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Hot hand belief and gambler’s fallacy in teams: Evidence from investment experiments

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Hot Hand Belief and Gambler’s Fallacy in Teams: Evidence from Investment Experiments

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January 30, 2013

Abstract

In laboratory experiments we explore the effects of communication and group decision making on investment behavior and on subjects’ proneness to behavioral biases. Most importantly, we show that communication and group decision making does not impact subjects’ overall proneness to biases like gambler’s fallacy and hot hand belief. However, groups decide differently than individuals as they rely significantly less on useless outside advice from “experts” and choose the risk-free option less frequently. Finally, we document gender differences in investment behavior: groups of two female subjects choose the risk-free investment more often and are slightly more prone to the hot hand belief than groups of two male subjects.

JEL classification: C91, C92, D81, G10
Keywords: Hot hand belief; Gambler’s fallacy; Experimental finance; Experts; Team decision making.

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1 Introduction

The gambler’s fallacy and the hot hand belief are two behavioral biases playing an important role in financial markets. People who are affected by these biases misinterpret random sequences. Specifically, when prone to the gambler’s fallacy, they expect that, even in a short sequence of events, possible realizations should be represented according to the overall probabilities (Tversky and Kahneman, 1971). Expressed more formally: a non-autocorreleated random sequence is believed to exhibit negative autocorrelation. Financial decisions are flawed by this misperception. One example is the disposition effect, which postulates that investors (private and institutional alike) sell winners too soon and hold losers too long (Odean, 1998; Shapira and Venezia, 2001; Rabin, 2002). In a portfolio selection task Kroll et al. (1988) document sequential dependencies, predominantly the gambler’s fallacy in subjects’ investment decisions.

Contrary to the gambler’s fallacy, people prone to the hot hand belief expect a positive autocorrelation in a non-autocorrelated random sequence, generating beliefs that a run of a certain realization will continue in the future. In financial markets this bias is observable when investors delegate decisions to experts, i.e., professional fund managers. Specifically, people mostly buy those funds which were successful in the past believing in the managers’ ability to prolong the performance record (see e.g. Sirri and Tufano, 1998). Rabin (2002) calls this phenomenon overinference.1

Biased decisions can lead to unfavorable or negative consequences for the decision maker. For instance, Goetzmann and Kumar (2008) document that U.S. investors who exhibit trend-related behavior - either trend chasing (hot hand) or contrarian (gambler’s fallacy) - hold less diversified portfolios implying negative risk and performance consequences. Another strand of literature documents that private investors believe in hot hands of mutual fund managers. As a consequence, Brown et al. (1996), Chevalier and Ellsion (1997), and Sirri and Tufano (1998) report that new fund inflows are positively related with historic mutual fund rank. However, this belief in hot hands of fund managers is wrong, as, among others, Carhart (1997) and Malkiel (2003, 2005) report no annual persistence in fund performance. In a different context, Dohmen et al. (2009) relate the hot hand belief and the gambler’s fallacy to an increased probability of long-term unemployment and to a higher probability to overdrawn bank accounts, respectively. Given the negative consequences of biases for those prone

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1Ayton and Fischer (2004) argue that people’s prior expectations affect their behavior when facing random sequences in different contexts. People believe that basketball players are getting “hot” (Gilovich et al., 1985) but we are less likely to develop the same belief in roulette playing. So, the hot hand belief is usually attributed to human skilled performance, whereas the gambler’s fallacy is often attributed to chance mechanisms.
to them, it is important to focus on potential strategies to neutralize them.

By using portfolio choice experiments Huber et al. (2010) investigate both biases in a unified framework. Experimental participants are confronted with a series of independent coin tosses showing head and tail with probability 0.5 each. They can choose to (a) predict the realization of the next coin toss themselves, (b) delegate the decision to computerized agents, called experts, or (c) take a risk-free payment. Huber et al. (2010) observe that subjects exhibit both, the hot hand belief and the gambler’s fallacy. Specifically, experts are selected more frequently, the more successful they had been in the past, i.e., subjects expect hot hands of the randomized experts. In contrast, among subjects picking head or tail themselves the authors observe the gambler’s fallacy as head (tail) is chosen less frequently after streaks of heads (tails). By using a similar framework but labelling experts differently, Powdthavee and Riyanto (2012) report strong hot hand beliefs into outside advice for the outcome of randomized coin tosses. In their paper “experts” were simple modelled as envelopes with predetermined advice for each period of the investment game.

In this paper we focus on one commonly applied approach to reduce decisions flawed by idiosyncratic characteristics of individuals, namely the installation of decision committees. For instance, the “Governing Council of the European Central Bank” consists of 23 members that jointly decide on the monetary policy for the Eurozone. In financial markets, teams of fund managers decide on the investment strategy of a fund and which stocks to pick. Ample evidence in the literature supports the positive impact of group decision making on decision quality. Irrespective of decisions being made in strategic or non-strategic situations, groups perform equally well or better than individuals. Though, group decision procedures are widely implemented, we know surprisingly little about how they affect potentially present behavioral biases in financial markets.

In this paper, we specifically focus on two research questions (RQ). The first part of each RQ centers on the decisions made by individuals or groups. In a second step we go more into detail and investigate potential gender effects.

**RQ 1**: Do groups decide differently compared to individuals in selecting their investment or in relying on outside advice? Does gender composition of the groups play a role?

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2 Ackert et al. (2012) report that hiding information of past realizations prevents subjects in their experiment from exhibiting the gambler’s fallacy in portfolio decision experiments. This approach, however, seems practically impossible, given the large amount of available financial data and the attention this data generates.


4 See Croson and Gneezy (2009) for a review of gender differences in economic experiments.
The second RQ investigates whether group decision making leads to financial decisions less influenced by behavioral biases. So far, there is no evidence on this specific issue, while Dohmen et al. (2009) and Suetens and Tyran (2012) provide some (inconclusive) evidence of gender effects on behavioral biases.

**RQ 2**: Are groups differently prone to behavioral biases such as the gambler’s fallacy and the hot hand belief compared to individuals?

Does gender composition of the groups play a role?

The presence of behavioral biases in the portfolio decision experiment of Huber et al. (2010) allows us to test the robustness of their results for group decision making. Using Treatment INDIV as reported in Huber et al. (2010) as our benchmark, we conduct further treatments with different levels of group decision making. In treatments COMM and GROUP subjects are assigned to groups of two and a chat is installed. While communication is possible in both treatments they differ in the way decision making takes place. In Treatment COMM subjects can communicate, but decide individually. In Treatment GROUP subjects have to agree on a decision as a group.

Most importantly we show that (i) communication and group decision making does not impact subjects’ overall proneness to behavioral biases like gambler’s fallacy and hot hand belief. (ii) We further report a lower proneness of groups in Treatment GROUP to useless expert advice compared to the other treatments. (iii) As third major finding we observe that group decision making in Treatment GROUP leads to fewer choices of the risk-free alternative and to more own guesses on the realization of the coin toss compared to the other treatments. (iv) Finally, we observe that gender composition of groups plays a crucial role in investment behavior: groups of two female subjects choose the risk-free investment significantly more often and delegate investment decisions less often to experts than groups of two male subjects. In addition, we are the first to document that women and female-only groups show a slightly higher proneness to the hot hand belief.

The paper is structured as follows: In Section 2 the experimental decision problem and the experimental treatments are outlined. Section 3 presents the results and Section 4 summarizes and discusses the results.

## 2 The experiment

### 2.1 Design of the experiment

At the beginning of the experiment subjects receive an initial endowment of 500 Taler (the experimental currency). In each of 40 periods subjects are asked to
choose between a risky and a risk-free investment which differ in payouts (see Figure 1).

![Decision Tree](image)

Figure 1: Decision tree and payouts for one period.

When selecting the risk-free alternative (RISKFREE) subjects earn 10 Taler with certainty. This option is offered to mirror real markets where (almost) risk-free investments are also available.

The risky investment is simulated by coin toss showing head and tail with equal probabilities. The subjects’ task when going for this alternative is to choose one side of the coin. This can be done in two distinct ways. First, subjects can make own guesses on the realization of the coin (RISKOWN) or, second, they can delegate the decision to one of five computerized agents - labelled “experts” (RISKEXPERT), who then randomly pick one side of the coin for the subject. The random sequence of coin tosses is used as analogy to financial asset markets, assuming that changes in asset prices are indistinguishable from random sequences.\(^5\)

It might be argued that the computerized coin toss as well as the expert labelling might generate (in fact false) beliefs of experimenter manipulations. In a similar setting Powdthavee and Riyanto (2012) explore potential consequences of these arguments by tossing the coin in public and by not labelling advice as “experts.” These changes, however, leave results almost unchanged revealing that they are of minor importance in the reported experiment.\(^6\)

\(^5\)See Fama (1970, 1991) for a review of papers discussing the random walk hypothesis. In real financial markets a positive expected return for stocks can be observed. Therefore the probabilities will not be exactly 50:50, but slightly biased upwards. We still decided to use a 50:50 coin toss as our stochastic process, as it is easy to understand for subjects in our experiment. When looking at real financial data we find that our assumption is quite accurate: of all daily changes of the NYSE Composite index from January 3, 1966 to December 31, 2012, 52.51\% were positive and 46.92\% were negative (on 68 trading days=0.57\% the index did not change). For the Dow Jones Industrial average figures are comparable. From January 3, 1928 to December 31, 2012, 52.17\% were positive and 47.40\% were negative (on 96 trading days=0.43\% the index did not change).
If subjects make own guesses on the realization of the coin toss, they earn 100 Taler if their guess coincides with the random realization, otherwise they lose 50 Taler, for an expected profit of 25 Taler. When subjects delegate decisions to the experts they have to pay two types of fees. First, an issue surcharge of 5 Taler is deducted if subjects select an expert that they did not choose in the previous period. Staying with the same expert in the following periods does not trigger the fee again. Second, a management fee of 1 Taler is collected each period a subject selects one of the experts. If the expert’s decision and the coin realization are identical, 100 Taler minus charges are added to the subjects’ account. In the opposite case, 50 Taler plus the charges are subtracted from his account (see Figure 1).

Taking a look at the payouts of the risky investment we can see that RISK\textsubscript{OWN} dominates RISK\textsubscript{EXPERT}. RISK\textsubscript{OWN} exhibits a higher expected value of payout and offers superior payouts for each state of nature (win, lose) as no fees apply.

At the end of the experiment subjects’ current holdings are exchanged into Euros at a known fixed rate of 100:1 and paid out privately in cash. The average payout was EUR 14.

2.2 Treatments

In Treatment INDIV each subject chooses between RISK\textsubscript{OWN}, RISK\textsubscript{EXPERT}, and RISK\textsubscript{FREE} individually. No communication between subjects is allowed and actions by one subject do not influence actions or outcomes of other subjects.

In Treatment COMM subjects are randomly paired at the beginning of the experiment. Pairs are kept unchanged for the entire experiment. The two subjects in a pair can chat for up to 90 seconds each period before making a decision.\textsuperscript{7} The chat area is placed in the lower third of the main screen such that subjects can access their past decisions, their performance, and the experts’ performance anytime during the experiment. While subjects can exchange information and expertise via the chat, their decisions are still individual decisions, i.e., the decision of the chat-partner has no influence on the subject’s payout.\textsuperscript{8}

In Treatment GROUP a chat is set up exactly as in Treatment COMM, but now the chat-partners are incentivized to reach a joint decision. While each subject still has to enter his decision individually on the screen, they can only earn a positive payoff if they chose the same decision. If the chat-partners’ decisions are identical, payouts are calculated as previously specified. However,

\textsuperscript{7}The chat time was reduced to 60 seconds after period 15 and it can be ended any time before the official stop by clicking an “End Chat”-Button.

\textsuperscript{8}Of 2,400 decisions in Treatment COMM 1,113 (46.4\%) were different between the two subjects of a group, while 1,287 (53.6\%) were identical.
when the decisions of the two chat-partners are not identical they are redirected to the chat for another 45 seconds. If the newly entered choices are still inconsistent, subjects are penalized by deducting 50 Taler from each subject's account irrespective of their choices.\(^9\)

### 2.3 Implementation of the experiment

During the experiment each subject has access to several sources of information on the trading screen (see Appendix B). His current wealth, the number of periods played, previous decisions, the current and past realizations of the coin, his success/failure, and the changes of his holdings in each period are displayed. Furthermore, subjects are informed about the past history of the experts. In the starting period subjects see a randomly generated series of the last five periods of the experts’ history.\(^10\) In the lower part of the screen a performance measure for experts is presented. It displays the percentage of correct decisions within the previous five periods. The realizations of the coin tosses are drawn randomly in advance and we use the same realizations for each session to ensure comparability across sessions. For a detailed list of the coin realization and information about the experts’ performance in each period see Table A1 in the Appendix.

We conducted 18 sessions (6 per treatment) with a total of 360 subjects (120 per treatment). In total we observe 4,800 decisions per treatment yielding a total 14,400 decisions to analyze. The experiments were conducted with z-Tree (Fischbacher, 2007) and took place at the University of Innsbruck. Subjects were recruited using ORSEE by Greiner (2004).

### 3 Results

#### 3.1 Investment decision quality

To tackle RQ 1 on the effects of group decision making on investment decisions we compute each subject’s/group’s ratio of decisions for predicting the coin toss on her/their own (RISK\(_{OWN}\)), the ratio of delegated decisions to experts (RISK\(_{EXPERT}\)), and the ratio of the risk-free alternative (RISK\(_{FREE}\)). Treatment averages (column 3), and averages by gender composition (columns 4-6) are outlined in Table 1. In Table 2 we summarize results from t-tests compar-

\(^9\)Out of 2,400 decisions in Treatment GROUP subjects did not reach a joint decision in 5 cases (0.2%), 4 of which happened in periods 1 and 2.

\(^{10}\)This sort of information is easily accessible on real financial markets as it is an important marketing tool of mutual funds. Kroll et al. (1988) document a high demand for past return realizations in their experiment, though the knowledge of the underlying process reveals the uselessness of this sort of information.
ing subject/group averages of RISK\textsubscript{OWN}, RISK\textsubscript{EXPERT}, and RISK\textsubscript{FREE} across treatments.

Table 1: Investment decisions across treatments and gender. RISK\textsubscript{OWN} stands for the ratio of subjects/groups predicting the realization of the coin flip on their own. RISK\textsubscript{EXPERT} measures the ratio of delegated decisions to experts among all decisions. RISK\textsubscript{FREE} indicates the ratio of choices for the risk-free alternative. M (F) denotes male (female) individuals, MM denotes male only groups, MIX are mixed groups, and FF are female only groups.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Decisions</th>
<th>All</th>
<th>M/MM</th>
<th>MIX</th>
<th>F/FF</th>
</tr>
</thead>
<tbody>
<tr>
<td>INDIV</td>
<td>RISK\textsubscript{OWN}</td>
<td>68.8%</td>
<td>67.6%</td>
<td>70.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RISK\textsubscript{EXPERT}</td>
<td>23.8%</td>
<td>27.1%</td>
<td>18.4%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RISK\textsubscript{FREE}</td>
<td>7.5%</td>
<td>5.3%</td>
<td>10.9%</td>
<td></td>
</tr>
<tr>
<td>COMM</td>
<td>RISK\textsubscript{OWN}</td>
<td>71.8%</td>
<td>67.9%</td>
<td>75.4%</td>
<td>66.9%</td>
</tr>
<tr>
<td></td>
<td>RISK\textsubscript{EXPERT}</td>
<td>23.6%</td>
<td>29.2%</td>
<td>20.5%</td>
<td>22.6%</td>
</tr>
<tr>
<td></td>
<td>RISK\textsubscript{FREE}</td>
<td>4.7%</td>
<td>2.9%</td>
<td>4.1%</td>
<td>10.4%</td>
</tr>
<tr>
<td>GROUP</td>
<td>RISK\textsubscript{OWN}</td>
<td>79.4%</td>
<td>80.6%</td>
<td>78.7%</td>
<td>79.5%</td>
</tr>
<tr>
<td></td>
<td>RISK\textsubscript{EXPERT}</td>
<td>17.2%</td>
<td>18.6%</td>
<td>18.4%</td>
<td>13.6%</td>
</tr>
<tr>
<td></td>
<td>RISK\textsubscript{FREE}</td>
<td>3.4%</td>
<td>0.8%</td>
<td>2.9%</td>
<td>6.9%</td>
</tr>
</tbody>
</table>

In all treatments the majority of decisions are observed in category RISK\textsubscript{OWN}. However, compared to the benchmark treatment (INDIV) we notice that in treatments COMM and GROUP choices for RISK\textsubscript{OWN} are 3.0 and 10.6 percentage points higher, respectively. While the impact of communication is small and insignificant, the marked difference between INDIV and GROUP reveals a significant transformation in the decision behavior between individuals and groups. This implies that groups are closer to an expected payout maximizing strategy.

A similar picture emerges for RISK\textsubscript{EXPERT}. Decisions delegated to experts are highest when subjects decide individually and communication among groups does not significantly impact decision behavior. However, when deciding in groups, experts lose significant market share as only 17.2% of all decisions are delegated compared to 23.8% and 23.6% in INDIV and COMM, respectively. This translates into a loss in market share of approximately 28%. Choices for RISK\textsubscript{FREE} are highest in INDIV where 7.5% of decisions are observed in this category. In treatments COMM and GROUP we observe a significant reduction as only 4.7% and 3.4% of decisions are made for RISK\textsubscript{FREE}. This constitutes a reduction of 37% and 55%, respectively.

In columns 4-6 of Table 1 we further split results by gender. In addition, Table 3 provides statistical tests by showing the differences in percentage points between gender (Mann-Whitney U-tests) within each treatment.

The results reveal no distinct gender effect in the ratio of decisions for RISK\textsubscript{OWN}. However, groups involving female participation seem to judge the experts more critically than groups involving male participants. We find that these groups choose RISK\textsubscript{EXPERT} less frequently as indicated by positive per-
Table 2: Treatment differences in percentage points of the ratios of RISKOWN, RISKEXPERT, and RISKFREE among all decisions (see Table 1 for ratios). The differences are calculated between the treatments in the columns and the ones in the lines. t-tests are applied to test for statistical differences. Sample sizes equal 240 (INDIV vs. COMM) and 180 (INDIV or COMM vs. GROUP).

<table>
<thead>
<tr>
<th></th>
<th>RISKOWN</th>
<th>RISKEXPERT</th>
<th>RISKFREE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>COMM</td>
<td>GROUP</td>
<td>COMM</td>
</tr>
<tr>
<td>INDIV</td>
<td>3.0</td>
<td>10.6**</td>
<td>−0.2</td>
</tr>
<tr>
<td>COMM</td>
<td>−</td>
<td>7.6*</td>
<td>−6.4*</td>
</tr>
</tbody>
</table>

Notes: *, ** and *** represent the 10%, 5% and the 1% significance levels.

The percentage differences in six out of seven cases. While these results indicate a clear tendency, they borderline conventional significance levels and should thus be interpreted carefully. The risk-free alternative (RISKFREE) is consistently chosen more frequently when female subjects are involved in the decision process. Percentage differences are negative in all subgroups and significant in three out of seven cases. Thus, our data supports the widespread evidence classifying female subjects and female-only groups as being more risk-averse than their male counterparts (see Croson and Gneezy, 2009, and citations therein for a review of evidence).

Table 3: Mann-Whitney U-tests for differences in percentage points (between the gender variable before the “–” and after) for RISKOWN, RISKEXPERT, and RISKFREE across treatments and gender. M (F) denotes male (female) individuals, MM stands for male only groups, MIX are mixed groups, and FF are female only groups.

<table>
<thead>
<tr>
<th></th>
<th>INDIV</th>
<th>COMM</th>
<th>GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>RISKOWN</td>
<td>M-F</td>
<td>MM-MM</td>
<td>MM-MIX</td>
</tr>
<tr>
<td>−3.1</td>
<td>1.0</td>
<td>−7.5</td>
<td>8.5</td>
</tr>
<tr>
<td>8.7</td>
<td>6.6</td>
<td>8.7</td>
<td>−2.1</td>
</tr>
<tr>
<td>−5.6**</td>
<td>−7.5</td>
<td>−1.2</td>
<td>−6.3</td>
</tr>
<tr>
<td>N</td>
<td>74/46</td>
<td>38/18</td>
<td>38/64</td>
</tr>
</tbody>
</table>

Notes: *, ** and *** represent the 10%, 5% and the 1% significance levels.

Finally, we study how frequently individuals and groups switch between the investment alternatives RISKOWN, RISKEXPERT, and RISKFREE over the course of the experiment. Table 4 outlines average switching frequencies for treatments and conditional on gender. Table A2 in the Appendix presents statistical tests. Across treatments we find a strong group effect as switching frequencies in Treatment GROUP are significantly lower compared to the other treatments. By splitting up results for gender it is evident that men switch less between investment alternatives than women in Treatment INDIV. Gender differences in treatments COMM and GROUP point into the same direction but turn out to be insignificant.
Table 4: Switching frequencies between investment alternatives $\text{RISK}_\text{OWN}$, $\text{RISK}_\text{EXPERT}$, and $\text{RISK}_\text{FREE}$. ALL comprises the full sample, M (F) denotes male (female) individuals, MM denotes male only groups, MIX are mixed groups, and FF are female only groups.

<table>
<thead>
<tr>
<th>Switching frequencies</th>
<th>INDIV</th>
<th>COMM</th>
<th>GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL</td>
<td>9.57</td>
<td>7.40</td>
<td>5.63</td>
</tr>
<tr>
<td>M/MM</td>
<td>7.51</td>
<td>8.08</td>
<td>4.50</td>
</tr>
<tr>
<td>MIX</td>
<td>6.39</td>
<td></td>
<td>5.61</td>
</tr>
<tr>
<td>F/FF</td>
<td>12.87</td>
<td>9.56</td>
<td>6.78</td>
</tr>
</tbody>
</table>

To summarize, we find marked difference in the decision behavior between treatments. While communication has a limited impact, group decision making leads to significantly more frequent decisions for $\text{RISK}_\text{OWN}$ compared to the dominated option $\text{RISK}_\text{EXPERT}$. Also $\text{RISK}_\text{FREE}$ loses significance. This results support findings regarding the positive impact of group decision making on decision quality. In addition, gender differences emerge within each treatment and are especially pronounced in the $\text{RISK}_\text{FREE}$ option.

3.2 Behavioral biases

We now turn to RQ 2 on the potential effects of communication and group decision making on the hot hand belief and the gambler’s fallacy. Remember that people prone to the hot hand belief (gambler’s fallacy) expect a non-autocorrelated random sequence to exhibit positive (negative) autocorrelation.

To document biases in subjects’/groups’ behavior we show their decision behavior conditional on the occurrence of streaks in Figure 2, i.e. either streaks of identical coin realizations in $\text{RISK}_\text{OWN}$ or streaks of successful expert decisions in $\text{RISK}_\text{EXPERT}$.

In the left panel we plot the average market share an expert gains (among all $\text{RISK}_\text{EXPERT}$ decisions) conditional on the recent streak of correct decisions for each treatment. Assuming unbiased decision behavior, each expert would on average gain one fifth of all decisions delegated to experts irrespective of past performance. However, what we can see is a pattern of biased behavior across all treatments. An expert’s market share increases steadily with the number of correct decisions in the past, resulting in numbers well above the naïve expectation. In general, this result is in line with Rabin (2002) who postulates that a subject who is affected by the overinference bias believes that a fund manager who is successful in two consecutive periods must be unusually good. Furthermore, these results support empirical findings in Sirri and Tufano (1998) showing that successful fund performance in the past leads to a disproportionate inflow of new investors and capital. Comparing market shares we find no statis-
tical differences on the streak level across treatments (Mann-Whitney U-tests, \(p>0.10\)) indicating that neither communication nor group decision making influences the hot hand belief. Thus, the overinference bias seems to map individual and group behavior quite accurately.

![Graphs showing Hot Hand Belief and Gambler's Fallacy](image)

**Figure 2:** *Left panel:* evidence on the hot hand belief between treatments by measuring the market share of experts after streaks of correct guesses. *Right panel:* evidence for the gambler’s fallacy between treatments by measuring the ratio for head (tail) conditional on streaks of head (tail) realizations in the past. \(EV\) indicates the expected market share assuming unbiased decision behavior.

In the right panel of Figure 2 we plot the average frequency (among all \(RISK_{OWN}\) decisions) of choosing head (tail) conditional on streaks of head/tail realizations previously drawn. Assuming unbiased decision behavior, each side of the coin should on average gain half of all coin decisions irrespective of past realizations. The figure reveals evidence for the gambler’s fallacy as a specific side of the coin is chosen less frequently after this side exhibited a streak of several identical realizations. The bias is observable in all treatments showing that subjects in groups are equally exposed to exhibit the gambler’s fallacy compared to individuals (Mann-Whitney U-tests, \(p>0.10\)). These results on the gambler’s fallacy are in line with the findings of Rapoport and Budescu (1997), expanded by Rabin (2002). Both results also support the findings of Ayton and Fischer (2004) and Caruso and Epley (2004).

In Figure 3 we deepen the analysis by splitting the sample by gender. The left (right) panel repeats the analysis for \(RISK_{EXPERT}\) (\(RISK_{OWN}\)). We report a weak gender effect in each treatment as women or female-only groups have a tendency towards a more pronounced hot hand belief. In Table A3 in the Appendix we report statistics testing for gender differences within each treatment.\(^{11}\) In line with the visual impression of the graphs we report a weak

\(^{11}\)With Mann-Whitney U-tests we calculate the ratio of choices for an expert among all choices for experts after streaks of successful experts decisions. We then test for gender effects within each treatment.
gender effect, indicating that women and female-only groups show a slightly higher proneness to the hot hand belief.

The right hand side panels of Figure 3 reveal no evidence of potential gender effects within treatments indicating that men and women exhibit the same proneness to the gambler’s fallacy (Mann-Whitney U-tests, p > 0.10).

To summarize, communication and group decision making do not cure subjects from the hot hand belief (overinference bias) or the gambler’s fallacy. In addition, women and female-only groups show a slightly higher proneness to the hot hand belief. These findings indicate limits to the superior performance of groups compared to individual decision making.

4 Conclusion

We reported results from financial decision experiments where subjects predicted coin tosses themselves, delegated the decision to experts or chose a risk-free alternative. We analyzed three treatments which were distinguished by the role of communication and group decision making: In the benchmark treatment INDIV decisions were made individually. In treatments COMM and GROUP subjects were assigned to groups of two and a chat was installed. While communication was possible in both treatments they differed in the way decision making took place. In Treatment COMM subjects were able to communicate, but decided individually. In Treatment GROUP subjects had to agree on a decision as a group.

Subjects’ decisions differed significantly across treatments. Most importantly, we showed that (i) communication and group decision making did not impact subjects’ overall proneness to behavioral biases like gambler’s fallacy and hot hand belief. (ii) We also reported a lower proneness of groups in Treatment GROUP to useless expert advice compared to the other treatments. (iii) As third major finding we observed that group decision making in Treatment GROUP led to fewer choices of the risk-free alternative and to more own guesses on the realization of the coin toss compared to the other treatments. (iv) Finally, we observed that gender composition of groups played a crucial role in investment behavior: groups of two female subjects choose the risk-free investment significantly more often and delegated investment decisions less often to experts than groups of two male subjects. In addition, we are the first to document that women and female-only groups showed a slightly higher proneness to the hot hand belief.

The main contribution of this paper is twofold. The first novel contribution is the finding that groups do not overcome the gambler’s fallacy and the hot hand belief. This result is remarkable and deserves further investigation as it
contrasts literature showing the superiority of groups compared to individuals. However, this superiority of groups holds in strategic (e.g., Feri et al. 2010; Sheremeta and Zhang 2010; Sutter et al. 2010; Cheung and Coleman 2011) and non-strategic situations (Blinder and Morgan 2005; Charness et al. 2007; Sutter 2007; Charness and Sutter 2012). In addition, the second major contribution shows that groups act more according to a risk-neutral benchmark. Groups invest more risky, choose the risk-free alternative less often and rely less on outside advice by experts compared to individuals.
Figure 3: Left panels: evidence on the hot hand belief between gender in each treatment by measuring the market share of experts after streaks of correct guesses. M stands for male, F for female, MM indicate male-only-, FF female-only- and MIX stand for mixed-groups. Right panels: evidence for the gambler’s fallacy between gender by measuring the choice for head (tail) conditional on streaks of coin realizations of head (tail) in the past.
References


Caruso, Eugene M., Nicholas Epley. 2004. Hot hands and cool machines: Perceived intentionality in the predictions of streaks. Poster session presented at the 5th annual meeting of the society for personality and social psychology, Austin, TX, USA.


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## Appendix

### Appendix A: Additional Tables

Table A1: Coin realization and expert performance.

<table>
<thead>
<tr>
<th>Period</th>
<th>Coin</th>
<th>Expert 1</th>
<th>Expert 2</th>
<th>Expert 3</th>
<th>Expert 4</th>
<th>Expert 5</th>
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<tr>
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</tbody>
</table>

| ∑ Tail/W | 20 18 21 21 16 15 |
| ∑ Head/L | 20 22 19 19 24 25 |

**Notes:** Experts: L=lose; W=win.
Table A2: Test statistics for differences in switching frequencies between investment alternatives RISK\textsubscript{OWN}, RISK\textsubscript{EXPERT}, and RISK\textsubscript{FREE}. The numbers indicate p-values of the corresponding tests. Top panel: t-test are run for treatment comparisons. Bottom panel: Mann-Whitney U-tests are run for gender comparison. M (F) denotes male (female) individuals, MM denotes male only groups, MIX are mixed groups, and FF are female only groups.

<table>
<thead>
<tr>
<th>Treatment comparison</th>
<th>INDIV-INDIV</th>
<th>INDIV-COMM</th>
<th>COMM-COMM</th>
<th>GROUP-GROUP</th>
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<tr>
<td></td>
<td>0.043</td>
<td>0.000</td>
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<th>INDIV</th>
<th>COMM</th>
<th>MM-FF</th>
<th>MM-MIX</th>
<th>MIX-FF</th>
<th>MM-MM</th>
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<td>0.496</td>
<td>0.052</td>
<td>0.673</td>
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Table A3: Mann-Whitney U-tests for the ratio of delegated decision to experts among all decisions of experts conditional on experts’ streaks of correct guesses. Differences between male (M) and females (F) in Treatment INDIV and between male (MM), female (FF) and mixed groups (MIX) in the other treatments are investigated. The difference in percentage points is provided (between the gender variable before the “-“ and after).

<table>
<thead>
<tr>
<th></th>
<th>INDIV</th>
<th>COMM</th>
<th>GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M-F</td>
<td>MM-FF</td>
<td>MM-MIX</td>
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<td>streak 0</td>
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<td>1.6</td>
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<td>streak 1</td>
<td>-3.2</td>
<td>-9.9*</td>
<td>2.2</td>
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<td>streak 2</td>
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<td>-1.1</td>
</tr>
<tr>
<td>streak 4</td>
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<td>-26.2</td>
<td>-16.1</td>
</tr>
<tr>
<td>streak 5</td>
<td>-2.4</td>
<td>-14.3</td>
<td>-8.8</td>
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</tbody>
</table>

Notes: *, ** and *** represent the 10%, 5% and the 1% significance levels.
Appendix B: Experimental Instructions for Treatment COMM and GROUP

Dear Participant! We welcome you to this experimental session and kindly ask you to refrain from talking to each other for the duration of the experiment. If you face any difficulties, contact one of the supervisors.

Background of the experiment
This experiment is concerned with replicating investment decisions that are made on asset markets. For the case of the experiment the decisions are simplified. During the experiment you may communicate with an (anonymous) partner via a chat device to exchange your knowledge and experience. You make your decisions together with an (anonymous) partner via a chat device.

Market Procedure
Each participant receives an initial endowment of 500 Taler, the experiment currency. Gains and losses that are made during the experiment are added or subtracted from your current holdings. At the end of the session your Taler holdings will be converted into euros at a 100:1 exchange rate. All gains and losses are your own and payment at the end will take place privately. The experiment lasts for 40 periods.

During the course of the experiment you make investment decisions (together with your partner). Your chat partner is determined at the beginning of the experiment and remains the same for all periods. Because the decision making process is simplified your possibilities are limited to two different investments. You can go for an investment that involves a certain amount of risk or you can pick a risk free alternative. Taking the risky investment you have to choose between two possible outcomes. In the experiment they are named “Head” and “Tail”. Like when you toss coins, only one of the two sides can be on top and decides the game. The probability for each side is therefore 50 percent.

Beside these possibilities, there are five “experts” in the market who claim that they are able to predict the market development (the coin) better than the majority of all market participants. They always invest in the risky alternative. Like on the real market these experts offer their knowledge to everyone who is interested in it and take over the investment decision for their customers. For this service they charge an issue surcharge and a management fee. If you hand over your decision to one of the experts he will opt for either “Head” or “Tail”. At the end of each period a random process determines, which side of the coin is on top: either “Head” or “Tail”. This result and your investment decision

\footnote{Instructions and screenshots are for COMM, text changes in GROUP are in \textit{italic}. Instructions for INDIV can be found in Huber et al. (2010).}
influence your final payment.

**Total Wealth (for each participant)**

Each decision you take will change your current Taler holdings. If your investment decision (which side of the coin will be on top) is correct 100 Taler will be added to your holdings. If you are incorrect 50 Taler will be subtracted. If you take the risk free possibility 10 Taler will be added no matter, which side of the coin is presented. *If you and your chat partner cannot agree on a common decision, a penalty of 50 Taler will be subtracted from your account, independent of your actual decision.*

These figures change if you hand over your decision to an expert. The conditions are comparable to conditions charged by investment funds on the real market. For the access to their knowledge they claim an issue surcharge of 5 Taler, which has to be paid only for the first period you follow a certain expert. If you trust the same expert again in the directly following periods this amount will not be charged again. Experts demand a second fee. This management fee has to be paid in each period you hand over your decision to an expert and will amount 1 Taler. If the expert’s decision is correct 100 Taler minus the payable fees will be added to your Taler holdings. If the decision is incorrect 50 Taler plus the payable fees will be subtracted from your account.

*e.g.: own decision: cor.: + 100 Taler incor.: - 50 Taler*

*expert X (first time): cor.: + 100 - 5 - 1 = + 94 Taler incor.: - 50 - 5 - 1 = - 56 Taler*

*expert X (con. periods): cor.: + 100 - 1 = + 99 Taler incor.: - 50 - 1 = - 51 Taler*

At the end of the experiment a history screen informs you about all your decisions and the outcomes. After that, your payment will be calculated according to the following schema.

100 Taler = 1 Euro

**How to make your decision**

You will now be informed on how to make your decisions. For a better understanding please see the screen-shot of the chat screen and the decision screen on the following pages. All relevant elements and details will now be explained.

Each period consists of the following steps:

- Chat with your partner - early leaving or end of time (1.5 min, reduced to 1 min from period 16 on).

- Individual input of your decision.

- *If both decisions are identical, the corresponding payoffs are realized (see below) and you proceed to the next period.*
• If decisions are different, you will be redirected to the chat for 45 sec. to reach a common decision. If decisions deviate a second time, 50 Taler are subtracted from your account.

Chat screen
In the upper part of the chat screen information about the number of periods and the remaining time for the current decision are displayed. Below this information you can see your member number within your group (M1 or M2) and your current Taler holdings.

In the middle of the screen a history screen is displayed. Here you find information about the number of periods played, your investment decisions, which side of the coin was on top, how that effected your result and how your holdings changed each period. The following 5 columns inform you about the performance of the 5 experts. If their investment decision was correct this is signaled via “!!!” (three exclamation marks). An incorrect decision is signaled via “—” (level bar). Finally the row below the history box provides you some additional information about the performance of the experts. The number stands for a performance ratio: it tells you how many of the previous 5 periods the experts’ decisions were correct (0.80 means that the expert was correct 4 out of 5 periods).

The chat can be found in the lower part of the screen. You have 1.5 min (1 min after period 16) to communicate with your partner and reach a common decision but the entry of your decision in the decision screen is made individually. The button in the upper right part of the chat allows you to leave the chat early.

Decision screen
If the chat is finished (either through time out or because both group members determined it) you will enter the decision stage. The chat disappears, but the history screen remains unchanged. Above the history, there are the 8 investment buttons. Via pushing one of them you make your decision for the current period. If you like to decide on your own the buttons “Head”, “Tail” or “risk free” are relevant. To trust one of the experts push one of the 5 expert buttons.

You earn a positive payment only if you and your partner agree on a common decision. If your decisions differ from each other, you are redirected to the chat for another 45 sec. Then each group member enters the decision individually. If you were not able to agree on a common decision, 50 Taler are subtracted from each of the group members’ accounts.

Important details:

• As soon as you made your decision via a click on the corresponding button,
it is not possible to undo or change your decision.

- To give you an impression of the predicting abilities of the different experts the experiments starts in period 6 and will end after period 45.

- Initial endowment: 500 Taler
- Correct decision: + 100 Taler
- Incorrect decision: - 50 Taler
- No agreement on decision: - 50 Taler
- “Risk free”: + 10 Taler
- Issue surcharge: 5 Taler (first period you choose a certain expert)
- Management fee: 1 Taler (per period)
## Decision screen

You are currently allocated £100 in your portfolio.

Your wealth

Make your decision in here

### Decide for one of the following investments

<table>
<thead>
<tr>
<th>Head</th>
<th>Tail</th>
<th>Decision</th>
<th>Expert 1</th>
<th>Expert 2</th>
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<td>Tail</td>
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<td>10</td>
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<td>10</td>
</tr>
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### Experts performance during the last 5 periods

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Hot hand belief and gambler’s fallacy in teams: Evidence from investment experiments

Abstract
In laboratory experiments we explore the effects of communication and group decision making on investment behavior and on subjects’ proneness to behavioral biases. Most importantly, we show that communication and group decision making does not impact subjects’ overall proneness to biases like gambler’s fallacy and hot hand belief. However, groups decide differently than individuals as they rely significantly less on useless outside advice from “experts” and choose the risk-free option less frequently. Finally, we document gender differences in investment behavior: groups of two female subjects choose the risk-free investment more often and are slightly more prone to the hot hand belief than groups of two male subjects.

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