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Overconfidence, self-esteem, and strategic deterrence

Gary Charness, Aldo Rustichini, and Jeroen van de Ven

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Abstract: We conduct experiments to examine the determinants of overconfidence, and the degree to which it reflects self-image (consumption or ego utility,) social image (utility from the perceptions of others), or perhaps-unconscious strategic concerns. First, we observe that, when asked about the likelihood of being in the top 50 percent, the average reported confidence is substantially above 50%. Second, people are much less accurate in updating their beliefs when new information concerns their own ability than when the information is about an impersonal issue. This would appear to show that information processing when own reputation (either in one's own eyes or the eyes of others) is at stake is of a different nature than abstract, neutral information processing. Many people seem reluctant to adjust their beliefs about own ability downward in the face of negative feedback. Some of our most novel results concern behavior in a strategic environment, in which another party observes the stated confidence level of another and then chooses whether or not to enter a tournament with this other person. We find that people do respond to statements about confidence made by others, taking the information conveyed into account when choosing whether or not to enter. Male participants in a potential tournament environment on average report significantly higher confidence levels than in the non-strategic ones, although women do not. Our simple estimation of the threshold own confidence value for entry does an excellent job of predicting actual entry decisions; relative stated confidence is a strong predictor of entry decisions. Inflating confidence can be part of an equilibrium strategy in an attempt to deter competition, providing a rationale for overconfidence of an instrumental nature.

Keywords: Overconfidence, strategic deterrence, unconscious behavior, self-deception, experiment

JEL Classifications: A12, C91, D03, D82

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1. Introduction

Beliefs about one's abilities are an important ingredient to many decisions, including making career choices, undertaking enterprises, and taking risks. Many studies in psychology and economics support the claim that people are overconfident in their ability (e.g., Svenson, 1981; Dunning, Meyerowitz, and Holzberg, 1989).[1] Often this evidence comes from verbal statements by people on their confidence in their relative ability, but some studies also show evidence of overconfidence in choice behavior (e.g., Hoelzl and Rustichini, 2005).[2] Such overconfidence can have negative consequences for people's choices and their corresponding economic outcomes. For example, Camerer and Lovallo (1999) find excess entry in a market game, Dohmen and Falk (2006) find that overconfident individuals are more likely to select themselves into a tournament contract, and Malmendier and Tate (2008) find that confident CEOs are more prone to take value-destroying merger decisions. In other field studies it is found that investors trade too much (Odean, 1999) and consumers overestimate their future attendance of health clubs (DellaVigna and Malmendier, 2006).[3]

Biased, and presumably unconscious, information processing would appear to be at the core of overconfidence. Are people simply unable to effectively process information or does this reflect an underlying bias about one's own abilities or character? The considerable evidence in the psychology literature about self-serving beliefs suggests that the latter may well be the case. People can maintain optimistic or self-serving beliefs in several ways. Often-mentioned strategies are recalling successes and forgetting failures, attributing success to one's self and failures to external sources (others or chance), and strategically acquiring information (through self-handicapping for

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[1] Moore and Healy (2008) mention a taxonomy of overconfidence, consisting of "(1) overestimation of one's actual performance, (2) overplacement of one's performance relative to others, and (3) excessive precision in one's beliefs." In this paper, we primarily consider the second of these categories.

[2] It is also found that overconfidence can turn into underconfidence when task difficulty increases (Hoelzl and Rustichini, 2005; Moore and Cain, 2007).

[3] See DellaVigna (2009) for more examples.

instance).[4] Wolosin, Sherman, and Till (1973) find that subjects tend to attribute success to their own ability in a coordination task with another subject, while failures are attributed to either others or the situation.

If overconfidence reflects a bias rather than a general inability to do correct Bayesian updating, it is natural to wonder if such a bias is useful in some manner, since it is clearly costly in terms of making accurate judgments and choosing actions. There are at least three main candidates for such personal benefits from overconfidence. First, one may receive consumption value from the belief that one is talented. In this view, people feel better with a favorable self-perception (but must pay the cost of being overconfident when reality intrudes). Second, one may value the belief of others about one's ability; one likes good (but not bad) information to be known. Thus, projecting overconfidence may enable one to feel the warmth of social approval. Third, while overconfidence may indeed be a form of social signal, it may also have the instrumental value of modifying behavior, in addition to providing social approval. For example, a lawyer might well need to project confidence to prospective customers in order to be hired.[5] In all three cases, it might well be that people need to be unaware of their bias in order to successfully influence themselves or others. To the extent that overconfidence functions at an unconscious level, self-deception seems an important component of the process.[6] There is considerable evidence from the psychology literature that, in contrast to the assumption that we always make conscious choices, we might routinely be unaware of some or even many of the determinants of our behavior and make decisions at a non-conscious

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[4] Classic studies include Berglas and Jones (1978) and Kolditz and Arkin (1982), showing that subjects engage in self-handicapping by taking performance-impoverishing drugs after they received good feedback about performance.
[5] A researcher might also need to be overconfident about a new project's prospects in order to commence working on the project.
[6] See Shapira-Ettinger and Shapira (2008) for a discussion of how overconfidence is underrated. Bénabou and Tirole (2002) show how overconfidence can have constructive value in situations in which people are subject to hyperbolic discounting.

level.[7] This seems to be an essential element to insure the success of self-deception; but it may also be useful in the attempt to influence others, because it may prevent an awareness of the deception from being revealed to others.

We conduct a series of experimental treatments in an attempt to delineate the forces behind overconfidence. First, we use an incentive-compatible mechanism to elicit confidence in one's relative ability in a cognition task, in order to establish the presence of overconfidence. Next, we consider an updating task when one receives a negative (but noisy) signal. We then compare behavior in an environment in which people receive feedback about their performance on a mental-ability task and in an isomorphic setting where this feedback relates to an abstract question. This comparison provides evidence to test whether people are generally unable to process information effectively, or whether there is a self-serving bias when one's own performance or ability is at stake.

In additional treatments, we test to see if reported confidence is sensitive to social saliency, and is it so for strategic reasons. To study this, we include social saliency (reported confidence shown to another participant) and strategic motivation to report high confidence. Each person knows that one's stated confidence will be reported to another person with whom one is paired (this is common information). When the confidence is simply reported to another person with no payoff consequences, this provides a test of whether people value a social signal in an anonymous environment. Instead, in the strategic setting there are payoff consequences: one person in a pair is automatically entered into a tournament, while the other decides whether to enter the tournament or to choose an outside payment option. Since winning the tournament is much better than losing, the first person has strategic reasons to deter the other person from entering. Stating a higher level of confidence may be an effective deterrent, although misreporting one's beliefs is costly. If we do

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[7] For a discussion of this literature, see the survey article by Ferguson and Bargh (2004).

observe apparent strategic deterrence, can there be an equilibrium in which people (consciously or unconsciously) inflate their reported confidence?

To summarize our findings, we do in fact find that the mean reported estimate in the baseline treatment about the likelihood that one is above average is 63.4 percent. Whether this is *per se* evidence of overconfidence is (Benoit and Dubra, 2009; Burks, Carpenter, Goette and Rustichini, 2010) controversial. We focus here on the evidence provided by the condition in which updating takes place: if different conditions that are equivalent from the point of view of a Bayesian observer lead to different beliefs, then something other than Bayesian updating must be taking place. It turns out that errors in updating about own ability are far more likely than the rare errors in updating about an abstract scenario. This indicates that people are fairly competent at processing neutral information, but not personal information; this suggests a possible consumption value in believing that one is better than average. We do not find any effect of a pure social signal, as the mean reported estimate in the social-information treatment about the likelihood that one is above average is almost identical, at 63.5 percent.

The hypothesis that stated confidence may have instrumental value can be tested in the tournament treatment. We find that there is substantial value in reporting a higher confidence level, as the likelihood that the person with discretion about entering the tournament is much higher when that person's stated confidence is as high as the other person's than when it is lower. Given this result, is reported confidence used as a deterrent? Our results indicate that males appear to inflate their reports, while females do not; also, even the males do not take full advantage of the opportunity. Interestingly, males appear to inflate their stated confidence levels in this competitive environment to the same extent, regardless of whether the other person can be deterred from entering the tournament. We suspect that this is evidence of unconscious decision-making, since debriefed

participants did not report a conscious awareness of inflating their stated confidence levels. There may be something about competition that *per se* leads to behavior on a subterranean mental level. This is more likely to occur if, as we have already hypothesized, the signal is decided at an unconscious level, so it is therefore more difficult for the individual to adjust it to the specific situation he or she is facing. We discuss this at greater length later in the paper.

Finally, we do find that females are significantly less likely to enter the tournament. However, this does not appear to be driven by shying away from competition, but instead by confidence level, as there is no significant difference in entry rates when we control for confidence. The difference in confidence across gender is only significant in the competitive environment. In fact, the difference in overconfidence across gender only manifests for those people who choose to enter the tournament, with little difference in stated confidence levels for men and women who choose not to enter into the competition.

The remainder of this paper is structured as follows. In section 2, we provide a review of the literature, and we describe our hypotheses and our experimental design in section 3. We present our experimental results in section 4, and we discuss these in section 5. We conclude in section 6.

2. Background and literature review

Social psychology has long considered the issues of self-esteem, overconfidence, and self-deception. James (1890) puts forth the view that feeling good about one's self is a fundamental characteristic of human nature. In the terminology of the Baumeister (1998) extensive review of the overconfidence phenomenon, the augmented self-esteem corresponds to the reflexive self, who performs self-examination; instrumental utility is related to the executive self, who makes decisions. Further evidence and discussion on the topic of self-esteem can be found in Leary, Tambor, Terdal, and Downs (1995) and Leary (1999). Image concerns lead to a selective demand for information.

Berglas and Jones (1978) and Kolditz and Arkin (1982) also study how self-handicapping is related to social saliency. Kolditz and Arkin (1982) find that subjects take performance-impoverishing drugs after receiving positive feedback about their past performance when their choice of drugs is visible to the experimenter. However, when subjects choose whether or not to take the performance-impoverishing drugs in private, no subjects take them. This suggests that performance/confidence is a social signal.

Rabin and Schrag (1999) provide a model of confirmatory bias, where people misinterpret new information as supporting previously held views; in this model such confirmatory bias induces overconfidence. An agent may come to believe with near certainty in a false hypothesis, even though he or she receives an unlimited amount of information. In perhaps a similar vein, Koszegi (2006) provides a formal economic model of overconfidence and ego utility, in which an agent derives internal benefits from positive views about his or her ability. The mechanism in this model is that each person receives an initial signal about own ability and can seek information if desired.

Many papers in economics study systematic deviations from Bayesian updating.[8] A number of recent papers examine overconfidence. Mobius, Niederle, Niehaus, and Rosenblat (2005-2010) study how subjects respond to noisy feedback about their performance in an IQ test; people receive signals about their relative rank that are correct with 75% probability. They find that subjects are conservative (not responding enough to new information) and asymmetric (reacting more to positive feedback than to negative feedback); women are more conservative than men, but not more asymmetric. High-confidence women have a higher value for information than men. They develop a model biased information processing inspired by the anticipatory utility model of Brunnermeier and Parker (2005), where these seemingly related phenomena naturally arise.

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[8] For example, Charness and Levin (2005) find that people have problems with Bayesian updating in an individual decision-making task, and observe considerably more affect from positive feedback than from negative feedback.

Ertac (2008) gives feedback to subjects in two different environments. In one case, feedback is about urns (non-performance related). In the other case, feedback is about performance in an algebra and verbal test. She finds no systematic bias in updating in the case of a neutral context, but subjects make systematic updating errors in the algebra/verbal test. The systematic mistakes tend to go against self-serving beliefs. One key difference is possibly the type of feedback that is given. In her case, feedback is always correct but incomplete (e.g., subjects are told they are not in the top 20%, but not if they are in the middle 60% or bottom 20%). We provide noisy feedback, which allows subjects to attribute negative feedback to external causes (noise), as psychologists would predict subjects would do.

Eil and Rao (forthcoming) study how people process and acquire objective information regarding intelligence and beauty. Each person's rank was compared bi-laterally to an anonymous and random-chosen participant, with each then told whether they rank high or lower. In this environment, people respond much more to positive feedback than to negative feedback. Negative feedback leads to less predictable updating behavior and also dislike acquiring new information. On the other hand, updating behavior corresponds fairly closely to Bayesian updating. When the information is about a non-personal phenomenon, updating and information acquisition were unaffected. The results suggest that confirmation bias is driven by direction.

Burks, Carpenter, Goette and Rustichini (2010) investigate whether concerns for self-image contribute to overconfidence and confidence judgments are consistent with Bayesian information processing starting from a common prior, based on data from a large study of truckers by Burks *et alii* (2009). Measurements include choice experiments, cognitive tests, and personality questionnaires. They derive restrictions that Bayesian updating places on the allocation function. The results indicate that individuals with higher beliefs are more likely to demand information, rather than less likely. These results clearly reject self-image concerns as a mechanism that yields

overconfident judgments, and are consistent with a model in which individuals like to hear good news. Burks *et alii* (2010) also reject the notion that confidence judgments are consistent with the Bayesian information processing mentioned above.

Grossman and Owens (2010) study experimentally how one's beliefs about own performance (on a quiz) are affected by noisy, but unbiased feedback. In the main treatment, participants overestimate their own scores, believing that they have received unlucky feedback. However, this is driven not by biased information processing, but rather by overconfident priors. In a control treatment, each participant expresses beliefs about another participant's performance, with (on average) accurate posteriors. They also find that even though feedback improves estimates about the performance on which it is based, this does not lead to improved estimates of related performances. This result suggests that the manner in which people use performance feedback to update beliefs about own ability differs from the manner in which they update their beliefs about own performance, which may have bearing on the issue of why overconfidence persists.

Self-deception has long been a subject of interest to social psychologists and evolutionary biologists, some of whom feel that people are susceptible to self-deception because most have emotional attachments to beliefs. Trivers (2002) suggests that one deceives one's self to trust something that is not true as to better convince others of that truth. When a person is convinced of this untrue issue, it is easier to mask the signs of deception; Trivers states: "Hiding the truth from yourself to hide it more deeply from others." Thus, self-deception may enable an agent to maintain overconfidence, which may be useful in certain cases (e.g., in attracting a mate or making a sale).[9]

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[9] Self-deception can also be useful for self-serving strategic purposes. For example, consider a two-person allocation problem that is not too transparent (an even split is not clearly mandated) and ask two people to state what they think is a just allocation. If one adds the amounts that each person recommends for one's self, we will typically find that the sum is larger than what is feasible, and never below. Views of fairness tend to be self-serving; see, for example, Babcock et al. (1995) and Konow (2000).

To the best of our knowledge, there are no empirical studies on self-deception in the economics literature, as it is quite difficult to identify this trait without confounding interpretations. Thus, this area is wide-open for researchers in economics. There is one recent experimental paper that perhaps bears on this issue, by Dana, Weber, and Kuang (2007). People can choose (at no monetary cost) whether or not to learn the relationship between their actions and resulting outcomes, thus giving subjects the moral "wiggle room" to behave self-interestedly (in one state maximizing one's payoff benefits the paired person, while this hurts the other person in the other state). Many people choose to not learn the true state, suggesting that many subjects behave fairly when they cannot hide behind uncertainty, as they dislike appearing unfair, either to themselves or others.[10] Yet, it is unclear how one can deceive one's self that one is being fair when it is clear that learning the state of the world is a deliberate choice.[11] If this matter were to be litigated, it seems quite likely that a judge would rule that the individual had a responsibility to acquire this information.

3. Hypotheses and Experimental Design

3.1 Hypotheses

In our view, emotions may be produced by the perception one has of own preparation for future actions; this is related to James' theory of emotions, according to which we first respond to an outside stimulus, and then we become aware of our own response. When a third party observes these emotions, they are costly signals that we send when anticipate actions and responses. We are somehow aware of what it is convenient or strategic for us to do in a given situation, for example because we are able to compute the equilibrium. If there are many equilibria of the game, we are

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[10] In this sense, self-deception may be useful for self-serving strategic purposes.
[11] In addition, Grossman (2010) finds that people learn the true state far more frequently when one must make an affirmative choice to not learn the true state, or when the default is changed from not learning the state to learning the state.

able to select one. We can then adjust the emotion to the purpose described above. Based on these principles, we formulate the specific hypotheses below.

H1: We will observe overconfidence when one's confidence level is unknown to other participants, despite incentivizing people for correct beliefs. This suggests that self-esteem or ego utility may be present.

H2: Statements of confidence are social signals, and individuals take them into account when they observe the self-evaluations of others. This is a first-order awareness of social implications of self-confidence. Individuals may also anticipate this effect and adjust this signal accordingly. Thus, we predict that stated confidence levels are higher when another person can observe the stated level of confidence.

H3: We will observe reluctance to lower the estimate of one's own ability, so that there will be more updating errors with a negative signal when the issue is one's own ability than with an updating task involving an impersonal environment.

H4: The stated confidence level will be higher in a strategic environment, where there is a possibility of deterring another person from entering into a tournament against a person stating the confidence level. This would indicate that there is a strategic aspect to overconfidence. We also predict that higher stated confidence levels will tend to discourage entry into the tournament.

In light of the evidence that males and females respond differently to competitive environments (see e.g., Gneezy and Rustichini, 2004; Gneezy et al., 2003; Niederle and Vesterlund, 2007), we also formulate a gender hypothesis.

H5: Males will have higher confidence levels than females, controlling for performance. We also predict that males are more likely to enter the tournament than females, controlling for confidence.

3.2 Experimental design

In every treatment, participants were randomly allocated to groups of four individuals. In each group, two players were randomly labeled as A players, and the other two were labeled as B players; each A player was randomly matched with one B player. All participants received the same 15 questions taken from Raven's Advanced Progressive Matrices (APM), a measure of mental ability (Raven, 2000). Participants had eight minutes to answer as many questions as they could, and did not get any feedback after completion on the number of questions they answered correctly.

The timeline of the experimental sessions is shown in Appendix A, while the experimental instructions can be found in Appendix B.

At this point participants only knew that they would be asked to evaluate their performance later, and that every player A would be matched to a player B with a possibility for the player with the higher rank to earn 10 points. At the completion of the APM test, participants were informed about all the subsequent steps in the experiment. First, they were asked to indicate their confidence in being in the top 2 of their group, on a probability scale from 0% ("certainly not among the top 2") to 100% ("certainly among the top 2"). They received payment for accuracy according to a quadratic scoring rule; for a stated probability p (their report divided by 100), a subject was paid 10 points times $1 - (1 - p)^2$ if he really was in the top 2, and 10 points times $1 - p^2$ if he was not.

Depending on the treatment, player B could observe player A's confidence. More specifically, none of the players in treatment 1 could see the confidence of another player. In treatments 2 and 3, each B player could observe the reported confidence by the paired A players A.

Furthermore, in treatments 1 and 2, of the two matched A and B players, the player with the higher rank received 10 points and the other received nothing. In treatment 3, each B faced a strategic decision: After observing A's reported confidence, B chose whether or not to enter a tournament, where the person with the higher rank received 10 points, while the other received nothing. In the low-outside-option version of treatment 3, B received 3.5 points by staying out of the tournament, while in the low-outside-option version of treatment 3, B received 5.5 points for doing so; in both cases, A received 10 points for winning the tournament. [HIGH-OUTSIDE-OPTION]

The description we have just given, including whether or not any player could see the reported confidence of others, or whether player B was given a choice between playing in or out, was common information and known to all subjects before reporting their confidence. They were

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also told, in all treatments, that they would find out at the end of the game who had the higher rank between the two matched A and B players, but not their rank in the group of four or the number of questions answered correctly.

Treatment 1 had some additional components, the Reports and the Machine questions, that we present now.

Reports: First, after reporting their confidence, participants were sent a report telling them if they were among the top 2 of their group or not. They were told that the report was always correct when it stated that one was among the top 2, but that the report was incorrect in 50% of the cases when it stated that they were not among the top 2 in their 4-person group. There was no deception: reports to participants were determined as stated. After receiving the report, they were asked if they thought it was more likely that the report was correct or incorrect (i.e., if they were in the top 2 or not). They received 10 points for a correct assessment.

Machine questions: Subsequently subjects were given an abstract scenario. They were told that there were two machines in a production hall. The left machine produces 50% good rings and 50% bad rings, the right machine produces only good rings; a mechanic inspected one of the machines every day by taking a ring. Participants were told the percentage of days the mechanic went to the left machine and were then asked if, given that the mechanic took a good ring, it was more likely that the mechanic went to the left machine or right machine. This question was asked three times, with varying percentages of days that the mechanic went to the left machine. For the first two questions, the percentage was randomly drawn from a uniform distribution between 45 and 85. This range was chosen because we expected that most confidence levels would be in this range and for values outside this range the question would be relatively easy. For the third question we

used reported confidence levels by participants as an input. Participants were not told how the percentages were selected. One of the three questions was randomly selected, and for that question they received 10 points for a correct assessment.

If a participant received the report 'not in top 2', the likelihood that the report was incorrect (i.e., the person is in the top 2) is $.5p/(.5p + 1 - p)$ and the likelihood that the report was correct (i.e., subjects is not in top 2) is $(1 - p)/(.5p + 1 - p)$. Conditional upon receiving the report 'not in top 2', incorrect (top 2) is thus more likely than correct if and only if $.5p > 1 - p$, that is $p > 2/3$. Similar reasoning shows that upon receiving the information that the ring is good, it is more likely that the mechanic went to the left machine than to the right machine if and only if $p > 2/3$, where p in this case is the probability that the mechanics went to the left machine.

The reports and the abstract questions have an identical statistical structure (this is illustrated in Figure C1 of Appendix C). In both, there are two possible states of nature, ω_1 and ω_2. The probability of state ω_1 occurring is p. One of two signals was sent, s_1 or s_2. If $\omega = \omega_1$, each signal was sent with equal probability .5; if $\omega = \omega_2$, signal s_2 was always sent. Upon observing s_1, state ω_1 must have occurred. Upon observing s_2, state ω_2 is more likely than ω_1 if and only if $p < 2/3$. In the report part, the states are $\omega_1 =$ 'in top 2', $\omega_2 =$ 'not in top 2', p is the reported confidence, and $s_1 =$ 'in top 2', $s_2 =$ 'not in top 2'. In the machine part, $\omega_1 =$ 'left machine', $\omega_2 =$ 'right machine', p is given in the question, and $s_1 =$ 'bad ring', $s_2 =$ 'good ring'.

Sessions were conducted in Amsterdam in November 2009 and March 2010 with 16 to 28 participants depending on the number of subjects showing up for the experimental session. Instructions were displayed on a computer screen and were read aloud. Participants were told that their decisions would remain anonymous to the other people present unless explicitly indicated otherwise, and that they would receive their earnings in an envelope from a person in a different

room who could only see login numbers and could not match these numbers to names or faces. Participants were paid for one task chosen at random, with one point equal to one euro.

We ran a total of 17 sessions with a total of 368 subjects; seven of Treatment 1 (N = 144), three of Treatment 2 (N = 68) and seven of Treatment 3 (three with low outside option, N = 60, four with high, N = 96). Sessions lasted for 40 to 50 minutes, with an average payment of €14 (of which €7 was a show-up fee). Sessions ended with a questionnaire. Almost all participants (97 percent) were undergraduate students (average age 21.9 years, standard deviation 3.06; see Table 1 for details), with the majority studying economics or business; 43 percent of these subjects were female.

4. Experimental Results

In this section, we present our results by topic, analyzing these results in turn. We first illustrate the distribution of performance in the APM mental-ability task in Figure 1 and provide some summary statistics about the characteristics of the participants in Table 1. As can be seen, the distribution of correct answers (out of 15) is approximately normal. The mean number of correct answers for males is 8.77 and for females the mean number is 8.73.

Figure 1: Distribution of number of correct answers (with normal distribution curve)

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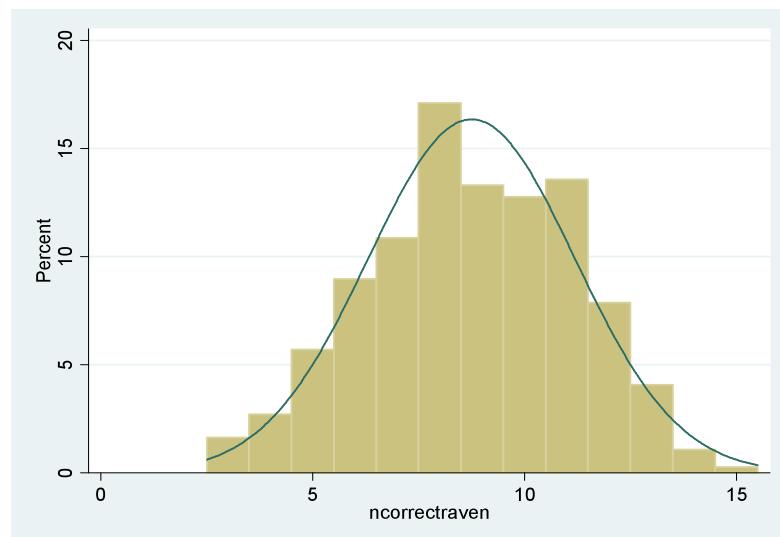
Table 1: Summary statistics

	Mean	Std. Dev.	Min	Max
Test				
Number correct answers	8.75	2.44	3	15
Confidence	65.23	21.14	0	100
Background characteristics				
Age	21.90	3.07	17	49
Number siblings	1.47	0.99	0	6
Gender (fraction females)	43%			
Member of sports club	52%			
Took Raven test before	52%			
Familiar with conditional probs.	60%			
Study category				
Economics/Business/Finance	59.56%			
Social Sciences and Law	15.30%			
Physics, Math, Computer science	6.56%			
Other study or not student	18.58%			
N	368			

4.1 Confidence

Figure 2 reports the cumulative distribution of reported confidence levels by condition. In the aggregate, there are no large or significant differences across conditions: the pairwise *p*-values are always larger than 10 per cent.[12] Only the difference between treatments 1 and 3 (high outside option) is close to significance ($p = .136$),[13] although we do see that a higher proportion of participants express a confidence level of at least 80 in the strategic environments than in the non-strategic environments (34.0 percent versus 23.6 percent). In all conditions less than 1/3 of the participants report a confidence level of 50 percent or below.

Table 2 reports the fraction of people with confidence below, equal, or above 50 percent. In data pooled over the conditions 72 percent of the people report a confidence above 50 percent;

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[12] They are: 0.717 (Treatment 1 and 2), 0.300 (1 and 3-Low outside option), 0.136 (1 and 3-High), 0.538 (2 and 3-Low), 0.362 (2 and 3-High), and 0.994 (3-Low and 3-High).
[13] Here and elsewhere, we round all *p*-values to three decimal places.

breaking this out into Treatments 1, 2, and 3, this proportion varies between 68 percent and 74

percent. The mean reported confidence is 65.22 overall, ranging from 63.40 in Treatment 1 to 67.64

in Treatment 3. While these differences are modest, a Wilcoxon-Mann-Whitney test comparing

Treatment 3 with Treatments 1 and 2 combined gives at least marginal significance ($Z = 1.900$, $p =$

0.058, two-tailed test); this suggests that confidence levels may in fact be somewhat inflated in the

strategic condition.

Table 2: Descriptive statistics of confidence

	Percent with confidence			Mean confidence
Group	<50	50	>50	
All (N = 368)	18	10	72	65.23 [1.10]
Treatment 1 (N = 144)	22	5	74	63.40 [1.71]
Treatment 2 (N = 68)	19	13	68	63.54 [2.73]
Treatment 3 (N = 156)	14	13	73	67.64 [1.68]

Standard errors are in brackets.

Figure 2: Cumulative distribution of confidence, by treatment. "Private" refers to Treatment 1, "social" to Treatment 2, "strategic high" to Treatment 3 with the high outside option of 5.5, and "strategic low" to Treatment 3 with the low outside option of 3.5.
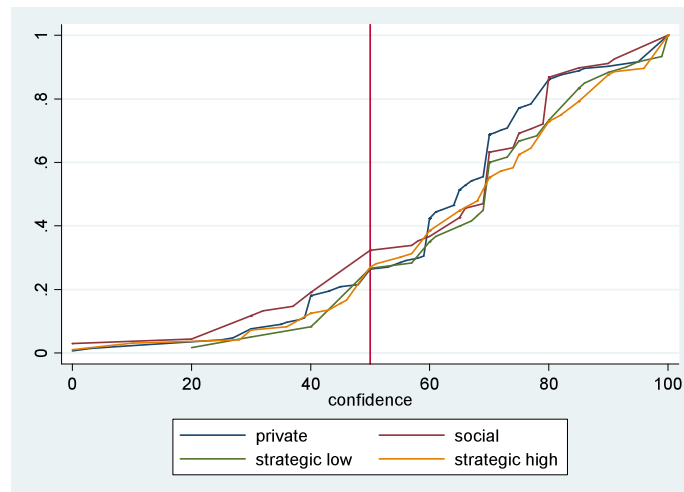

Figure 3 shows a treatment and gender effect with respect to confidence. Men are

considerably more confident in the strategic condition compared to the other treatments, while no

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such effect is present for women. Note that the participants are told about the strategic interaction and asked for their confidence *after* taking the Raven test, so that performance *per se* could not be affected by awareness that a strategic decision would follow, whereas statements might be affected.

Figure 3: Confidence of being in top 2, by condition and gender.
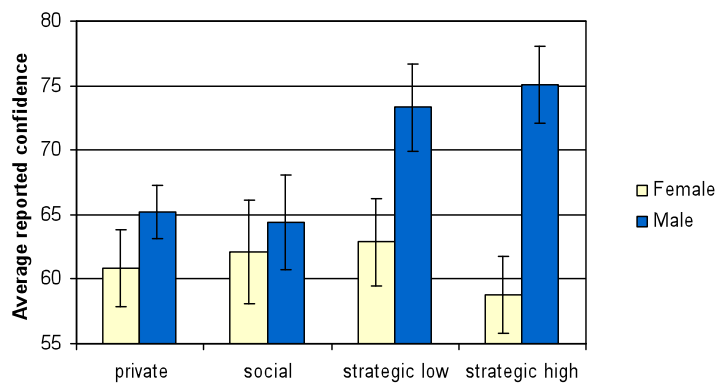See Figure 1 for descriptions of the variables.

Table 3 presents OLS estimates of the determinants of confidence; the baseline condition reflects male behavior in the private treatment (Treatment 1). Specification (1) shows that the number of correct answers is a strong predictor of confidence, adding about 3 percentage points for each correct answer; this result is robust over different specifications. Recall that subjects were not told their number of correct answers, so the effect of correct answers on stated confidence is not based on any external information. In specification (1), there is no evidence of treatment effects. Specification (2) adds controls for the role of the subject (player A or B) and interaction terms for the treatment and role. Being a player A has no effect by itself, and there is also no significant interaction effect with the treatments.

Table 3: Determinants of confidence (0 – 100) -- OLS estimates

Dependent variable: Confidence	(1)	(2)	(3)	(4)
Number of correct answers	3.26***	3.27***	3.29***	3.10***
	(0.42)	(0.42)	(0.41)	(0.43)
Social	0.28	0.59	0.62	-1.49
	(2.88)	(4.10)	(3.99)	(4.02)
Strategic (low and high option combined)	3.59	3.86	9.98**	9.70**
	(2.26)	(3.21)	(3.94)	(3.95)
Player A		1.65	2.06	2.12
		(3.28)	(3.20)	(3.16)
Treatment social * Player A		-0.63	-0.96	0.65
		(5.82)	(5.66)	(5.68)
Treatment strategic * Player A		-0.54	-1.60	-1.61
		(4.54)	(5.32)	(5.32)
Female			-3.23	-2.76
			(2.70)	(2.70)
Treatment strategic * Female			-10.88**	-12.10**
			(5.09)	(5.09)
Treatment strategic * Player A * Female			-0.56	-1.05
			(6.14)	(6.13)
Familiar with conditional probabilities				5.43***
				(2.10)
Constant	35.10***	34.18***	35.19***	29.99***
	(3.98)	(4.42)	(4.43)	(9.35)
Controls	No	No	No	Yes
N	368	368	368	366
Adj. R^2	.14	.14	.19	. 22

Control variables: familiarity with Raven test, study category, age, number of siblings, birth order, member of sports club, entity theory question.

Introducing a dummy for gender and interaction effects for gender and treatment in specification (3) shows a negative but insignificant gender effect. However, we now observe a significant treatment effect, as Treatment 3 increases reported confidence by almost 10 percentage points. This effect is only present for males: the coefficient of the interaction between Treatment strategic and female shows a negative coefficient of about equal size as the treatment coefficient. There is no difference for player A or with the interaction of treatment 3 and player A, and no difference for the three-way interaction female, player A and treatment 3. Finally, specification (4) adds several controls. People who indicated they were familiar with conditional probabilities are more confident (by more than 4 percentage points); this familiarity is a significant effect even accounting for the difference in the number of correct answers (9.31 versus 8.14).

B players inflate their confidence levels to the same extent as the A's, even though there is no actual strategic reason to do so. While our view is somewhat speculative, we feel that the inflated levels of stated confidence do reflect strategic motivations generated by the competitive setting, but that people are not flexible enough to switch this on and off depending on the specific strategic environment. Since it seems that no one is aware of inflating his or her stated level of confidence, the process apparently operates on an unconscious level.[14] It may well be that the notion of competition triggers a reaction in the unconscious mind, without consideration for how the competition is actually structured. This could be seen through the lens of evolutionary psychology (Barkow, Cosmides and Tooby, 2007). Fershtman, Gneezy, and List (2009) provide experimental evidence that the mere presence of a competitive environment can trigger strong behavioral changes. While people exhibit typical social preferences in a standard dictator-type decision, the same people who were generous in this baseline behaved very differently when relative performance on a task

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[14] There is considerable evidence in the psychology literature that many decisions and realizations are created or manifested on an unconscious level and even that the unconscious mind ; see, for example, consider for example, the idea of 'sleeping on it' or having an 'aha' or 'eureka; realization.

determined the allocation, as they competed hard for the more remunerative (and less egalitarian) outcome. Similarly, in Liberman, Samuels, and Ross (2004) participants play a Prisoner's Dilemma game that is labeled either the "Wall St. Game" or the "Community Game". People were significantly more likely to choose defection when they played the Wall St. Game. They react to the labels that are associated with different degrees of competition, even when the monetary payoffs of the underlying game are unchanged.

Results (confidence):

1. *The real performance of participants, measured by the (unknown to the participants) number of correct answers, greatly influences reported confidence in the expected direction. Those people who are familiar with conditional probabilities also report higher confidence.*
2. *There is a significant treatment effect for men, who report 10 percentage points higher confidence in Treatment 3 (where confidence is observed and may have strategic effects), even though it is only known after taking the test that there will be strategic interaction. There is no significant treatment effect for women.*
3. *Player A does not report higher confidence than Player B does in any treatment. This may reflect automatic response to competition on an unconscious level.*

The confidence reports in Treatment 3 will be discussed again in the analysis of the strategic behavior of participants.
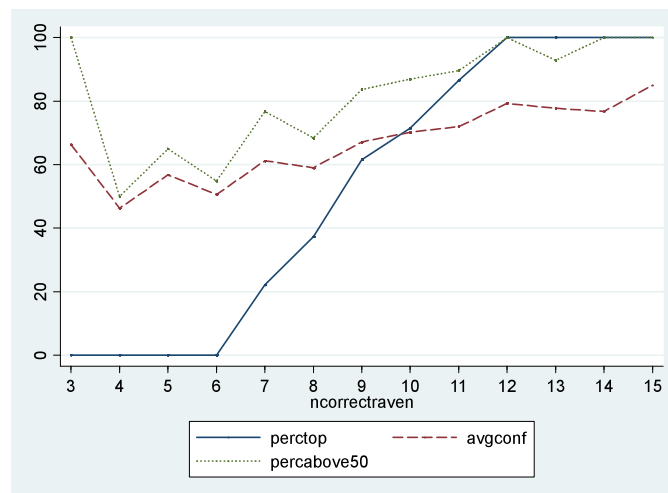
4.2 Overconfidence

Several definitions of overconfidence are available; here we explore some of them. Here we use the term overconfidence as a definition, and do not mean to imply a bias with respect to the Bayesian updating benchmark. A simple test of overconfidence is to compare the fraction of subjects that report confidence above 50 to the fraction of subjects that report confidence below 50. With a binomial test, we can easily reject the null hypothesis that these proportions are equal ($Z =$ 6.41, 4.30, 7.89, and 10.98 for Treatments 1, 2, and 3 and all treatments pooled, respectively; each of

these test statistics are significant at $p = 0.000$.). Similarly, the fraction of people with confidence above 50 is significantly higher than 50 percent in all cases.[15]

Figure 4 shows the proportion of subjects actually in the top two of their group by the number of correct answers (solid line). No one with fewer than seven correct answers is in the top two, while everyone with more than 11 correct answers is in the top two. The dashed line shows average confidence according to the number of correct answers. Those with few correct answers appear overconfident, while those with many correct answers appear under-confident. The dotted line shows the percentage of people with reported confidence above 50; the percentage of people who think they are most likely in the top 2 always exceeds 50%.

Figure 4: Number of correct answers and confidence

Actual percentage of subjects in top 2 (solid line), average reported confidence
(dashed line), percentage of subjects with confidence above 50 (dotted line).

Results (overconfidence):

1. *We observe overconfidence, as the average reported confidence is 65 rather than 50.*

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[15] We can also compare confidence estimates with actual performance. Of all participants who are in the top two of their 4-person group, 86 percent report confidence above 50, versus 72 percent of those who are not in the top two. Thus, we cannot reject rational Bayesian updating using the Burks *et alii* (2009), so that we cannot conclude that subjects deviate from common prior, Bayesian updating and truthful statement of their estimated relative position.

2. *The average reported confidence is systematically higher than the actual percentage in the top 2 for participants with relatively few correct answers, and it is lower for participants with relatively many correct answers.*

3. *We cannot reject rational Bayesian updating using the Burks et alii (2009) allocation function. This may reflect our having only two intervals, either above or below the median.*

4.3 Updating errors

Comparing choices across the Reports and Machine questions tasks in Treatment 1 allows us to test the hypothesis that the patterns of stated confidence that we observe are due to errors in Bayesian updating. Recall that each person received a report about his or her rank in the group, and then answered three machine questions, each with a different percentage of days that the mechanic went to the left machine.[16] With this information, we can test whether mistakes in the Reports task are self-serving beliefs or due to a general inability to update posterior probabilities.

First recall that since a report that one is in the top 2 can only occur when one really was in the top 2, such report is fully informative and should be believed (and it always is). So we now focus on the response to negative feedback ("not in the top 2").

We distinguish three intervals in the range of stated confidence. Consider first confidence statements below 50. People reporting such confidence levels appear to believe that they are most likely not in the top 2. For them, receiving negative feedback only confirms the beliefs previously held, and so should consider the event "not in the top 2" as the most likely. People with confidence above 50 who receive a negative report and do Bayesian updating should consider the event "not in the top 2" most likely when the confidence is below 2/3. However, they may err in the only possible way and state that they are still most likely to be in the top 2; we call this a self-serving error, in that

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[16] Note that no feedback about actual performance is given, so that nothing is learned and the estimates given for the Machine questions seem independent of the estimate given for the Reports question. There is no obvious reason why the order of these choices should matter; if anything, one might expect the estimate for the Machine question with the same probability of visits as the level of confidence reported to be sticky, rather than changing.

maintaining a positive belief may provide ego utility. Finally, for participants with confidence above

66.7, negative feedback should not be enough to reverse their prior assessment that they are more

likely to be in the top 2. In this case, participants may only err by stating that they are more likely

not to be in the top two; we call this error self-defeating, since one gives up the ego utility from the

initially-reported positive belief.

In the case of both intervals, the informative comparison is between the frequency of errors

when belief is about one's relative skill and when it is about an abstract evaluation. We find

evidence of significantly more frequent errors in the Reports than in the Machine questions.

Figure 5 compares mistakes made by subjects in each of those intervals after they receive negative

feedback in the reports, compared to the mistakes with the machine question.

**Figure 5: Updating errors for Reports and Machine questions, by confidence
interval.** Error is defined as answer different from the one provided by Bayesian
updating of a prior equal to the stated confidence of the subject.
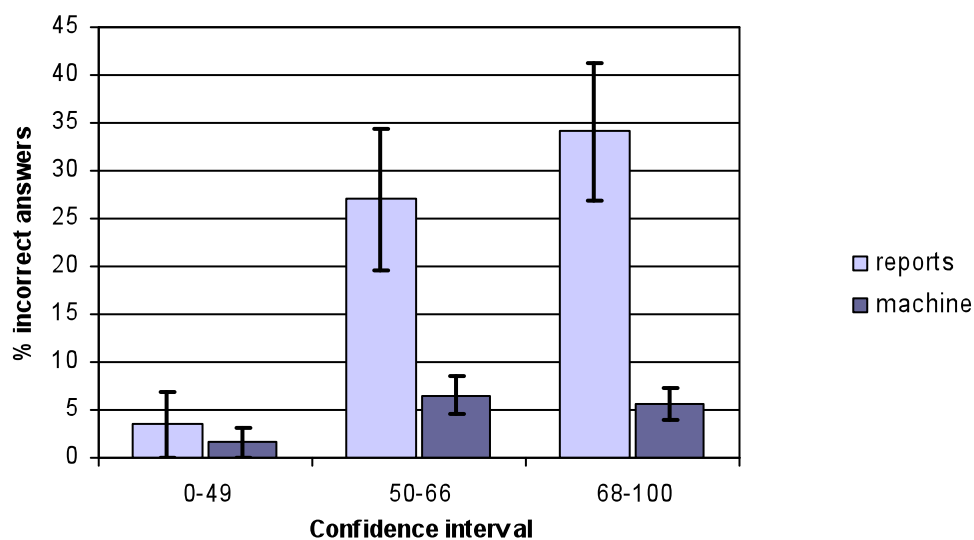
Updating mistakes are rare with the Machine questions, as the percentage of mistakes ranges

from less than two percent to less than seven percent. The picture is very different for the Report

questions. While we (unsurprisingly) see very few errors for people with stated initial confidence

below 50, 27 percent of subjects make updating mistakes in the interval between 50 and 67 (stating they are more likely to be in the top 2 when they are not), and 34 percent of subjects believe negative feedback when stated confidence was larger than 67 percent. Statistical tests confirm this analysis. In Interval 1 (confidence less than 50), the updating error rate (1/29) for the Report questions is not significantly different from the updating error rate (1/62) for the Machine questions ($Z = 0.56$, $p = 0.289$, one-tailed test). In Interval 2 (range of confidence 50 to 67), the proportion of mistakes (10/37) in response to the Report questions is significantly different from the proportion of mistakes (11/168) (in response to the Machine questions $Z = 3.72$, $p = 0.000$). Finally, in Interval 3 (range of confidence larger than 67) the updating error rate (15/44) for the Report questions is not significantly different from the updating error rate (11/194) for the Machine questions ($Z = 5.46$, $p = 0.000$). There is no significant difference across the second and third intervals in the proportion of mistakes for the Reports question ($Z = 0.69$, $p = 0.493$, two-tailed test). These results are largely unchanged if we exclude 50 from Interval 2 and/or include 67 in Interval 3. Furthermore, if we restrict the sample of machine questions to the third round, where reported confidence levels are used as an input, the difference in error rates between the reports and machines questions are still significant at the 5% level ($Z = 1.78$, $p = 0.038$ for interval 2; $Z = 3.87$, $p = 0.000$ for interval 3, both one-tailed tests).

We note that participants making updating errors seem to do worse in terms of performance relative to other participants in this same confidence interval. They have fewer correct answers on the Raven test (8.40 with self-defeating errors versus 9.55 without; the Wilcoxon-Mann-Whitney test gives $Z = 1.776$, $p = 0.038$, one-tailed test),[17] and 6.30 with self-serving errors versus 7.37 without ($Z = 1.107$, $p = 0.134$, one-tailed test). Since the median number of correct answers is 9 (mean 8.75), the difference for those making self-defeating errors translates into a large effect on the likelihood of actually being in the top 2. Indeed, they are much less likely to be in the top 2: 20 percent with self-

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[17] This difference becomes insignificant if we include a confidence level of 67.

defeating errors versus 59 percent without ($Z = 2.44$, $p = 0.007$, one-tailed test). This difference is 20 percent with self-serving errors versus 33 percent without ($Z = 0.69$, $p = 0.245$, one-tailed test).

Results (updating errors):

1. *Errors in updating are more likely to occur for questions involving own skill judgment than for the abstract questions; hence such errors do not merely reflect a general inability to perform Bayesian updating. In fact, errors in response to the abstract questions are rare.*
2. *There is no significant difference in the rates of self-serving errors and self-defeating errors.*
3. *People who make self-defeating errors do worse on the Raven test and are much less likely to be in the top 2 than people in the same interval of confidence levels that do not make errors. These same effects are observed with respect to people who make self-serving errors, but the differences are not significant.*

4.4 Tournament entry

In Treatment 3, player B chooses whether to enter a tournament with player A, who is automatically entered into the tournament; this result contrasts with Treatments 1 and, where both people are effectively entered into a tournament. B decided whether to enter after he had seen A's reported confidence, so he could take that confidence into account when estimating the probability of winning the tournament. Player A in turn knew that player B would observe his statement at the moment of stating his confidence (and player B knew this, etc., since the instructions were identical for all participants), and could anticipate the effect of the statement on player B's decision. A does not observe B's statement, so this statement could not affect A's behavior. In light of this, what determines player B's choice?

Our data show that with the high outside option, player B is more likely to enter the

tournament when own confidence is higher and when the opponent's confidence is lower.[18] Indeed,

as is shown in Figure 6, we observe that relative confidence is a phenomenally good predictor of

entry. Twenty-three of 25 B's (92.0%) enter when their confidence level is at least as large as the

paired A's reported confidence level, while only four of 23 B's (17.4%) enter when their confidence

level is lower than the paired A's reported confidence level; the difference in these proportions is

highly significant ($Z = 5.21$, $p = 0.000$). Thus, there is strong potential for strategic deterrence on

the part of the A player.

Figure 6: Entry rates by higher/lower confidence with high outside option.
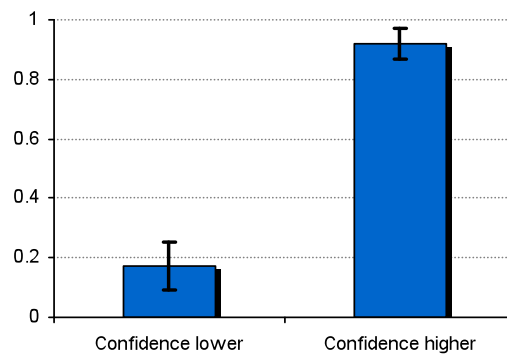
We also find that males enter twice as frequently as do females, 75.0 percent versus 37.5

percent ($Z = 2.62$, $p = 0.009$, two-tailed test), as is shown in Figure 7. However, this does not reflect

a difference in performance: females in the B role in the high-option condition do nearly as well as

males on the Raven test (the mean score for males is 9.12 and the mean score for females is 8.88; the

Wilcoxon-Mann-Whitney test gives $Z = 0.28$, $p = 0.779$, two-tailed test). At first glance, this seems

to be evidence that females are *per se* averse to competition. However, female B's state significantly

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[18] We focus primarily on entry with the high outside option, since 28 of 30 B's chose entry with the low outside option, so that statistical tests have little power.

lower confidence levels than do male B's in this condition, 58.76 versus 75.04 ($Z = 3.07$, $p = 0.002$, two-tailed test). Men choose to enter a tournament much more frequently than women do, but this reflects a lower stated confidence level. Interestingly, this effect is only seen for people who choose to enter the tournament; the average stated confidence level for male entrants is 84.17, compared to 69.89 for female entrants, while the average stated confidence level for males who take the outside option is 50.83, compared to 48.67 for female entrants.

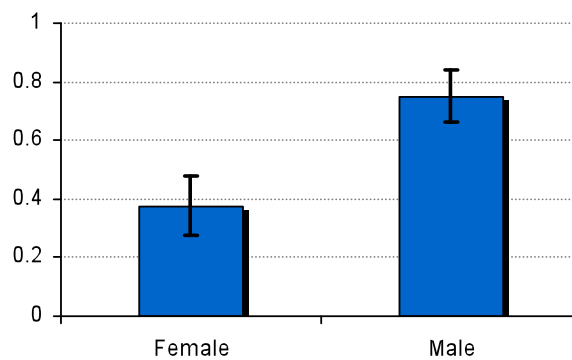**Figure 7: Entry rates by gender with high outside option.**

Table 4 reports the probit estimates of the decisions to enter the tournament for the high-option sessions of Treatment 3.[19] Specification (1) shows that own confidence increases the likelihood of entering the tournament, while higher reported confidence by the opponent lowers the likelihood of entering. Each variable substantially affects the probability of entering. Specification (2) includes a dummy variable that simply compares if own confidence is higher or lower than that of the opponent. This is a very good predictor.

The next two specifications add some controls. From (3), we see that the gender coefficient is negative but not significant. Finally, controls in (4) for gender, number of correct answers, and risk aversion have no significant effect. Thus, the fact that females are less likely to enter is mainly

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[19] Estimates from the Linear Probability Model are very similar to the reported Probit marginal effects.

driven by the fact that they are less confident, rather than less competitive. This also suggests that males are not just reporting higher confidence, but also feel more confident. If they were just reporting higher confidence without believing it, then, controlling for confidence, males should have been less likely to enter the tournament.

Table 4: Determinants of entering tournament, Probit estimates, marginal effects

Dependent variable	Choice = IN			
	(1)	(2)	(3)	(4)
Sample	High outside option	High outside option	High outside option	High outside option
Own confidence	.044***	.015**	.015**	.014*
	(.012)	(.007)	(.007)	(.008)
Opponent's confidence	-.029***			
	(.010)			
Lower confidence		-.619***	-.610***	-.621***
		(.138)	(.141)	(.141)
Female			-.121	-.096
			(.199)	(.203)
Number correct answers				-.019
				(.042)
Risk aversion[†]				-.029
				(.080)
N	48	48	48	48
Pseudo R^2	0.59	.56	.57	.57

[†]Eight missing observations were replaced by the mean. Lower confidence is equal to 1 if B's confidence is lower than the reported confidence of the paired A, and is 0 otherwise.

Results (tournament entry):

1. *When deciding whether to enter the tournament, participants are more likely to enter when their confidence is higher; they are also sensitive to the confidence reported by the opponent: If own confidence is lower than that of the opponent, subjects are far less likely to enter.*

2. *Females are less likely to enter the competition (by choosing IN), but this effect is mainly due to the difference in confidence. Once we control for confidence, the entry rate of women is not significantly lower.*

Finally, Figure 8 illustrates graphically a Lowess-smoothed estimation of B's reaction function to the difference in own and other reported confidence. We will use this response function of B when analyzing the optimal decisions for player A in the next section.

Figure 8: Estimated rate of B entry by difference in reported confidence

Lowess smoother, bandwidth = .8
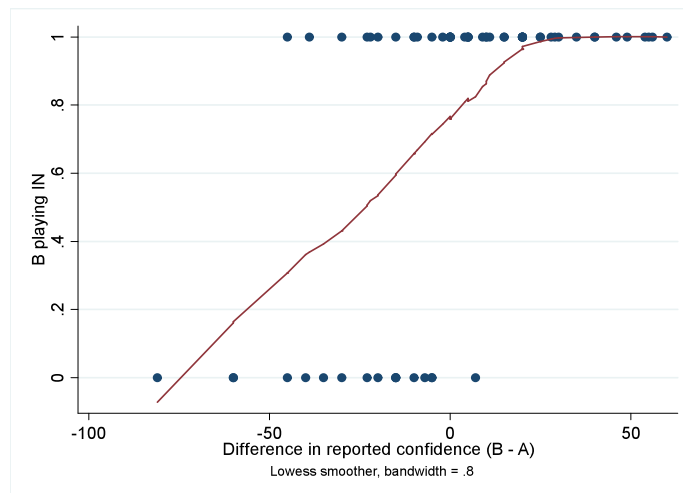
5. Discussion

In this section, we discuss the extent to which our data indicate the presence of self-esteem, social concerns, and self-deception. We then proceed to an analysis of the A player's optimal behavior in the high-outside-option condition, given the B player's anticipated responses. Finally, we discuss whether strategic overconfidence can be an equilibrium in our setting. Indeed, we find that strategic overconfidence can survive in equilibrium, and we demonstrate that this equilibrium is unique under the natural assumption of monotonicity.

5.1 Results regarding motivations for overconfidence

One key potential motivation for being overconfident is the ego utility that one derives, corresponding to an increase in self-esteem. Our data provide support for this notion. First, we observe substantial overconfidence even when the stated confidence level is not observed by anyone else, suggesting that people are either poorly calibrated when it comes to estimating own ability or that they receive some internal benefit from this inflated belief. The fact that people make far fewer updating errors with the Machine questions than with the Reports questions suggests that this may not an issue of calibration; furthermore, the reluctance of people to revise downward their beliefs about their ability (the self-serving errors), despite the fact that it is likely that their initial stated confidence is unrealistically high, provides further evidence that people derive ego utility from self-serving beliefs.

Of course, a conscious belief that one's ability is higher than it is could also represent a form of self-deception. By the same token, a refusal to update downward could also reflect some degree of self-deception. In fact, the puzzling result that there are many cases where people update downward when they shouldn't (the self-defeating errors) may indicate that some people are initially able to deceive themselves, but on some level don't really believe their stated confidence levels, abandoning them in the face of hard (but noisy) evidence. This story hangs together if people do have some awareness that their initial report is inflated. For example, we shall see in the next-subsection that A's should optimally over-report confidence in the high-outside-option tournament setting by as much as 20 percentage points. Since 80 percent of the self-defeating errors occur when the initial report is 75 or below, it may be that these people are updating correctly. However, we don't wish to push this point too strongly, given the potential confounds in the interpretation.

Regarding social concerns, we find no evidence that one's stated confidence is affected simply by the awareness that an anonymous paired other person will see one's report, absent any strategic considerations. In this respect, it seems that the social aspect must be more salient (as with a lower degree of anonymity, for example) in order for any potential effect to manifest. However, there is strong evidence that an increase in A's reported confidence can have deterrence value in terms of keeping B out of the tournament. We also see some evidence (see Figure 2, Table 2, and Table 3) that people report higher confidence in the strategic condition than in Treatments 1 and 2. How close is this behavior to that which is optimal for the A players? We take this up in the next subsection.

5.2 Determining optimal confidence reporting in the strategic setting

Since we have already established that B players are sensitive to reported confidence by A players, we investigate the best response of player A. We take the response of players B in the game (as shown above in Figure 8) and compute the best response of player A, under the assumption that he knew this response function. We then compare the best response of player A to the actual behavior.

To analyze the best response of player A, denote by $t_A \in [0,100]$ and $r_A \in [0,100]$ the true confidence and the reported confidence respectively by player A, and similarly t_B and r_B for B. The distribution of t_B is assumed to be normal with density $f(t_B)$ and c.d.f. $F(t_B)$ and truncation points 0 and 100. Let $P_B(IN)$ be the probability that player B plays IN. This depends on the reported confidence of A. Based on Figure 8, we estimate player B's response function as:

$$P_B(IN) = \begin{cases} 1 - \beta(r_A - t_B) & \text{if } r_A > t_B \\ 1 & \text{if } r_A \leq t_B \end{cases}$$

where we estimated $\beta = .01$.

If $\Pi(t_A,t_B)$ is the probability that player A wins if B plays IN, the expected payoff for player A of the tournament is given by:

$$\int_0^{100} 10[1 - P_B(IN) \cdot (1 - \Pi(t_A,t_B))]dF(t_B).$$

Player A can expect to earn 10 points, except if B plays IN *and* wins. The benefit of a higher report is the decreased probability that B plays IN. On the other hand, since players are incentivized by the quadratic scoring rule, there are costs associated with reporting a higher confidence than the true confidence. The optimal reported confidence for a risk-neutral player A is determined by the following equality:

$$r_A^* = t_A + \tfrac{1}{2}c\int_0^{r_A^*} \beta(1 - \Pi(t_A,t_B))dF(t_B).$$

The constant $c = 10,000$. This, and the '1/2' come from the quadratic scoring rule. For our estimation of r_A^*, we specify $\Pi(t_A,t_B)$ as a logistic function:

$$\Pi(t_A,t_B) = \frac{e^{\delta(t_A - t_B)}}{1 + e^{\delta(t_A - t_B)}}$$

For equal abilities, each player has a probability .5 of winning. From the Treatment 1 data (with no incentives to over-report) we obtain an estimate of $\delta = .025$.

Finally, we need to make assumptions about the density function f(t_B). We assume that true confidence is normally distributed (truncated at 0 and 100) with mean μ and standard deviation σ. In treatment 1 there is no scope to over-report for strategic reasons for any of the players. In this treatment, the mean and the standard deviation are given by $\mu = 65$ and $\sigma = 21$. However, as a benchmark we will assume that players believe the mean to be $\mu = 50$ so that they don't believe that other players are on average overconfident.

Figure 9: Optimal over-reporting of confidence in the high-option strategic setting

Confidence of A (t_a)
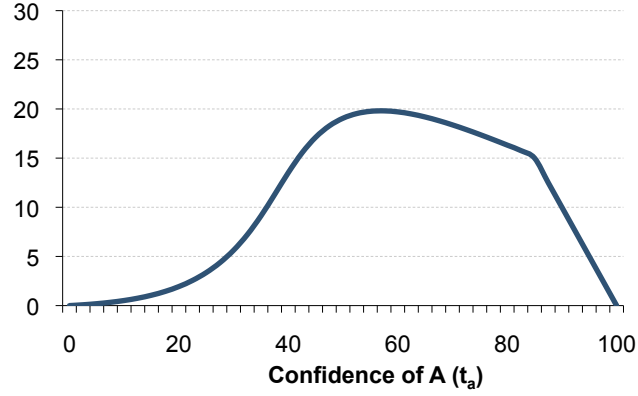
We use the above estimates as the benchmark case. Using these parameter estimates, we can derive the optimal overconfidence $r_A^* - t_A$, which is shown in Figure 9. The curve is largely unchanged with different parameter values. We see that player A has an incentive to over-report by an amount that 1) is low or zero for small values of the true confidence; and 2) has a peak at intermediate values, where the report is as much as 20 percentage points higher than the true confidence level. For participants with true confidence above 85, the optimal report is 100. There is no possibility to inflate reported confidence further. For participants with a true confidence level of 100, the optimal overconfidence is of course constrained to 0.

Is the amount of over-reporting (in the strategic setting versus the baseline treatment) comparable to the best response we calculated? According to Table 3, male A players report approximately 8.4 percentage points higher confidence in the high-option strategic setting, while the confidence reports for female A players do not differ across the strategic and non-strategic settings. The fact that reported confidence of male players A is sensitive to whether or not player B can respond to this signal, suggests that confidence is indeed used as a social signal to influence others. Given the actual distribution of reported confidence in Treatment 1, we calculate that the average optimal degree of over-reporting relative to Treatment 1 is about 14.1 percentage points.

5.3 Determining the optimal entrance decision

It also appears that B players may realize that A players over-report, and deflate these statements. In specification (1) in Table 4, the coefficient 'own confidence' is almost 50 percent higher than 'confidence other' in absolute terms, so one's own feeling is more important for the decision to enter than that of the opponent; this difference is significant at the 10 percent level.

To examine if B players are best responding, assume they believe that players A over-report in accordance with estimates from the previous sector (see Figure 9). Let $\mu(t_A|r_A)$ be the beliefs that B assigns to a type of A (t_A) after observing r_A. With an outside option of ω, a risk neutral player B is indifferent between IN and OUT if $t_B = \widetilde{t}_B$, where:

$$\int_0^{100} 10\Pi(t_A, \widetilde{t}_B)\mu(t_A|r_A)dt_A \equiv \omega.$$

Any player B with $t_B < \widetilde{t}_B$ will opt out. If all beliefs are concentrated on a single type t_A, then:

$$\widetilde{t}_B = t_A - \frac{1}{\delta}\ln\left(\frac{10-\omega}{\omega}\right).$$

If $\omega = 5.5$ (high outside option) and $\delta = .025$, then $\widetilde{t}_B \approx t_A + 8$. If several types of A players pool and report the same confidence, then B computes the expected payoff based on the conditional distribution of all types in the pool.

Let the inferences that B makes after observing A's report, i.e., $\mu(t_A|r_A)$, be based on $r_A^* - t_A$ as derived in the previous section. All types t_A exceeding 84.7 will pool at a report of 100. For types below 84.7, the report is below 100 and the report reveals the true type of player A. Again, we

will assume that players believe the mean confidence of others to be $\mu = 50$ and a standard deviation

of 21, so that they don't believe that other players are on average overconfident.

Figure 10 shows the threshold of B and IN/OUT decisions for the high-outside-option

treatment. The reported confidence of A players is on the horizontal axis, and that of the B players

is on the vertical axis. The dots represent all choices of the players. The players that chose OUT are

represented by the solid dots, the IN choices by the open dots. The solid curve plots the threshold

level for B. If this were the true threshold level, all B players with a confidence above the threshold

level should choose IN. The computed threshold level is consistent with 87.5% of the actual

choices; furthermore, the few inconsistent choices are quite close to the threshold. This remarkably

strong predictive power seems very close to the upper bound permitted by the noise in the data.

Figure 10: Entry choices of players B in the high-option strategic setting
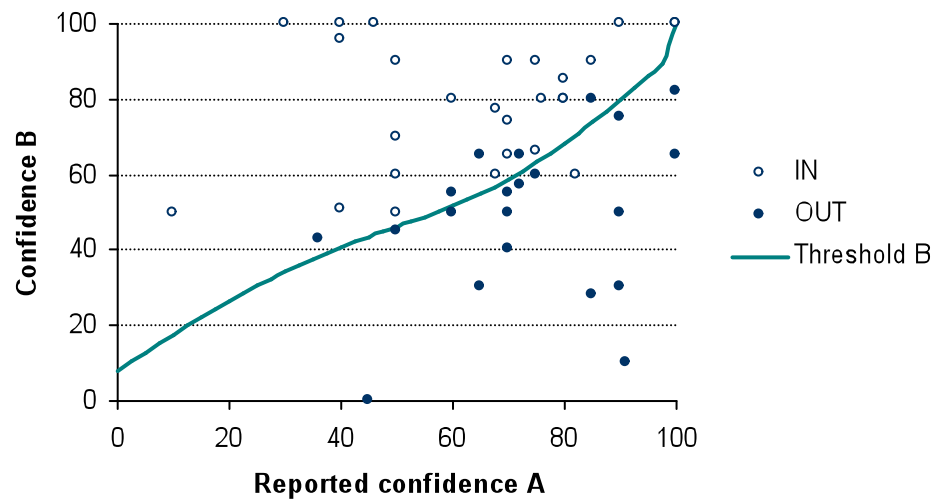
5.4 Equilibrium

This takes us to the issue of whether strategic overconfidence is sustainable in equilibrium. In Figure 9, players A over-report, and the only pooling interval occurs for players with a confidence above 84.7, all reporting 100, while all others separate. Hence, players B can identify the true type from the reported type of A for reports below 100. Can it be that players A over-report in equilibrium even though players B can infer the true type of A, and even though over-reporting is costly for A? The answer is yes. The reason is that if players B believe that there will be over-reporting by A, then if some player A reports her true type, B will associate A with an even lower type of A player. This is analogous to games of limit pricing under incomplete information, where incumbent firms try to signal their strength to potential entrants by lowering their price. Lowering the price is a costly action, but may deter competition by making it appear unattractive to enter (see, for instance, Milgrom and Roberts, 1982). Such games can have equilibria with (partial) separation of types.

6. Conclusion

We conduct experiments to examine the determinants of overconfidence, and the degree to which it reflects self-image (consumption or ego utility,) social image (utility from the perceptions of others, or strategic concerns. First, we observe that the preponderance of the participants state a belief that they are above the median in their ability on the task. Second, people are much less accurate in updating their beliefs when new information concerns their own ability than when the information is about an impersonal issue. This would appear to show that information processing when own reputation (either in one's own eyes or the eyes of others) is at stake is of a different nature than abstract, neutral information processing. Many people seem reluctant to adjust their beliefs about own ability downward in the face of negative feedback. These two effects suggest that

there is a degree of ego utility involved in overconfidence. There is no difference in behavior when another party can observe another person's stated confidence but cannot act upon the information; however our experimental social context may not be very salient.

Many people adjust their beliefs downward more than they should with negative feedback. This could also represent a form of self-deception. The updating errors may not in fact be errors, but may instead indicate that some people are initially able to deceive themselves, but on some level don't really believe their stated confidence levels, abandon their stated confidence levels when presented with real feedback. Since this behavior mainly occurs when the initial report is close to the threshold for changing one's beliefs about relative standing, it may be that these people are updating correctly. In the same vein, the refusal to update beliefs downwards when it is appropriate may also represent a more stubborn case of self-deception.

Some of our most novel results concern behavior in a strategic environment, in which another party observes the stated confidence level of another and then chooses whether or not to enter a tournament with this other person. We find that people do respond to statements about confidence made by others, taking the information conveyed into account when choosing whether or not to enter. Male participants in the 'incumbent' position on average report significantly higher confidence levels in this treatment than in the non-strategic ones. Remarkably, the observed level of (costly) inflated stated confidence is not too far from the estimated optimal level, and also serves as an effective deterrent. Our simple estimation of the threshold own confidence value for entry does an excellent job of predicting actual entry decisions; relative stated confidence is a strong predictor of entry decisions. There is an equilibrium in which stated confidence is inflated (at a direct cost to the sender).

Considerable research has been done on gender, overconfidence, and competition, and our results provide some evidence in this regard. We find that in a non-competitive environment, males state confidence levels only slightly higher than those stated by females, and have identical ability levels on the IQ-Raven test. So men and women are equally overconfident in this case. However, stated confidence levels are substantially higher for men when they know that there will be a tournament and that their confidence level will be observed. Men choose to enter a tournament much more frequently than women do, but this in fact corresponds to a lower stated confidence level. So women are not necessarily less competitive than men, just less overconfident in a competitive environment.

It is not obvious why men appear to unconsciously try to deter entrants from entering a tournament against them and women do not do so. In fact, males inflate their confidence in a tournament condition whether or not they are would-be entrants, suggesting some sort of automatic response to competition.

Is the unconscious mind strategic? How much of the behavior we have observed, particularly the strategic behavior, is induced through some form of self-deception? We provide some evidence on these questions, but we have only scratched the surface. We plan to follow up on these issues in subsequent research, and invite others to do so as well.

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Appendix A: Timeline

Timeline

	Before actions, participants informed about:	Actions
Part 1	**They will take the Raven test and we will ask them afterwards about how well they think they did,** • **They will be matched against another player (A/B),** • *No* **mention made of visibility confidence estimates to other players,** • *No* **mention made of strategic decision player B.**	**They take that Raven test**
Part 2	**We will ask for their confidence. Before they report this, they are informed about:** • **the visibility of their estimate to player B,** • **the player with the highest rank receives 10 points (private, social) or that player B takes decision (strategic)**	**They report their confidence level**
Part 3	**They will receive a report (private)**	**They answer in the report question**
Part 4	**They receive machine questions (private)**	**They answer the machine question**
Part 5	**Player B will make a decision (strategic) and they will see who has the highest rank (all).**	**Player B takes a decision (strategic) and they will see who has the highest rank among player A and B.**

Appendix B: Instructions

The comments in square brackets are meant to illustrate instructions to the reader and were not part of the instructions.

General instructions

Introduction
Welcome to our experiment. You will receive €7 for showing up, regardless of the results. The instructions are simple. If you follow them carefully, you can earn a substantial amount of money in addition to your show up fee. Throughout the stages we will ask you to answer questions. At each stage, you will receive more detailed instructions.

You will be part of a group of 4 persons. You don't know who the other persons are, and you will remain anonymous to them. All your choices and the amount you will earn will remain confidential and anonymous, except if explicitly indicated otherwise. You will receive your earnings in an envelope. The person that puts the money in the envelopes can only see the login number that has randomly been assigned to you, and cannot match any names, student numbers, or faces with the login numbers and the decisions made.

Payments
There are several items in the experiment for which you can earn points. At the end of the experiment, one item is randomly chosen and your points for that item are paid in addition to the show-up fee (1 point is worth €1).

One of the participants is randomly chosen to be an assistant during the experiment. There is a random component in the experiment. The task of the assisting person will be to throw a dice which will determine the outcome.

No deception
Remember, we have a strict no deception policy in this lab.

Questions
Please remain seated and raise your hand if you have any questions, and wait for the experimenter. Please remain silent throughout the experiment.

Part 1.

In the first stage, all group members receive the same 15 questions. You will see a matrix with one missing segment at the bottom right. Your task is to identify the segment that would logically fit at the position of the missing segment, by choosing from the suggested answers. You can make your choice by clicking the corresponding number on the right of your screen. [A screenshot with an example question was provided.]

You can go back and forth between the questions. There is a time limit of 8 minutes. The time remaining is indicated on your screen.

After the time limit, we will rank all 4 people in your group depending on the number of questions answered correctly. The person with the highest score will get rank 1, and the person with the lowest score will get rank 4. In case of ties, the computer will randomly determine who gets the higher rank. After this, you will get some questions regarding how well you think you did.

We then randomly divide the group in 2 players A and 2 players B. Every player A will be matched against a player B. If your rank is higher than the player with which you are matched, you can receive 10 points.

Part 2.

All four group members have now finished with the questions, and we have determined the rank of every person.

We now ask you to indicate how likely you think that you are among the top 2 of your group. You can indicate this on a scale from 0 to 100%. Indicating 0% means that you are sure you are not among the best 2 of your group, while indicating 100% means that you are sure you are among the top 2 of your group. Similarly, 50% indicates that you think it is equally likely that you are among the best 2 of your group, or that you are not among the best 2 of your group.

We will pay you for the accuracy of your estimate. You earn more points for this item if your estimate is more accurate. The formula that is used to calculate the amount of money you earn is chosen in such a way that your expected earnings are highest when you report to us what you really believe. Reporting any value that differs from what you believe decreases your expected score for this item. If you are interested, you can find some detailed examples of this to see how this works.

[An explanation with examples was available to participants, see next page.]

The role of player A and player B
We matched you with one other randomly chosen person from your group. You are either Player A or B, and this is randomly determined.

[private] None of the players can see the other player's estimate of being in the top 2.

[social] Player A will not see the estimate by player B that he or she is among the best two in the group, but player B will see the estimate by Player A that he or she is among the best two of the group.

[private and social] Later on in the experiment, we will compare the rank of player A with the rank of player B, and for that item the player with the highest rank receives 10 points, the other nothing. Both of you will see who has the highest rank, and this ends the stage.

[strategic] Player A will not see the estimate by player B that he or she is among the best two in the group, but player B will see the estimate by Player A that he or she is among the best two of the group.

Later on in the experiment, after player B has observed the estimate of player A, player B will choose between two options: IN or OUT.

If player B chooses OUT, then for that item player B receives 3.5 [5.5] points and player A automatically receives 10 points. Both players will see who has the highest rank, and this ends the stage.

If player B chooses IN, we will compare the rank of player A with the rank of player B, and for that item the player with the highest rank receives 10 points, the other nothing. Both of you will see who has the highest rank, and this ends the stage.

[Participants could see their role on the next screen.]

Determination of your score

What follows is a brief explanation about the determination of your score, showing that it is in your interest to report truthfully what you believe in order to maximize your expected earnings.

The score is determined as follows. You start with 10 points. We subtract points depending on how close your reported belief is to the outcome. The outcome is set to 1 if you are in the top 2, and to 0 if you are not.

For instance, if you report 70% (.7), and you are in the top 2 (outcome is 1), you are .3 away from the outcome, while if you are not in the top 2 (outcome is 0), you are .7 away from the outcome.

The difference with the outcome is squared and multiplied by 10, and then subtracted from the 10 points that you start with. Thus in the example with 70%: if you are in the top 2, this gives you $10 - 10(.3)^2 = 9.1$. If you are not in the top 2, this gives $10 - 10(.7)^2 = 5.1$. You would weight these two scores by your belief about the likelihood of each occurring.

Larger differences between your reports and the outcome decrease your score proportionally more than small differences. To minimize the expected difference, and maximize your expected score, you should report what you believe.

The following examples illustrate that your expected score is highest when you report your true beliefs. All numbers used are for illustrations only and are no indication for the decisions for you to take.

Example 1
You believe 50% and report 50%. As a simple example: if you believe there is a 50% chance you are in the top 2, and you report 50%, then there is always a difference of .5 with the outcome, and since this is squared we always subtract 10 times $(0.5)^2$ points from your score, i.e. 2.5 points. Your expected score is 7.5.

You believe 50% but you report 100%. If you report 100%, then in one case there is no difference (if you are in the top 2) and no points are subtracted. But in the other case the difference is 1 (if you are not in the top 2), and then we subtract 10 times $10(1)^2 = 10$ from your score. If you believe the likelihood of being in the top 2 is 50%, you expect this to happen in 50% of the cases, so the amount subtracted would be $10(.5) = 5$. This gives you an expected score of 5, which is lower than if you report your belief of 50%.

Example 2

You believe 70% and report 70%. As another example, suppose that you think there is a 70% likelihood that you are among the best 2. If you report 70%, your score will be either 9.1 (if you are in the top 2) or 5.1 (if you are not in the top 2). You believe that with 70% chance your score will be 9.1, and with 30% your score will be 5.1. So your expected score is $.7(9.1) + .3(5.1) = 7.9$.

You believe 70% and report 100%. Now suppose that, instead of reporting this belief of 70%, you report another number. For instance, you report 100% (1). This means that if you are in the top 2, the outcome is as predicted, and you get $10 - 10(0)^2 = 10$ points. If you're not in the top 2, you are 1 away from the outcome, and your score will be $10 - 10(1)^2 = 0$. Since you actually expect to be in the top 2 with 70% chance, your expected score is 7. This is lower than if you would have reported 70%.

You believe 70% and report 20%. The same is true if you report a number below your belief, for instance 20% (.2). If you are in the top 2, your score would be $10 - 10(.8)^2 = 3.6$ points. If you're not in the top 2, your score will be $10 - 10(.2)^2 = 9.6$. Since you actually expect to be in the top 2 with 70% chance, your expected score is $0.7(3.6) + 0.3(9.6)^2 = 5.4$, again lower than if you would have reported 70%.

The table below shows the expected scores for some more possible beliefs you may have and reports you give. As you can see, expected scores are highest when the reported belief is equal to the true belief (the cells on the diagonal that highlighted in green).

Expected scores

Your report (%)	Your Belief (%)										
	0	10	20	30	40	50	60	70	80	90	100
0	10	9	8	7	6	5	4	3	2	1	0
10	9.9	9.1	8.3	7.5	6.7	5.9	5.1	4.3	3.5	2.7	1.9
20	9.6	9	8.4	7.8	7.2	6.6	6	5.4	4.8	4.2	3.6
30	9.1	8.7	8.3	7.9	7.5	7.1	6.7	6.3	5.9	5.5	5.1
40	8.4	8.2	8	7.8	7.6	7.4	7.2	7	6.8	6.6	6.4
50	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
60	6.4	6.6	6.8	7	7.2	7.4	7.6	7.8	8	8.2	8.4
70	5.1	5.5	5.9	6.3	6.7	7.1	7.5	7.9	8.3	8.7	9.1
80	3.6	4.2	4.8	5.4	6	6.6	7.2	7.8	8.4	9	9.6
90	1.9	2.7	3.5	4.3	5.1	5.9	6.7	7.5	8.3	9.1	9.9
100	0	1	2	3	4	5	6	7	8	9	10

Part 3.

Based on your true ranking in the group, we will send you a *report*. The report will say if you are among the two best of your group, or if you are not among the two best of your group.

However, **sometimes the report will be incorrect**. The way this works is as follows.

If you **are not** among the top two of your group, then the report will always be correct and inform you that you are not among the best two of your group.

If you **are** among the top two of your group, the report is mistaken in half of the cases. That is, in half of the cases, the report correctly informs you that you are among the top two of your group. In the other half of the cases, the report is incorrect and says you were not among the top two of your group, even if you were.

Whether or not the report you receive is correct when you are among the top two of your group, depends on the outcome of a dice throw by the assistant. You will not see the outcome, but if the assistant throws 1, 2, or 3, you will receive a correct report when you are among the top two. If the assistant throws 4, 5, or 6, you will receive an incorrect report when you are among the best two of your group. (For some groups, the incorrect report is sent after different values of the dice, but in any case the report is incorrect in half of the cases when you are among the best 2.)

After you see the report, we will ask you if you think the report is more likely to be correct or incorrect.

You earn 10 points if you are right.

In this part, we ask you some questions about the scenario below. The first part is always the same, but some additional information is given in the question, so please read it carefully. For this part, we randomly choose a question and this is treated as a single item.

Scenario
Consider two machines placed in two sides of a large production hall, left side = L and right side = R. The two machines produce rings, good ones and bad ones. Each ring that comes from the left machine, L, has a 50% chance of being a good ring and a 50% chance of being a bad ring. Each ring that comes from the right machine, R, is good. Both machines produce 100 rings every day.

The mechanic visits the production hall every day, and randomly examines one of the machines by taking one ring. On some days, he takes a ring from the left machine, and the other days he takes a ring from the right machine. Suppose the ring he takes is *good*.

We will ask you if it is more likely that the mechanic went to the left or right machine.

Example question
'On 50% of the days, the mechanic takes a ring from the left machine, and the other 50% of the days from the right machine.

Of the rings that come from the left machine, on average half are good and half are bad. Each ring that comes from the right machine is good.

Imagine the ring he takes is good. Is it more likely to come from the left or right machine?'

You will get 3 questions like this one. We vary the percentage of days that the mechanic goes to the left or right machine, but everything else remains the same.

You earn 10 points if you are right.

Part 5.

In this part, you are informed if player A or B has the highest rank.

Player A will not see the estimate by player B that he or she is among the best two in the group.

Player B will see the estimate by Player A that he or she is among the best two of the group, and then gets the choice between two options: IN or OUT.

If player B chooses OUT, then player B receives 3.5 [5.5] points and player A automatically receives 10 points. Both players will see who has the highest rank, and this ends the stage.

If player B chooses IN, we will compare the rank of player A with the rank of player B, and the player with the highest rank receives 10 points, the other nothing. Both of you will see who has the highest rank, and this ends the stage.

Appendix C

Figure C1: Illustration of the signal structure in the Report and the Machine question.
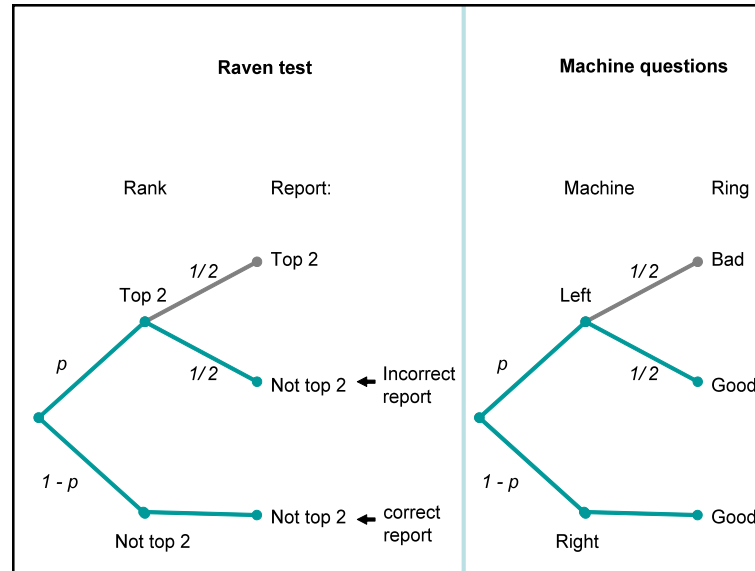
This figure was not provided to subjects, and is only meant as illustration.