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RESEARCH ARTICLE

Levelling as a Female-Biased Competitive Tactic

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Abstract
Direct contests occur more frequently between men than between women. This produces the conclusion that men are more competitive than women. However, no sex differences have been found in other more indirect competitive tactics such as self-promotion and reputation derogation. Qualitative evidence further suggests that one competitive tactic, levelling, may be more commonly used by girls and women than by boys and men. Levelling initially was defined as occurring when several lower-ranked men physically overpowered a higher-ranked man. When institutional support backs equality, however, levelling can be effectively employed by a lower-ranked individual against a higher-ranked individual. Qualitative evidence with humans indicates that beginning in early childhood and continuing through adolescence, individual levelling is used by girls and women more than by boys and men. To empirically test whether individual levelling is more common among women than men, we modified a popular economic game to include a levelling option. In a pre-registered study, we asked 252 women and 258 men from four developed world regions to play the game for monetary compensation three times: with an equal-performing, higher-performing, and lower-performing partner. In each game, participants chose which tactic they wanted to employ: a winner-take-all contest, levelling, or working alone. Rational payoff-maximizing decisions should lead more participants to choose contests with lower-performing partners and to select levelling with higher-performing partners. No sex differences occurred in choice of contests with lower-performing partners, but more women than men employed levelling with higher-performing partners, supporting our hypothesis. Despite sex-biased preferences for competitive tactics, overall no sex differences arose in payoff maximizing decisions.

Keywords Competition · Contests · Economic games · Equality · Levelling · Sex differences

Reproductive success typically varies more between males than females, leading evolutionary biologists to conclude that competition benefits males more than females (Darwin, 1871; Janicke et al., 2016; Trivers, 1972). More recent research across many species however highlights the survival and reproductive benefits to females of competing for resources, territory, allies, and mates (Clutton-Brock & Huchard, 2013; Stockley & Bro-Jørgensen, 2011). Some research even indicates that sex differences in variance in reproductive success may be minimal (Clutton-Brock & Isvaran, 2007; Lukas & Clutton-Brock, 2014), especially where males engage in paternal care (English et al., 2013). Consistent with this, in humans both sexes desire high status to the same extent (Anderson et al., 2015), even though they may achieve it in different ways (Benenson & Abadzi, 2020). Understanding how females compete therefore merits further investigation.

Most studies of competition have compared a single competitive tactic instantiated by winner-take-all contests to an individualistic approach in which a person simply gathers their own resources without attempting to take resources from a competitor. In the following, we suggest that a second form of competition, individual levelling, also is effective and may be preferentially employed by human females.

Winner-Take-All-Contests

Across multiple domains, boys and men engage in more winner-take-all contests than their female counterparts. In Western, Educated, Industrialized, Rich, and Democratic

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(WEIRD) nations (Henrich et al., 2010), boys and men engaged in more direct physical [$d = 0.59$] and verbal [$d = 0.30$] contests than girls and women (Archer, 2019). More specifically, a meta-analysis showed that men use more verbally combative speech (directing, criticizing, informing, and disagreeing) than women when discussing nonpersonal topics in WEIRD cultures [$d = 0.48$] (Leaper & Ayres, 2007). Ethnographers in non-WEIRD cultures also report greater use of physical aggression by men than women (Fry, 1998). Cross-cultural linguistic reports similarly conclude that men engage in direct verbal contests more than women do (Locke, 2011). Sex differences in preference for contests have been found to emerge as early as 3 years of age (Sutter et al., 2019).

This same sex difference occurs in competitive sports. Of 248 sports documented in 50 demographically representative traditional societies worldwide, boys and men played 95% of the sports, and girls and women played 20% (Deaner & Smith, 2013). Similar results have been reported historically for centuries (Craig, 2002; Leibs, 2004). In an American study ($n > 100{,}000$), 4.45% of men versus 1.29% of women reported playing 1:1 sports [$d = 0.95$] in the past day (Deaner et al., 2012). Likewise, in WEIRD (Lever, 1976; Piaget, 1932) and non-WEIRD (Belle, 1989) societies, winner-take-all games are played by more boys than girls.

Sex differences in preferences for winner-take-all contests are also found in economic games. In a popular economic experimental paradigm created by Niederle and Vesterlund (2007) (hereafter NV), participants earn points by solving problems. Before beginning, participants must choose one of two compensation schemes: guaranteed payment for each problem correctly solved or a winner-take-all contest, with identical expected payoffs. Findings from most studies indicate that more boys and men than girls and women choose winner-take-all contests worldwide (Klege et al., 2021; Lowes, 2021; Markowsky & Beblo, 2022; Sutter et al., 2019). Exceptions occur in a few matriarchal societies (Andersen et al., 2013; Gneezy et al., 2009).

Analyses of the underlying factors associated with sex differences in choosing winner-take-all contests indicates that cross-culturally women tend to avoid contests even when their task performance is higher than average. Furthermore, lesser confidence, greater risk aversion, and more negative attitudes towards competition are linked with women's lower preference for winner-take-all contests (Lowes, 2021; Markowsky & Beblo, 2022; Niederle & Vesterlund, 2011). In addition, when contexts are more competitive, the sex difference widens (e.g., Iriberri & Rey-Biel, 2019), although inclusion of a prosocial option decreases this difference (Cassar & Rigdon, 2021). These and similar results have led to the conclusion that human males are more competitive than females.

Levelling

Primatologists and anthropologists have identified another competitive strategy in addition to contests: levelling. The term "levelling" originally was applied to competitive interactions in which two or more lower-ranked individuals form a coalition in order to reduce a higher-ranked individual's resources or status and increase their own (Boehm, 1999). Levelling can be defined mathematically as a coalition against a higher-ranked individual which results in an overall increase in equality of outcomes (see Pandit & van Schaik, 2003).

In non-human primates, levelling has been used to describe an interaction in which two or more subordinate males jointly displace a higher-ranking male, typically by preventing him from mating (Bissonnette et al., 2015; Pandit & van Schaik, 2003). Likewise in humans, researchers living with mobile hunter-gatherers describe communities that are highly egalitarian and enforce equality through levelling (Boehm, 1999). High-ranking individuals, including skilled hunters and leaders and other prominent men and women in the community, are expected to behave as equals by sharing resources with lower-ranked individuals and avoiding "any sign of assertive self-aggrandizement" (Boehm, 1999, p. 72) (Bissonnette et al., 2015; Boehm, 1999; Wrangham, 2019). Refusal to comply typically elicits ridicule and denigration often initially by only one other individual, which often stops selfish behavior. Continued refusal by a self-aggrandizing individual to reduce selfish behavior however is reported to other community members, leading to community-wide condemnation, ostracism, and even capital punishment. Similarly, ethnographic researchers observing children's interactions conclude that "a girl cannot assert social power or superiority as an individual" without risking denigration or ostracism by another girl (Maltz & Borker, 1982) p. 205). Failure to comply with a girl's demand for equality results in bystanders or others informed of the lack of compliance by the superior acting girl leads to denigration or ostracism by her peers (Benenson, 2013). Levelling thus constitutes a competitive strategy designed to reduce the differences between higher-ranked and lower-ranked individuals, one that explicitly increases the degree of resource equality.

Levelling can also be found in other contexts. Thus, a younger sibling will demand equal shares of resources from an older and bigger sibling. If the younger sibling's demands are not met, a report to parents often lead to enforcement of equal distributions between the two siblings (Ihinger, 1975). Another form of levelling occurs when the participation of individuals with fewer resources or lower status nevertheless becomes necessary for successful completion of a joint task, as in a business deal, military action, political negotiation, sports team, or other organizational activity. In this case, the lower-ranked individual has the leverage to demand equal payoffs.

The original definition of levelling in non-human primates was applied to situations in which one higher-ranking individual was confronted by several lower-ranked individuals. There are many instances however in human society through the use of information spread or gossip in which a single individual can use levelling by demanding that someone who is acting selfishly share resources more equally. Thus, as previously described in hunter-gatherer societies, children's play, siblings' interactions, and tasks where one participant necessary for completing a task holds leverage over others, there are many instances in human societies in which a single individual is capable of demanding equality by reference to community norms and the use of gossip. Should the selfish individual refuse to comply with an individual's demand for equality, a lone individual can depend upon the community, peer group, parents, or organization, respectively, to enforce an equal distribution.

Sex Differences in Levelling

A number of studies indicate that in humans, one-on-one levelling may be practiced more by girls and women than by boys and men. Worldwide children begin to segregate their social interactions by sex by middle childhood (Maccoby, 1998; Munroe & Romney, 2006). From middle childhood onwards, males become more group-oriented than females (Benenson & Markovits, 2014; David-Barrett et al., 2015; Rose & Rudolph, 2006). In contrast, girls and women interact with one or only a few same-sex peers at a time (Benenson & Markovits, 2014; David-Barrett, 2022; Maccoby, 1998). This results in girls and women being less accepting than boys and men of hierarchies (Maccoby, 1998; Williams & Tiedens, 2016), which are better suited to groups than to 1:1 interactions.

Accordingly, girls and women are more likely than boys and men to find aversive and punish higher-performing same-sex peers. Detailed ethnographic observations of children suggest that when faced with unequal access to resources, girls use a demand for equality as a way to compete, compared to boys who are happy to engage in direct contests over resources (Benenson, 2013; Eder, 1985; Goodwin, 1990; Maltz & Borker, 1982). Qualitative studies of adults similarly show that in organizations, women are more likely than men to prefer working with equal-performing same-sex colleagues and to dislike higher-performing peers (Heim et al., 2001; Litwin, 2014; Sheppard & Aquino, 2017). Empirical studies bear this out. Girls and young women dislike same-sex friends who outperform them more than boys and young men do (Benenson & Benarroch, 1998; Benenson & Schinazi, 2004). A meta-analysis concluded that women more than men dislike and do not want to hire higher-ranked same-sex peers, which is termed the "backlash effect"(Williams & Tiedens, 2016).

In the economic literature, levelling can be viewed as a form of economic redistribution, which can be a competitive strategy for poorer recipients to gain resources from richer individuals (Petersen et al., 2013). Although motivations underlying the sex difference have not been investigated, several large-scale studies have shown that women have a stronger preference for redistributive policies than men (Alesina & La Ferrara, 2005; Keely & Tan, 2008). Consistent with these results are recent ones showing that women are more willing to compete in an economic game format when they have the option to donate rewards to potential losers, thus decreasing inequality resulting from direct competition (Cassar & Rigdon, 2021).

Girls and women may also prefer levelling over winner-take-all contests because it is less risky. As described, one explanation for sex differences in preferences for winner-take-all contests is females' lower appetite for risk (Niederle & Vesterlund, 2011). Sex differences in risk-taking appear from infancy onwards (Benenson & Markovits, 2014; Byrnes et al., 1999).

Our aim in the current study was to demonstrate that individual levelling is a competitive tactic that is an alternative to winner-take-all contests and that women use it more than men to compete. In a pre-registered study, we hypothesized that sex differences exist in the utilization of winner-take-all contests and levelling. As found repeatedly in prior studies, we first hypothesized that winner-take-all contests generally will be preferred by more men than women. Second, we predicted that when faced with someone with greater resources, women more than men will preferentially choose levelling, which requires that a higher-ranked individual share resources with a lower-ranked one.

The Current Study

To test our hypotheses, we designed a modified version of the NV paradigm which we conducted online. We made two major modifications. First, unlike the original game and variants, all participants were given explicit information about how they performed relative to their specific partner before they made their decisions about which competitive tactic to select. This is a critical component of the present study since information about relative performance is independent of participants' actual performance and necessary for making informed decisions in real life about entering winner-take-all contests and using levelling. Furthermore, previous studies have shown that simply providing information about overall relative performance can reduce if not eliminate sex differences in choice of winner-take-all contests (Jeworrek, 2016; Wozniak et al., 2014).

By providing relative performance information, we allowed participants to utilize their relative status to make

more informed decisions. Furthermore, provision of relative performance information represents a more ecologically valid instantiation of competition. In real-life contexts, such as in the workplace, sports tournaments, the military, religious organizations, academia, or other venues, individuals are knowledgeable about relative status. Thus, the current study simulates competitive situations in which knowledge about relative performance is available.

Our second modification consisted of including only same-sex partners. In real-life settings, intrasexual competition is more common than intersex competition. This likely stems from the cross-cultural sexual division of labor in which individuals are more likely to work with same-sex partners (Su et al., 2009; Wood & Eagly, 2002). Prior studies suggest that same-sex partners may reduce sex differences in selection of winner-take-all contests (Markowsky & Beblo, 2022). Thus, we provide relative performance with respect to one same-sex partner.

Provision of information about the relative performance of a same-sex partner then allows us to manipulate the rationality of strategy choice that results in maximization of payoffs. Participants played three games each with a different partner: one whose performance level was equal to that of the participant, one whose performance level was better than that of the participant, and one whose level was worse than that of the participant. With an equal-performing partner, each competitive tactic produces identical expected payoffs. With a higher-performing partner, levelling maximizes expected payoffs to the participant. In contrast, with a lower-performing partner, a winner-take-all contest would maximize the participant's payoffs.

Method

Participants

Our original goal was to recruit participants from all major world regions using the participant recruitment site Prolifics https://www.prolific.co/. However, we were unable to obtain enough participants from Africa, Eastern and Southeastern Asia, and South America. Consequently, our study was limited to Eastern and Western Europe, Oceania, and the USA. We aimed to include 50 women and 50 men between the ages of 21 and 40 years in each of these four regions. Sample sizes varied however due to initial lesser participation from some regions which led us to oversample to ensure as close to 50 individuals of each sex as possible. Further, when we recruited for Western Europe, over half of our sample came from the UK. Consequently, we created a fifth region, the UK, and then recruited additional participants from Western Europe who were not from the UK. Table 1 lists the number of individuals from each of the final 5 regions by sex and age (see Table 1).

Procedure

The study was approved by the Research Ethics Board at the Université du Québec à Montreal. The study was preregistered at the Open Science Foundation (OSF) https://osf.io/jk6qf/ and run online on the Gorilla platform https://gorilla.sc/. All instructions and measures are presented in full on the OSF site.

To begin the study, interested participants clicked on the consent form which described the task, time, and monetary payoffs. The task, which consisted of entering pairs of two symbols (e.g., %*) from the top row of a standard keyboard, was created to ensure it had no prior sex-linked associations (see Fig. 1).

Practice Task

The study began with a practice task. An empty box appeared in the middle of the screen with one pair of symbols at the top of the screen as shown in Fig. 1. Participants entered the paired symbols into the box and then pressed NEXT, which then produced the next screen with a different pair of symbols and a new blank box. Individuals had to first correctly copy 4 pairs of symbols in the practice task, or they were not permitted to continue to participate in the study.

Table 1 Number and mean (SD) age of female and male participants by region

		Women		Men	
Region	Nation (*n*)	*n*	Mean age	*n*	Mean age
Eastern Europe	Czechia (1) Estonia (2) Hungary (11) Latvia (8) Poland (76)	50	25.28 (4.44)	48	24.46 (4.03)
North America	USA (101)	51	30.10 (5.64)	50	30.14 (4.92)
Oceania	Australia (99) New Zealand (17)	57	28.35 (6.21)	59	28.61 (4.78)
UK	UK (83)	39	28.72 (5.55)	44	29.20 (5.61)
Western Europe	Belgium (12) Denmark (3) Finland (30) France (9) Germany (15) Greece (5) Italy (10) Luxemburg (1) Portugal (21) Spain (4) Sweden (1) Switzerland (1)	55	27.55 (5.08)	57	27.74 (4.69)
Total		252	27.98 (5.61)	258	28.04 (5.14)

Baseline Task

Following the practice task, participants completed the baseline task. This task consisted of copying as many paired symbols as possible in 30 s with 5 pence awarded per correct response. After the task, participants were informed of the number of pairs they had correctly copied.

Three Tasks: with Equal-, Higher-, and Lower-Performing Partners

Once the baseline task was completed, participants then performed the three critical tasks for 30 s each with three separate fictitious partners: one with a partner who had scored the same as they had on the baseline task (equal-performing partner), one partner who had scored 30% higher than the participant had on the baseline task (higher-performing partner), and one with a partner who had scored 30% lower on the baseline task (lower-performing partner). In order to ensure that there were no effects of the order of presentation, each participant was randomly assigned to one of four sequences of partners (e.g., sequence 1 = equal-performing partner first, higher-performing partner second, and lower-performing partner last) to ensure that no order effects influenced choice of strategy. The use of fictitious partners was necessary because finding a sufficient number of real players whose performance was matched to the actual performance of each participant would have been beyond our resources and led to discarding many participants.

Three Compensation Schemes/Competitive Tactics: Going Alone, Equal Division, or Winner-Take-All Contest

Prior to beginning each of the three tasks, participants were informed of their partner's performance on the baseline task (equal-performing, higher-performing, or lower-performing) and then asked to select which compensation scheme the participant wanted to choose for that task. The three compensation schemes were described, and the participant had to select one before beginning the task knowing their partner's performance on the baseline task.

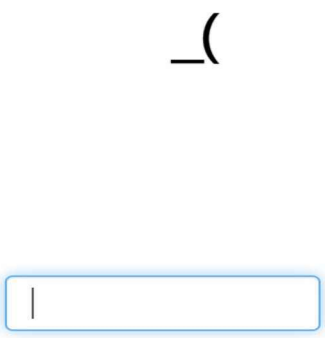

Fig. 1 Screenshot of task showing an example of the two symbols that the participant needed to copy and the box below into which the participant copied the symbols

The precise instructions for a female participant are shown below:

> Going alone: You earn 10p for the number of problems you answered correctly. The other participant also gets 10 p for the average number she has answered correctly.
> Equal division: The number of problems that you answered correctly and the number correctly answered by the other participant are added together, and 10p is given for each one of your combined number of correct responses. The total earnings are then divided equally between the two of you.
> Winner-take-all contest: The number of correct responses you gave and the number of correct responses the other participant gave are compared. If you did better than the other participant, then you receive twice as much money for each of your correct responses (20p), and she receives nothing. If the other participant answered more problems correctly than you did, then she receives twice as much money for her correct responses (20p), and you receive nothing. In case of a tie, you both get 10p per correct response.

Thus, if the participant chose the working alone tactic, the participant would copy as many paired symbols as possible within the time limit and receive 10p for each correct answer. The participant was informed that the partner would do the same.

If the participant chose the equal division tactic, the participant would copy as many paired symbols as possible within the time limit and receive 10p for each correct response. The participant was informed that the partner would do the same, then both of their earnings would be combined, and their combined total is divided equally between them. In the case of choosing equal divisions with the higher-performing partner, the participant is employing the levelling tactic.

If the participant chose the winner-take-all compensation scheme, the participant would copy as many paired symbols as possible within the time limit, as would the partner. Then, the number of correct answers would be compared for the participant and the partner. Whoever obtained the higher score would receive 20p for each correct response, while the other one received nothing. The participant was further informed that in the case of ties, the participant and the partner would each receive 10p per correct response. Table 2 displays the choices and the probability of maximizing or minimizing payoffs.

The participant then completed each of the three tasks. No feedback on personal performance was provided. All

three tasks were completed following the same procedure of introducing the partner, then asking the participant to select a compensation scheme/competitive tactic, and finally completing the task by typing the symbols as rapidly as possible.

Payoffs for Each Compensation Scheme/ Competitive Tactic

For the working alone compensation scheme, payoffs consisted of the individual's performance, regardless of the partner's performance. For the equal division compensation scheme, participants' earnings directly reflected the combination of the individual's own performance combined with their partners' performance. Thus, choice of equality resulted in individuals earning 15% more than what they would have earned by themselves when playing with the higher-performing partner, which we term levelling. The choice of equal divisions with the lower-performing partner resulted in earning 15% less than what they would have earned by themselves. With the equal-performing partner, equal divisions returned earnings equal to what individuals would have earned by themselves. For the winner-take-all contest, payoffs were determined by a random number generator that was programmed to reflect the odds of winning. The participant had a 30% greater than chance level of winning, a 30% lesser chance level of winning, or an equal chance of winning with the higher-, lower-, or equal-performing partners, respectively. Participants were informed of their payoffs only after the entire study was completed. All participants were paid within 24 h of participating.

Participants' Rationale

After the three tasks were completed, individuals were shown their choice of tactics for the three tasks and then asked to describe the one primary reason for their pattern of choices. Five non-mutually exclusive potential answers were provided, and participants were asked to select the one that *best* described their rationale. The five choices were (1) to not upset the other player, (2) it is fun, (3) to earn the most money, (4) to play it safe, or (5) other (please describe). The last response allowed participants to explain their reasoning in their own words. Finally, each participant was thanked for participating and informed of the amount of money they would receive.

At the conclusion of the study, each participant was thanked for participating and informed of the amount of money they would receive. In total, the entire procedure from the practice task to the final rationales took 10 min. Average total earnings were £4.28 (SD = £1.25) and ranged from £1.25 to £9.45. This included payoffs from playing with the three different partners, earnings from the baseline task, plus a £1 guaranteed participation payment.

Data Analyses

All data are available at the Open Science Foundation (OSF) https://osf.io/jk6qf/. Data were analyzed using general linear mixed models (GLMM) and chi-square tests. Repeated measures GLMMs were used initially to examine the number of participants who chose a particular strategy across the three types of partners (higher-, lower-, and equal-performing). To test the hypothesized sex differences, GLMMs were used to examine for each type of partner, the number of women and men who chose a predicted strategy with age as a covariate, and sequence as fixed factors and region as a random factor.

Results

Table 3 and Fig. 2 present the number of women and men who selected each compensation scheme with each partner type (see Table 3 and Fig. 2). These results show that both women and men tended to choose the maximizing competitive strategy, choosing the winner-take-all contest strategy more than the other compensation schemes with the lower-performing partner and the equal division or levelling strategy more than the other compensation schemes with the higher-performing partner.

Table 2 Choices of compensation schemes (competitive tactics) with probabilities of payoffs

Partner's performance relative to participant on baseline task			
Compensation scheme	Partner scored the same (column 1)	Partner scored 30% higher (column 2)	Partner scored 30% lower (column 3)
Winner-take-all contest (row 1)		(Minimizes payoffs)	**Maximizes payoffs**
Equal division (row 2)		**Maximizes payoffs**	(Minimizes payoffs)
Working alone (row 3)			

Table 3 Mean (SD) proportion of compensation scheme (competitive tactic) by type of partner and sex

Partner	Compensation scheme/ competitive tactic	Women	Men
Equal	Contest	0.14 (.35)	0.24* (.43)
	Equal division	0.47 (.50)	0.44 (.50)
	Working alone	0.38 (.49)	0.32 (.47)
Higher-performing	Contest	0.10 (.29)	0.16* (.37)
	Equal division/ levelling	0.67* (.47)	0.56 (.50)
	Working alone	0.23 (.42)	0.27 (.45)
Lower-performing	Contest	0.46 (.50)	0.53 (.50)
	Equal division	0.23 (.42)	0.25 (.43)
	Working alone	0.31* (.46)	0.22 (.42)

*Significant difference between women and men using a Wilcoxon test

Analysis of Payoffs

Before examining strategy choices, we looked at the distribution of payoffs. We first examined payoffs within the three partner types by sex as shown in Table 4 (see Table 4). We then performed an ANOVA with mean payoffs within the three partner types (equal-performing, higher-performing, lower-performing) as a repeated measure and sex of participant as the dependent variable. This produced only a significant effect of partner type, $F(1, 507) = 3.64$, $p = 0.027$. Post hoc analyses using paired t-tests indicated that the mean payoff (in pence) for the participant was significantly higher with the lower-performing partner ($M = 104.80$, $SD = 79.5$) than with the equal-performing partner ($M = 96.10$, $SD = 52.4$),

Table 4 Mean (SD) payoffs (pence) sex based on performance with each partner

Sex	Partner		
	Equal-performing	Higher-performing	Lower-performing
Women	93.2 (45.4)	102.4 (41.0)	101.3 (77.2)
Men	98.9 (58.3)	101.0 (49.0)	108.2 (81.6)

$t(509) = 2.23$, $p = 0.013$. Further, the mean payoff was significantly higher for the participant with the higher-performing partner ($M = 101.71$, $SD = 45.2$) than with the equal-performing partner, $t(509) = 2.26$, $p = 0.0132$. There was no difference in payoffs between the higher-performing and the lower-performing partners. This pattern of payoffs is consistent with the fact that both the lower- and higher-performing partners allow use of a specific competitive strategy that should maximize payoffs.

Use of Payoff Maximizing Strategies

To analyze the use of the contest strategy, a simple repeated measures GLMM was conducted using a binomial distribution and a logit link with choice of contest (1 = contest, and 0 = other) as the dependent variable on the number of individuals who chose a contest with type of partner (equal-, higher-, and lower-performing) as a repeated measure. As predicted, this produced a significant effect of partner, $F(2, 2354) = 127.776$, $p < 0.001$. Paired t-tests showed that as would be expected, significantly more individuals chose

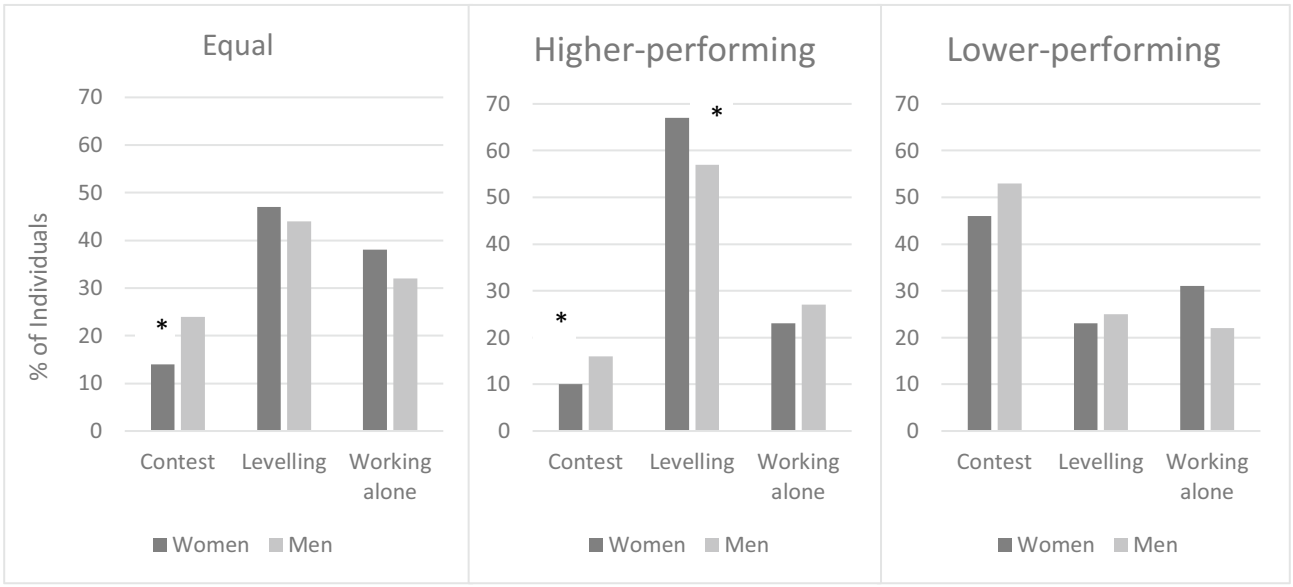

Fig. 2 Percentage of individuals who chose each compensation scheme with **a** equal-, **b** higher-, and **c** lower-performing partners. Single asterisk indicates significant sex difference

a contest against the lower-performing partner which is the payoff maximizing choice ($EMM = 0.490$, $SE = 0.021$, 95% CI [0.450, 0.530]) than against the equal-performing partner ($EMM = 0.199$, $SE = 0.016$, 95% CI [0.170, 0.232]), $t(509) = 12.93$. $p < 0.0001$, and more against the equal-performing partner than against the higher-performing partner ($EMM = 0.138$, $SE = 0.013$, 95% CI [0.100, 0.159]), $t(509) = 3.82$, $p < 0.0001$.

The same GLMM was conducted on the number of individuals who chose levelling [1 = levelling, 0 = other] with each of the three types of partners. Again, this yielded a significant effect of partner, $F(2,2354) = 93.33$, $p < 0.001$. Paired t-tests showed that as predicted, more individuals chose levelling with the higher-performing partner, the payoff-maximizing choice ($M = 0.595$, $SE = 0.024$, 95% CI [0.548, 0.640]), than with the equal partner ($M = 0.440$, $SE = 0.023$, 95% CI [0.394, 0.487]), $t(509) = 6.67$, $p < 0.0001$. Further, more individuals chose levelling with the equal-performing partner than with the lower-performing partner ($M = 0.245$, $SE = 0.019$, 95% CI [0.209, 0.285]), $t(509) = 9.28$, $p < 0.0001$. Figure 2 shows that equal divisions or levelling were used most often against higher-performing partners.

Sex Differences in the Use of Payoff Maximization Strategies

We next tested our specific predictions concerning sex differences. First, we examined for each of the three types of partners whether more men than women chose contests. Second, we analyzed whether more women than men selected levelling with the higher-performing partner. For each prediction, we first conducted a chi-square analysis, then a confirmatory binomial GLMM with a logit link with sex as independent variable and age as a covariate and region as a random factor.

Choice of Winner-Take-All Contests with Each Partner

Despite variability in effect sizes, prior research across diverse fields shows that more men than women choose winner-take-all contests. Although we added a third option, levelling, we investigated whether the same male-biased preference for contests would appear when, as in the economic paradigm, there is no payoff maximizing choice.

Choice of Winner-Take-All Contests with an Equal-Performing Partner

Therefore, for the first analysis, we tested the prediction that more men than women would choose winner-take-all contests in the equal-performing partner condition where expected payoffs are identical regardless of strategy. Overall, the choice of the winner-take-all contest was the *least favored* compensation scheme for both sexes against the equal-performing partner. Nonetheless, even with the addition of the levelling compensation scheme, we found the predicted male preference for contest. The chi-square analysis showed that with the equal-performing partner, a significantly higher percentage of men (24.0%) than women (14.3%) chose a contest, $X^2(1) = 7.80$, $p = 0.005$. The GLMM analysis confirmed this as shown in Table 5 (see Table 5). More men ($EMM = 0.24$, $SE = 0.027$, 95% CI [0.189, 0.294]) than women ($EMM = 0.14$, $SE = 0.022$, 95% CI [0.101, 0.188]) chose the contest with the equal partner even though this choice did not increase expected payoffs.

Choice of Winner-Take-All Contests Against a Higher-Performing Partner

For the second analysis, we tested whether more men than women chose a winner-take-all contest against the higher-performing partner where a contest would be expected to produce the *lowest* payoffs. As shown in the middle graph in Fig. 2, once again contests were the *least favored* compensation scheme for both sexes against the higher-performing partner. Nevertheless, the chi-square analysis showed that against the higher-performing partner, a significantly higher percentage of men (16.3%) than women (9.5%) chose a winner-take-all contest against a higher-performing partner, $X^2(1) = 5.16$, $p = 0.023$. The GLMM analysis confirmed this (see Table 5). More men ($EMM = 0.16$, $SE = 0.029$, 95% CI [0.113, 0.228]) than women ($EMM = 0.09$, $SE = 0.021$, 95% CI [0.057, 0.141]) chose a contest with the higher-performing partner even though it produced the lowest expected payoffs.

Choice of Winner-Take-All Contests Against a Lower-Performing Partner

The third analysis examined conflicting predictions. In our OSF pre-registration, we made conflicting predictions about sex differences in the use of winner-take-all contests against a lower-performing partner. Economic analyses show that men generally prefer contests more than women. However, in the Niederle and Vesterlund (2007) paradigm, the expected payoffs are equal. In contrast, against a lower-performing partner, a contest would produce the *highest* expected payoffs. Thus, we predicted that women might be more likely than men to choose a contest against a lower-performing partner because it both reduces risk and maximizes payoffs. Thus, it is possible that women would make an exception to eschewing

Table 5 Summary of sex differences in choice of competitive tactics for each type of partner (see text for details)

Partner		Sex difference $F(1, 507) =$	$p =$	Sex that chose competitive tactic significantly more often
Equal-performing	Contest	7.75	.006	Men
	Equal division	< 1	n.s	
	Working alone	2.21	.138	
Higher-performing	Contest	4.67	.031	Men
	Equal division/levelling	6.38	.012	Women
	Working alone	1.16	.238	
Lower-performing	Contest	2.30	.130	
	Equal division	< 1	n.s	
	Working alone	4.76	.034	Women

winner-take-all contests when their probability of winning was high. As previously reported, contests were the *most favored* compensation scheme for both sexes against the lower-performing partner (see Fig. 2).

The chi-square analysis testing sex differences was not significant, $X^2(1) = 2.78$, $p = 0.131$, reflecting the conflicting hypotheses. The GLMM analysis confirmed this (see Table 5). Thus, when maximization of payoffs depended on using a contest against a lower-performing partner, neither sex maximized payoffs significantly more. Furthermore, when a power analysis using Gpower3 was conducted with the number of participants, there was a 0.73 chance of detecting a small effect size ($d = 0.2$), suggesting that the lack of sex difference was not simply due to a lack of power. However, we cannot exclude the possibility that the experimental manipulation was not strong enough.

Choice of Levelling Against a Higher-Performing Partner

Next, we then tested the hypothesis that more women than men would choose the levelling strategy with a higher-performing partner, which produces the *highest* expected payoffs. Levelling with the higher-performing partner was the *most favored* compensation scheme for both sexes (see Fig. 2). The chi-square analysis showed that a significantly higher percentage of women (67.5%) than men (56.6%) chose levelling with the higher-performing partner, $X^2(1) = 6.39$, $p = 0.011$. The GLMM analysis confirmed this (see Table 5). More women ($EMM = 0.68$, $SE = 0.032$, 95% CI [0.611, 0.737]) than men ($EMM = 0.56$, $SE = 0.034$, 95% CI [0.496, 0.629]) chose levelling as a competitive strategy with the higher-performing partner.

In order to examine whether there was any global sex difference in use of the levelling strategy, we examined this for the equal-performing and worse-performing partners. With an equal-performing partner, there was no difference between the percentage of use of levelling for women (44.8%) and men (43.9%), $X^2(1) = 0.04$, $p = 0.84$. Similarly, with a lower-performing partner, there was no difference between women (24.3%) and men (25.3%), $X^2(1) = 0.11$, $p = 0.74$. The GLMM analyses confirmed these results (see Table 5).

Maximization of Payoffs

We then examined the use of a combined maximization strategy which consisted of choosing a contest with the lower-performing partner combined with levelling with the higher-performing partner. The chi-square analysis showed that the percentage of women (32.9%) using an overall maximizing strategy was similar to that of men (29.5%), $X^2(1) = 0.40$, $p = 0.396$, which was confirmed by the GLMM analysis which showed no effect of sex, $F(1, 503) = 1.08$, $p = 0.299$.

Rationale for Choices

Finally, using chi-square analyses, we examined individuals' self-reported intuitions about the primary reason they chose their compensation schemes. The results are presented in Table 6 which shows that the two most frequent explanations for participants' choices were (1) to make the most money and (2) to play it safe (see Table 6).

Similar to prior findings across diverse measures including economic gains (Byrnes et al., 1999; Klege et al., 2021; Niederle, 2017; Niederle & Vesterlund, 2007), women were significantly more likely than men to cite safety, whereas men were significantly more likely than women to cite earning more money. No other sex differences in reasons for choices were obtained. We did not attempt a content analysis of the 53 "other" responses as many of them duplicated parts of the four major responses we provided.

Discussion

Competition is a way of acquiring resources from another individual. Competition traditionally has been defined as a winner-take-all contest. Based on diverse findings from observational and experimental findings, we proposed that a second form of competition, which we term levelling, should also be considered a competitive tactic. Levelling is defined as a transfer of resources from an individual having more resources to one having less, under the explicit guise of equality. We hypothesized that addition of this strategy provides a more comprehensive and accurate definition of resource acquisition strategies than simply winner-take-all contests. Critical to using this strategy however is knowledge of the expected relative performance of a partner. This creates differing incentives for employing contest versus levelling tactics. Indeed, results clearly showed that participants generally responded in a rational way to incentives for maximizing payoffs associated with the two proposed competitive strategies as shown in see Fig. 2. A majority of individuals chose contests against a lower-performing partner. Similarly, a majority chose levelling with a higher-performing partner. These two strategic choices theoretically maximize resource acquisition under these two conditions, and the fact that the distribution of strategy choices closely mirrors these incentives clearly shows the value of considering levelling as a second competitive tactic.

Overall, both men and women were equally successful in choosing the appropriate combination of tactics that would maximize payoffs. This is consistent with research in simple real-world environments that shows that women maximize payoffs at least as much as men do (Klege et al., 2021). Nevertheless, it should be noted that only about a third of participants chose payoff maximizing strategy choices. More research is necessary to understand the reasons that participants did not maximize their payoffs.

In this study, participants were told that they would be playing only with same-sex partners and were given specific information about how well they performed relative to each partner. Both of these have been shown to reduce sex differences in the use of winner-take-all contests (Gneezy et al., 2003; Jeworrek, 2016; Markowsky & Beblo, 2022; Wozniak et al., 2014). Despite this, we found two clear sex differences, which were consistent with our hypotheses. When contests were actually disadvantageous in terms of maximizing payoffs such as against a higher-performing partner, or when no benefit accrued from selecting contests as with the equal partner, more men than women selected contests. When levelling was advantageous in terms of maximizing payoffs such as with a higher-performing partner, more women than men selected levelling.

These results are consistent with the idea that men *enjoy* contests more than women do. The fact that men chose contests more than women when this choice was actually disadvantageous thus reinforces the conclusion of Niederle and Vesterlund (2007) and many replications that men use winner-take-all contests more than women do. However, it is also notable that when a winner-take-all contest was the optimal choice, i.e., with the lower-performing partner, the difference between men and women was no longer significant. Thus, despite enjoying contests less than men, women employed contests when the expected value indicated contests would maximize payoffs. In the original Niederle and Vesterlund (2007) paradigm, the expected payoffs are identical for contests and working alone, so the maximization strategy does not favor one compensation scheme over the other.

Our results show that more women than men use a levelling tactic when paired with a higher-performing partner. Once again, this difference was not observed with the equal-performing or worse-performing partners, indicating that levelling is a competitive tactic specifically geared towards individuals who have more resources. This is consistent with empirical findings that more girls and women than boys and men find higher-performing same-sex individuals aversive and aim to punish them ("the backlash effect"). Furthermore, informal observations find that among younger children, girls prefer asking for additional resources from other girls who have more, under the guise of equality (Maltz & Borker, 1982).

An alternative explanation for women's greater use of levelling is that women explicitly value equality more than men do. If levelling with higher-performing partners was simply aimed at achieving equality, however, then women also should be more likely than men to choose equal outcomes with equal-performing or lower-performing partners, which was not the case.

Table 6 Percentage of women and men selecting a rationale to describe their choices of competitive tactics

Reason	Sex				
	Women ($n=252$)	Men ($n=258$)	Total	X^2	p
To earn the most money	30.2% ($n=76$)	42.2% ($n=109$)	186	8.06	.005
To play it safe	38.9% ($n=98$)	23.6% ($n=61$)	157	13.81	$<.001$
It is fun	13.9% ($n=35$)	18.2% ($n=47$)	82	1.77	.183
To not upset the other player	6.0% ($n=15$)	6.2% ($n=16$)	31	.01	.916
Other	11.1% ($n=28$)	9.9% ($n=25$)	53	.28	.599

Importantly, the results challenge fundamental understanding of sex differences in competitiveness. Thus, it is often concluded that women are simply less competitive than men, with corresponding implications for real-life conditions. Certainly, our results reinforce the conclusion that men are more prone than women to enter winner-take-all contests. When the definition of competition is extended to other forms of competition such as levelling, however, then women are shown to be as competitive as men. Most critically, there is no difference between women's and men's payoff maximizing choices. In addition, when there is a clear advantage to entering into a direct contest, men's overall preference for direct contest is countered by women's rationality. In other words, when given explicit information about relative performance and a more complete range of competitive tactics, women and men are equally competitive. However, there remain clear differences in their preferred tactic for competing.

Importantly, both competitive tactics require enforcement. While classic winner-take-all contests occur when one individual physically overpowers another, such as in duels or sports, in the NV economic paradigm or our modified version of it, individuals do not interact at all. Instead, it is assumed that the paradigm simulates what would occur in real-world contexts in which organizations enforce outcomes between winners and losers. Likewise, levelling would occur when the lower-performing individual in real-life denigrates or excludes the higher-performing individual until payoffs are shared equally which has been described in studies of indirect aggression (Benenson et al., 2013; Coyne et al., 2006). Implicit in the lower-performing individuals' insistence on equality is that other lower-performing individuals could be recruited as coalition partners, as exemplified in instances of social exclusion in children (Benenson et al., 2008) and in hunter-gatherer societies (Boehm, 1999).

Results of this study are limited to developed nations and interactions with same-sex partners between 20 and 40 years of age. Inclusion of individuals from non-WEIRD cultures and individuals younger than 20 and older than 40 years is necessary before the results can be generalized to these additional populations. Nonetheless, this study included adults from several world regions during a time in their lives when they typically are most invested in forging their career paths.

An additional caveat is the use of an online format. While this differs from most previous studies which have used the Niederle and Vesterlund (2007) paradigm, it would be difficult to reconstruct the specific conditions required to examine rational strategy use with clearly defined partner differences in a real-life context. In addition, a recent study (Buseer et al., 2021) has shown that an online adaptation of the NV paradigm is a robust predictor of a variety of outcome measures and a good predictor of individual differences in competitiveness.

Finally, there is evidence that risk aversion and confidence levels are associated with choice of competitive tactics (Niederle & Vesterlund, 2011). It is likely that other factors too, including height, muscularity, sports participation, and skill at particular tasks, also affect choice of competitive tactics. The underlying explanations for choices of competitive tactics merit further investigation. Additional research is necessary however using both the NV paradigm and other ones to better understand which components of sex are associated with different competitive tactics. For example, evidence indicates that providing relative performance information reduces, if not eliminates, some of these additional factors that are associated with sex (Jeworrek, 2016; Wozniak et al., 2014).

In conclusion, from an evolutionary perspective, it seems likely that women benefit from engaging in intrasexual competition just as men do (Campbell, 1999; Stockley & Bro-Jørgensen, 2011). Nonetheless, their tactics differ to some extent with women employing less direct and conspicuous ones than men. We provide evidence for a competitive tactic that has not been the focus of investigation: levelling. Viewing levelling as a competitive tactic demonstrates that women and men are equally competitive, with men more likely than women to employ winner-take-all contests overall and women more likely than men to use levelling with higher-performing peers. Overall, however, neither sex was more rational, suggesting that both sexes similarly behave strategically to maximize their benefits.

Author Contribution Joyce Benenson conceptualized the study, devised the measures, and wrote the initial version of the manuscript; Henry Markovits wrote the code, conducted the study, and ran the statistical analyses; both authors revised the manuscript and agreed to the final version.

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Data Availability and Materials The pre-registration, data, and complete instructions that participants read are available on the OSF website https://osf.io/jk6qf/.

Declarations

Ethics Approval Approval was obtained from the Research Ethics Board at the Université du Québec à Montreal. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Competing Interests The authors declare no competing interests.

Consent Informed consent was obtained from all individual participants included in the study.

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