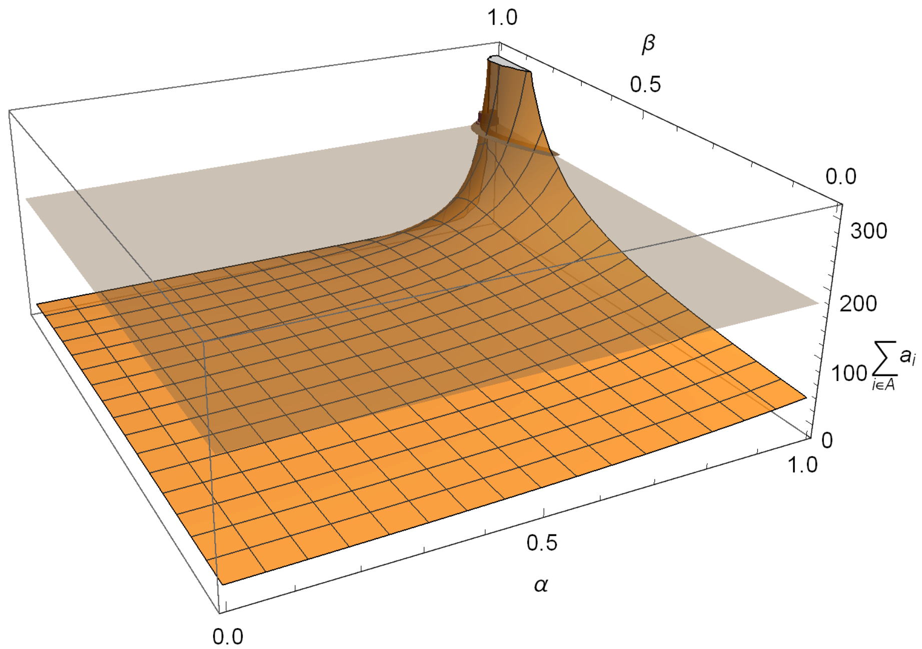


Figure 17: Equilibrium Group Contribution ($\sum_{i\in A} a_i$) as a function of Own-Group (α) and Other-Group (β) Social-Identity Parameter if $z_i = 40$ as in our experiment. The plot range corresponds to the limits defined by the calibrations of the experiment, i.e. $\sum_{i\in A} a_i \in [0, 300]$ for a large group of $n = 5$. The semi-transparent grey surface indicates the upper bound for a small group of $n = 3$.

in the control group) and an alternative hypothesis μ_1 when there is a treatment effect (in the treatment group). We then investigate the true treatment effect, being $\theta = \mu_1 - \mu_0$ under the null hypothesis (θ_0) that $\mu_1 = \mu_0$. In this section our focus is on understanding the potential Type II error associated with this investigation in the context of our experimental design. We will use the results of this analysis to make an informed decision on the sample size required for reliably investigating our research questions.[18]

Using the result from Chowdhury et al. (2016) we calculate the standardised effect size at the group level between 0.6401-0.8463. We target at a significance level of $\alpha = 0.05$ and statistical power of 0.8. Using the Optimal Design Software (Raudenbush et al., 2011) we calculate that the total number of small groups pairs should be between 12-18 and larger group pairs should be between 6-10. Therefore, in total we require 168-268 participants.

Figure 18 shows the total number of group contest groups required for a given level of power. The n in the legend is the number of participants in a group ($n = 6$ for small group and $n = 8$ for the large group). δ is the standardized effect size. α^2_δ is effect size variability. To be conservative we took R^2 as zero.

[18]Executing and reporting the results of a cogent power analysis also contributes substantially at qualifying potential null effects (Nikiforakis & Slonim, 2015). As part of the scientific process, well-designed studies with null effects deserve consideration for publication when part of a well-powered study. Ignoring null results in the body of scientific evidence would feed the publication bias.

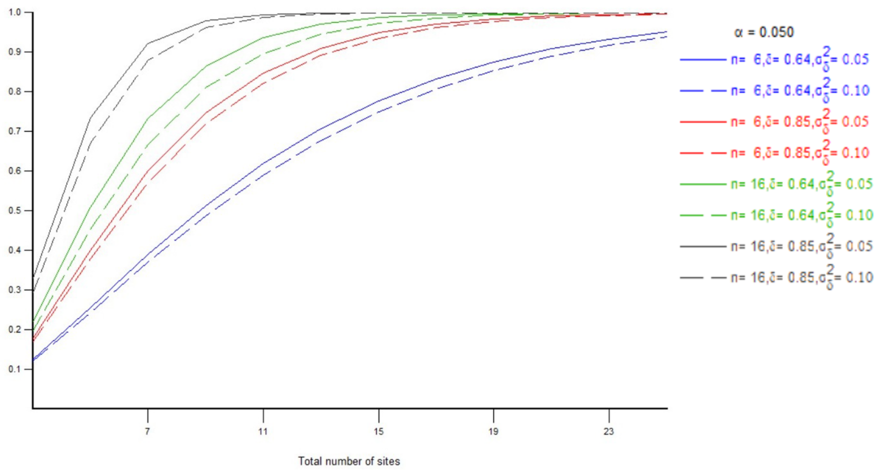


Figure 18: Plot of the Power Analysis. Number of groups (called "sites") on the x-axis, power on the y-axis. The lower four curves (in red and blue colour) represent the power for small groups, the upper four curves (in green and black colour) represent the large groups. Solid lines depict power calculations for an effect size variability of $\alpha_\delta^2 = 0.05$, dashed lines depict power calculations for an effect size variability of $\alpha_\delta^2 = 0.10$

.

Appendix D Results Tables

This appendix complements the results from Section 4 providing tabular representations of the data. Table 4 provides data corresponding to Sub-Figure 6a. While the boxplots depict the median (50th percentile), the 25th and 75th percentiles, as well as the minimum (0th) and maximum (100th percentile) excluding outliers, the following table provides the mean, standard deviation and number of independently distributed observations, i.e. group pairs for each treatment.

Table 4: Group contest investment per group pair averaged over all rounds.

	Average	Standard Deviation	N
Symmetric Control	48.811	28.227	9
Asymmetric Female Control	56.693	8.727	7
Asymmetric Male Control	61.219	23.876	8
Symmetric Identity	54.000	26.283	8
Asymmetric Female Identity	69.287	30.383	8
Asymmetric Male Identity	58.806	11.890	8
Total	57.972	23.117	48

Table 5 presents results from an OLS regression with error terms clustered at group-pair level regressing individual contest investment averaged over the ten rounds of the the group contest on the individual gender identity survey score and other factors. This analysis complements the discussion in Subsection 4.6 and shows that the gender identity score does not influence contest investment decisions. The regression does reproduce the stationarity with respect to the investment level of the own (that is investment of *other* group members, i.e. excluding i) and the other group.

Table 5: OLS regression with error terms clustered at group-pair level regressing individual contest investment averaged over all 10 rounds on the gender identity score and other factors.

	(1)	(2)	(3)	(4)
	Average Individual Contribution			
Gender Identity	0.692	0.200	−0.532	−0.195
Survey Score	(0.68)	(1.14)	(1.14)	(1.51)
Identity		−3.059		
		(6.63)		
Identity × Gender		0.897		
Identity Survey Score		(1.47)		
Female			−2.892	
			(7.88)	
Female × Gender			1.819	
Identity Survey Score			(1.91)	
Alpha				3.290
				(12.57)
Alpha × Gender				1.214
Identity Survey Score				(2.91)
Average Contribution	0.075**	0.074**	0.054*	0.075**
Other Groupmates	(0.03)	(0.03)	(0.03)	(0.03)
Average Contribution	0.063*	0.062*	0.083**	0.060*
Other Group	(0.03)	(0.03)	(0.03)	(0.03)
Constant	6.103*	7.915	8.560*	6.116
	(3.36)	(5.20)	(4.95)	(6.96)
Number of observations	350	350	350	350
R-squared	0.050	0.052	0.084	0.087

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Clustered standard errors in parentheses.

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