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Gender differences in investment reactions to irrelevant information*

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ABSTRACT

Economic agents often irrationally base their decision-making on irrelevant information. This research analyzes whether men and women react to futile information about past outcomes. For this purpose, we run a laboratory experiment (Study 1) and use field data (Study 2). In both studies, the behavior of men is consistent with falsely assumed negative autocorrelation, often referred to as gambler's fallacy. Women's behavior aligns with falsely assumed positive autocorrelation, a notion of the hot hand fallacy. On the aggregate, the two fallacies cancel out. Even when individuals are, on average, rational, the biases in the decision-making of subgroups might cause inefficient outcomes. In a mediation analysis, we find that a) the agents' stated perceived probabilities of future outcomes are not blurred by irrelevant information and b) about 40 % of the observed biases are driven by differences in the perceived attractiveness of available choices caused by the irrelevant information.

Keywords: Hot hand fallacy, gambler's fallacy, gender, irrelevant information
JEL Codes: D81, J16, C91

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1 Introduction

Rational economic agents base their decision-making on all available relevant information. However, behavioral research has shown that humans do not only incorporate relevant but also irrelevant information into their decision-making processes (Abeler, Falk, Goette, & Huffman, 2011; Bordalo, Gennaioli, & Shleifer, 2012; Spektor & Seidler, 2022). In finance, for example, individuals might unsubstantiatedly infer future developments from past events leading to non-optimal portfolio choices (Goetzmann & Kumar, 2008), or in politics, incumbents get more votes when the local college football team wins (Healy, Malhotra, & Mo, 2010).

In this study, we focus on the potentially biased decision-making of two groups, namely men and women. In recent years, gender, mainly motivated by the persisting gender inequalities in wage and labor force participation, has gained a lot of attention in economic literature (Sevilla, 2020). Persistent gender differences are reported for (economic) preferences, such as risk or social preferences (Croson & Gneezy, 2009; Falk et al., 2018). When it comes to financial decision-making, the two genders seem to act substantially differently. Women are more risk-averse (Charness & Gneezy, 2012), follow different strategies (Powell & Ansic, 1997), assess probability information differently (Fehr-Duda, De Gennaro, & Schubert, 2006), and process information more comprehensively (Meyers-Levy & Loken, 2015).

There are two common biases related to the processing of information about past events. First, agents might believe that a positive event is *less* likely after receiving positive irrelevant information about the past (and more likely after negative information). Such a falsely perceived negative autocorrelation - or negative recency - is called gambler's fallacy (Stöckl, Huber, Kirchler, & Lindner, 2015). Second, agents might falsely predict that a positive event is *more* likely after receiving positive irrelevant information about the past (and less likely after negative information). Such a wrongly assumed positive autocorrelation - or positive recency - is called hot hand fallacy (Stöckl et al., 2015). We use the term hot hand fallacy to describe the exact inverse of the gambler's fallacy.

We seek to explore whether the two biases, namely the gambler's fallacy and the hot hand fallacy, are detectable in risk decision-making of men and women. In two different environments, we analyze aggregate decision-making as well as the decisions of men and women separately. In Study 1, we design a laboratory experiment in which subjects receive positive, negative, or no information about the previous outcome of a simple lottery. This signal is irrelevant to rational decision-making. Then, subjects can allocate their investment between the reference and an alternative lottery. In Study 2, we analyze decision-making in the professional sport of diving. Before each round of international competitions, athletes can newly decide on which dive to perform. We explore whether this decision is biased by irrelevant positive and negative information about their performance in the previous round of the competition.

Our combined approach has several advantages over previous studies. First, we can investigate both the hot hand fallacy and the gambler's fallacy within a single environment. Existing research shows the prevalence of both biases (Ayton & Fischer, 2004; Chen, Moskowitz, & Shue, 2016; Croson & Sundali, 2005; Huber, Kirchler, & Stöckl, 2010; Suetens, Galbo-Jørgensen, & Tyran, 2016). With respect to gender differences, Stöckl et al. (2015) find that women are more prone to the hot hand fallacy than men. Suetens and Tyran (2012) observe the gambler's fallacy for men but not for women. Similarly, Roney and Sansone (2015) report that men are more prone to the gambler's fallacy than women. However, previous research can only detect the hot hand fallacy in one and the gambler's fallacy in another environment, which does not allow for a classification of groups of individuals.

Second, by ensuring the irrelevance of information, in our design, any reaction of the decision maker to the information can be considered as a bias. Existing literature investigates hot hand sequences - also called momentum - in sports (Cotton, McIntyre, Nordstrom, & Price, 2019; Livingston, 2012; Meier, Flepp, Ruedisser, & Franck, 2020; Miller & Sanjurjo, 2021; Morgulev, Azar, & Bar-Eli, 2019) or in finance (Jagannathan, Malakhov, & Novikov, 2010). However, the concept of momentum implies that the autocorrelation is not only believed to be positive but that it is, in fact, positive, which would make reacting to the information rational and not a bias (Miller & Sanjurjo, 2018).

Third, for the experimental study, we observe the individuals' perceptions of the lotteries after the reception of the irrelevant information but before their investment decision. In most studies dealing with the hot hand and gambler's fallacies, the underlying mechanism is assumed to be a misconception with respect to the success probabilities of the choices. This stems from the implicit assumption that even with a small number of random repetitions, actual outcomes would be in line with the underlying distribution (Rabin, 2002; Tversky & Kahneman, 1971). Dohmen, Falk, Huffman, Marklein, and Sunde (2009) use a coin-toss experiment to show that agents have systematically biased probability perceptions. In our research, we investigate the (stated) perceived probability of success and attractiveness together with incentivized investment decisions. The impact of the former on the latter is investigated using a mediation analysis framework, which allows us to gain insight into the mechanisms of potentially irrational decisions.

Fourth, with our two environments, we combine the internal validity of the controlled design of an experimental study with the real incentive situation by observing people in their daily tasks. While laboratory experiments are the gold standard for causal studies, observational studies in sports can examine professionals performing non-artificial tasks and making decisions in their usual roles without being in a clinical setting. Observing similar decision problems in two research settings improves the generalizability of our results.

The experimental results of Study 1 show the prevalence of relevant gender differences in the reaction to irrelevant information. We find that women show behavior in line with the hot hand fallacy, reacting with an increase in investment to an increase in the positiveness of the irrelevant information about the previous outcome of the lottery. For men, we find evidence for a bias in line with the gambler's fallacy. The more positive the irrelevant information, the more men reduce their investment. The overall response then appears to be rational, masking that both men and women are biased. Study 2 replicates the experimental findings in the domain of professional sports. As in the experimental study, we find that women are more prone to have the hot hand fallacy than men. Men are inclined to the gambler's fallacy.

While those individuals who have a higher perceived success probability for the reference lottery also invest higher amounts, the allocated (positive/negative) signal does not shift the perception of the lottery's success probability. Therefore, in contrast to Dohmen et al. (2009), the fallacies are not related to biased perceptions of the success probabilities but can at least partly be explained by perceived attractiveness. In a mediation analysis, we find that for both genders about 40 percent of the effect is mediated by the shifted perceived attractiveness of the reference lottery.

Our main findings are in line with research on gender differences in the desire for independence. Cross and Madson (1997) argue that women tend to construct an interdependent self-construal, while men tend to have an independent self-construal. In the context of our research, this relates to the fact that women, in our study, follow the information while men do the opposite of what the information suggests. Similarly, women are more likely to conform, while men are more prone to non-conforming (Eagly & Chrvala, 1986; Griskevicius, Goldstein, Mortensen, Cialdini, & Kenrick, 2006). Griskevicius et al. (2006) argue that this is due to evolutionary reasoning. Finally, our results are in line with the finding that women react stronger to feedback about their performance than men (Berlin & Dargnies, 2016; Roberts & Nolen-Hoeksema, 1994).

2 Study 1: Experiment

2.1 Experimental Design

The core of the pre-registered design of our laboratory experiment is an incentivized investment decision.[1] Subjects allocate an initial endowment of 400 Experimental Currency Units (ECU) between two risky assets. They invest into a low-risk lottery (L) or a high-risk lottery (H). Each ECU invested into the lottery L is either multiplied by the factor 1.25 (labeled as "successful lottery") or by the factor 0.75 (labeled as "unsuccessful lottery"). Both outcomes are equally likely and subjects are fully informed about this fact. Each ECU invested in H is either multiplied by the factor 1.75 or the factor 0.25. Again, both outcomes occur with a probability of one-half. The outcome of lotteries L and H are independent of each other. On expectation, the two lotteries, L and H, yield the same profit.

The experimental treatment variation takes place before the main investment decision. We apply a 2x3 between-subjects treatment design with random treatment allocation. The first treatment dimension is regarding a reference lottery. To make the reference salient, subjects receive a hypothetical endowment which they have to fully invest into an exogenously determined reference lottery. Half of the experimental subjects have the low-risk lottery as the reference (treatments *Low*), while the other half's reference is the high-risk lottery (*High*). The parameters of the hypothetical lotteries are identical to those in the incentivized main investment decision. Subjects are aware that this hypothetical investment is for illustration purposes and not payoff-relevant. The reference might already impact the main investment decision (Clist, D'Exelle, & Verschoor, 2021).

The second treatment dimension is with respect to the information that subjects receive

[1] OSF: osf.io/s8p9x, "The grass is greener on which side again? Irrelevant information and the stickiness of reference risk choices". We collected subjects' informed consent to participate in the study. We have received an Institutional Review Board Certificate from the German Association for Experimental Economic Research e.V.

about the outcome of the hypothetical lottery. Subjects in treatments *Noinfo* receive no information about the outcome of the hypothetical lottery before taking their payoff-relevant investment decision. In treatments *Positive* and *Negative*, subjects receive information about the outcome of the hypothetical lottery before deciding on their investment. Depending on the outcome of the hypothetical lottery, the information is either that the hypothetical lottery was successful (*Positive*) or unsuccessful (*Negative*). Importantly, the outcomes of the hypothetical lotteries and the incentivized lotteries are fully independent. Hence, any reaction to the positive or negative information provided can be classified as a bias.

The sequence of the game is the following: As a first step, subjects receive the hypothetical endowment and must allocate it into the exogenously determined reference lottery. Depending on the treatment, subjects then receive information about the outcome of the hypothetical lottery or no information. In the second step, they receive their actual endowment of 400 ECU. Next, they state their perception of the attractiveness of the two lotteries, L and H, using a Likert scale reaching from 1 (very unattractive) to 7 (very attractive). Furthermore, they state their perception of the probability that each of the lotteries is successful. Here, we use a slider to elicit a more emotional perception since subjects cannot directly enter the rational probability of 50 percent. Finally, subjects make their incentivized investment decision. They decide freely on their investment into the two lotteries, with the only restrictions that they must invest their whole endowment and that investments must be integers. Then, subjects are informed about the outcome of the incentivized lottery and their payoff. Each 10 ECUs are converted to EUR 0.10, with amounts being rounded up. A timeline of the main experiment can be found in Online Appendix S.1.

Our treatment variation allows us to analyze whether subjects are, on average, reacting to irrelevant information (indicating a bias) or not. We consider 3 archetypes displayed in Table 1. The 3 archetypes differ fundamentally in their predicted investment into the respective reference lottery (lottery L in *Low* and lottery H in *High*). To align with the archetypes, we calculate the difference between the investment (into the reference lottery) for the information treatment to the non-information treatment. This allows us to classify the behavior of groups of agents as rational or biased.

If agents are rational, then the information does not alter the average investment. For this archetype, the difference between, for example, *High-Positive* and *High-Noinfo* would be around zero. In Table 1, this is displayed as "No reaction". Biased agents react to the information. For the type *Gambler's Fallacy*, the average investment into the reference would be lower (higher) after positive (negative) information than after no information. Subjects being prone to the gambler's fallacy, assume that the outcome of the reference lottery is lower (higher) when the previous, hypothetical lottery was successful (unsuccessful). The opposite would be the case when subjects are of the type *Hot Hand Fallacy*. Here, the average investment into the reference would be higher (lower) after positive (negative) information than after no information. Subjects having the hot hand fallacy expect that the outcome of the reference lottery is higher (lower) when the previous lottery was successful (unsuccessful).

Table 1: Predicted investment reaction to irrelevant information by archetype.

	Rational	Gambler's Fallacy	Hot Hand Fallacy
Low-Positive (vs *Low-Noinfo*)	No reaction	Decrease	Increase
High-Positive (vs *High-Noinfo*)	No reaction	Decrease	Increase
Low-Negative (vs *Low-Noinfo*)	No reaction	Increase	Decrease
High-Negative (vs *High-Noinfo*)	No reaction	Increase	Decrease

Notes: The table shows how different archetypes alter their investment into the reference lottery after receiving positive or negative irrelevant information. The reaction is calculated by subtracting the investment in respective *Noinfo*-treatment from the investment in the respective treatment with (positive/negative) information.

The experiment was conducted at the Potsdam Laboratory for Economic Experiments in the autumn of 2022. In each of the 14 experimental sessions, all six treatments were run. We used zTree (Fischbacher, 2007) and ORSEE (Greiner, 2015). Printed instructions inform about the general rules of the laboratory. Detailed instructions on the experiment were provided on screen (see Online Appendices S.2 and S.3). Instructions stress the independence of the lotteries within and between stages. Control questions verify that subjects understand this detail. The experiment described above is followed by the experiment described in Späth (2023), and each session is concluded by a final questionnaire. As pre-registered, we collected data from 150 subjects, each being an independent observation. About 47 percent of subjects stated to be female. A Fisher exact test cannot reject independence of the treatment status and gender ($p = 0.125$).

We find no differences between women and men with respect to relevant characteristics. Subjects of both genders are about the same age (median for both: 22 years, (Wilcoxon) rank-sum test: $p = 0.413$). An almost identical share of subjects studies economics (mean female:

0.28, mean male: 0.34, rank-sum test: p = 0.539). An equally small share of subjects studied in a Masters program (mean for both genders: 0.14, rank-sum test: p = 1.000). Finally, subjects of the two genders participated in the same number of previous experiments (mean for both genders: 3.38, rank-sum test: p = 0.743).

2.2 Experimental Results

2.2.1 Average treatment effects

Table 2 provides a descriptive overview of the investments into the reference lottery. In treatment *Low*, the reference is the low-risk lottery, and in treatment *High*, the high-risk lottery. The maximum investment into the reference lottery is 400 ECU. Any ECU not invested into the reference lottery is invested in the alternative lottery. The total mean of 200 ECU, presented in Table 2, shows us that the reference does not impact decision-making. A mean investment into the reference lottery of more than 200 ECU would have implied that subjects follow the reference. Furthermore, we find that individuals are risk averse. A rank-sum test shows that investments into the reference category (pooled over information types) are significantly larger when the reference is the low-risk lottery than when it is the high-risk lottery (p = 0.008).

Table 2: Investments into the reference lottery by treatment.

Treatment	Mean	Median	SD	N
Low-Noinfo	214.63	200	79.90	27
High-Noinfo	185.85	200	88.84	27
Low-Positive	197.92	225	108.83	24
High-Positive	190.60	200	75.00	25
Low-Negative	234.17	235	87.72	24
High-Negative	178.26	150	102.45	23
Total	200.32	200	91.19	150

Notes: SD denotes the standard deviation. N denotes the number of observations. Values for Mean, Median, and SD in ECU.

We find that, on average, subjects do not react to irrelevant information. The rank-sum tests presented in Table 3 show no significant differences when we compare the investment into reference lottery between the treatments with information and the respective *Noinfo*-treatment. Also, when pooling the two references, we do not find a significant response to the irrelevant information. Further analysis shows no correlation between the positiveness of the information and the investment into the reference (Spearman's rank correlation, rho = 0.008, p = 0.924). Subjects, on average, can be best classified as rational (see again Table 1).

Table 3: Observed investment reaction to irrelevant information.

Comparison	Mean		Pooled
Low-Positive (vs *Low-Noinfo*)	-16.7129	p = 0.910	*Positive* vs *Noinfo*:
High-Positive (vs *High-Noinfo*)	4.7481	p = 0.501	p = 0.845
Low-Negative (vs *Low-Noinfo*)	19.5371	p = 0.633	*Negative* vs *Noinfo*:
High-Negative (vs *High-Noinfo*)	-7.591	p = 0.465	p = 0.966

Notes: The table shows how subjects, on average, differ in their investment into the reference lottery after receiving positive or negative irrelevant information. The reaction is calculated by subtracting the investment in respective Noinfo-treatment from the investment in the respective treatment with information. Analysis using rank-sum tests.

2.2.2 Gender-specific treatment effects

Going one step deeper, we analyze whether heterogeneity in the reactions to irrelevant information between genders does exist. Previous literature reports that the hot hand fallacy is more common among women, while the gambler's fallacy is more typical for men (Roney & Sansone, 2015; Stöckl et al., 2015; Suetens & Tyran, 2012). Our study replicates these findings in one single framework. This allows us to relate the average reaction by gender to the archetypes presented in Table 1.

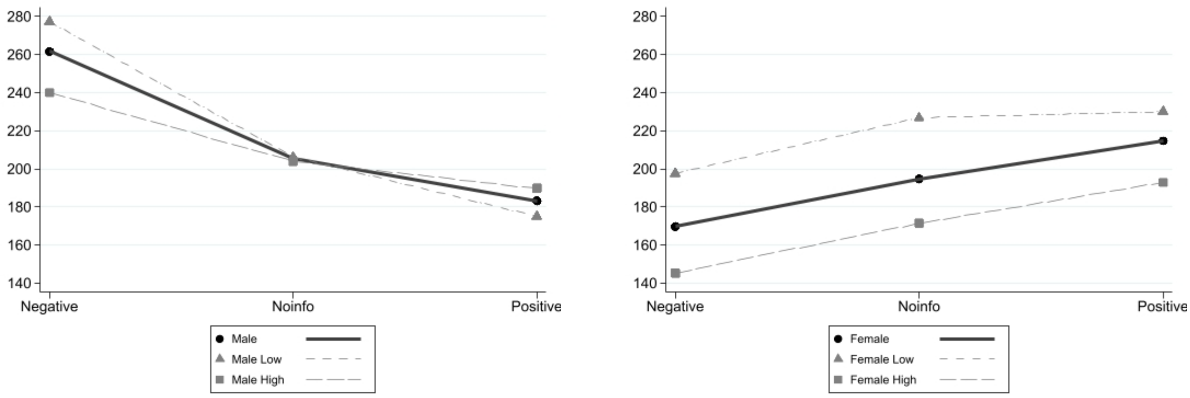
Table 4 shows that gender differences exist in our framework. Column (1) confirms that, on average, subjects do not react to positive or negative irrelevant information. Yet, Column (2) shows that the reaction of women to negative information is significantly more negative than the reaction of men. The positiveness variable in columns (3) and (4) combines positive and negative information. We code negative information - 1, no information as 0, and positive information as +1. As before, Column (3) shows no impact of the positiveness of the information on the aggregate reaction. Yet, Column (4) shows that men respond with lower investment, while women invest significantly more than men in the reference as the positiveness of the information increases.

Table 4: Linear regression on investment into the reference lottery.

Investment into the reference	(1)	(2)	(3)	(4)
Positive Information	-9.179	-22.004		
	(18.059)	(22.892)		
Positive Information x Female		41.903		
		(35.852)		
Negative Information	9.219	56.293**		
	(18.173)	(26.294)		
Negative Information x Female		-81.458**		
		(35.664)		
Positiveness			-9.199	-37.532**
			(9.991)	(14.886)
Positiveness x Female				60.309***
				(18.535)
Female	-23.202	-10.478	-23.202	-22.911
	(15.309)	(24.094)	(15.260)	(14.647)
N	150	150	150	150

Notes: Linear regression. Robust standard errors (in parentheses). *, **, and *** represents statistical significance at the 10 %, 5 %, and 1 %, respectively.

Importantly, Figure 1 shows that both women and men react irrationally to irrelevant information. Women show indications of the hot hand fallacy. In line with the definition of a hot hand fallacy with respect to the archetypes (as presented in Table 1), women increase their investment after positive irrelevant information and decrease their investment after negative information. The broken lines in figure 1 show similar patterns for both exogenously determined references. Pooled over the two references, Spearman's rank correlation coefficient between the positiveness of information and the investment of women is positive and significant (rho = 0.292, p = 0.013). Men show indications of the gambler's fallacy. They decrease their investment after positive irrelevant information and increase their investment after negative information. Again, Figure 1 shows similar reactions for both references. The Spearman's rank correlation coefficient for the pooled data is negative and significant (rho = -0.246, p = 0.030).

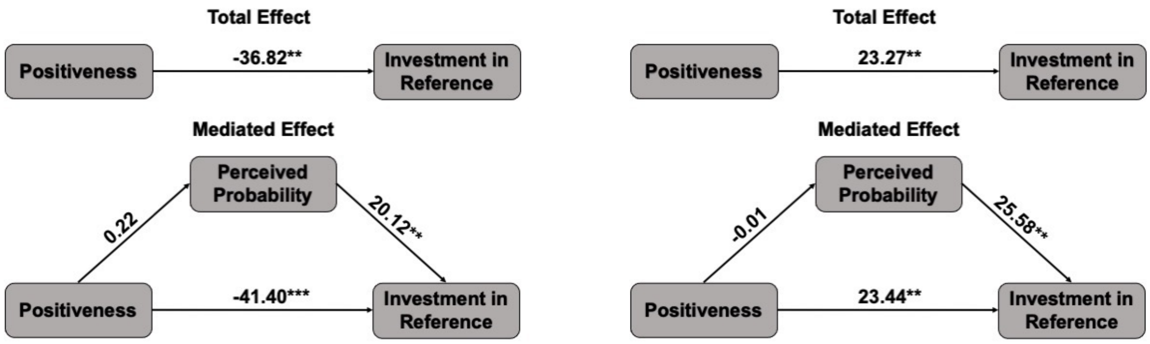


(a) Men (b) Women

Figure 1: Average investment into the reference category by information and gender.

2.2.3 Perceived probability of success and perceived attractiveness

Besides our analysis of investments, our experimental design allows us to use two items on the relative perception of the lotteries in a mediation analysis (Imai, Keele, & Tingley, 2010). The treatment effects of our main analysis might be mediated by the perception of both the probability of success and the attractiveness of the lotteries. We calculate and normalize the perceived attractiveness as the relative attractiveness of the reference lottery to the alternative lottery. Similarly, for the analysis of the perceived probability of success, we calculate and normalize the relative perceived probability of the reference lottery to the alternative lottery.

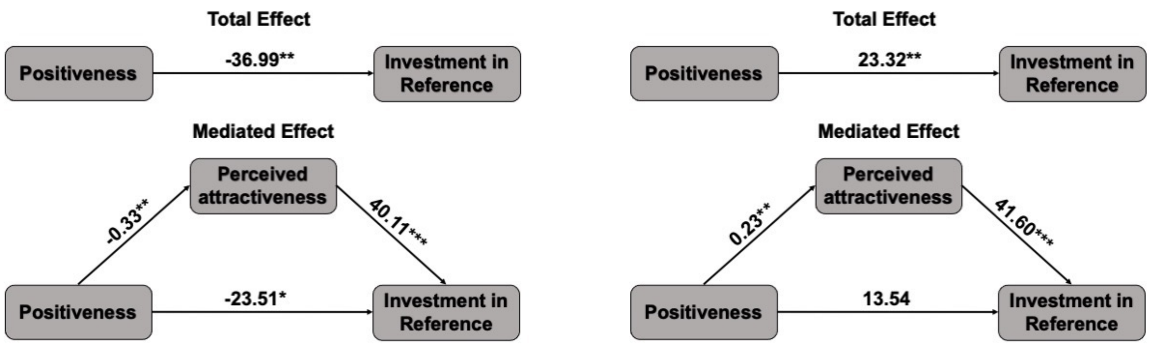


(a) Men (b) Women

Figure 2: Perceived probability, mediation analysis

Subjects largely hold correct beliefs. For the reference lottery, the median of the stated perceived probability that the lottery is successful is 50 percent (mean 52 percent), which is the true ex-ante probability. The mediation analysis shows that, for both men (Figure 2.a) and women (Figure 2.b), there is a similarly positive relation between the perceived success probability and the investment. Yet, we find no statistical correlation between the positiveness of the signal and the perceived relative probability of success of the lotteries. Hence, the treatments do not shift the (stated) perceived success probabilities of the lotteries, and the treatment effects are not mediated by the perceived probability.

For the relative attractiveness of the lotteries, we find for men a negative statistically significant correlation with the positiveness of the received signal (see Figure 3.a) and a positive correlation for women (see Figure 3.b). Furthermore, perceived relative attractiveness is similarly positively related to investment in the reference for both genders. Separating the direct and indirect (mediation) effect, Table 5.a shows that 36 % of the total effect for men, i.e., a mediation effect of -13.48, is mediated by the perceived relative attractiveness. For women, 42 %, i.e., a mediation effect of 9.77, is mediated by the perceived relative attractiveness (Table 5.b).



(a) Men (b) Women

Figure 3: Perceived attractiveness, mediation analysis

Table 5: Perceived attractiveness

(a) Men

Effect	Mean	90% CI
Mediation effect	-13.48	[-26.82 ; -2.77]
Direct effect	-23.51	[-45.40 ; -1.04]
Total effect	-36.99	[-60.71 ; -11.14]
% mediated	0.36	[0.22 ; 1.07]

Notes: Mediation analysis. 90% Confidence intervals (CI) based on 1000 bootstrap replications. Men, N=79.

(b) Women

Effect	Mean	90% CI
Mediation effect	9.77	[0.97 ; 19.92]
Direct effect	13.54	[-2.53 ; 30.05]
Total effect	23.32	[5.15 ; 42.37]
% mediated	0.42	[0.22 ; 1.35]

Notes: Mediation analysis. 90% Confidence intervals (CI) based on 1000 bootstrap replications. Women, N=71.

In sum, the information treatment shifts the perceived attractiveness of the reference lottery, which itself influences the investment in the reference lottery. A significant proportion of the effects, 58% for women and 64% for men, is not attributable to perceived attractiveness but stems from something unobservable. This remaining direct effect is not mediated by the perceived probability – which also shows us that the individuals understood the experimental instructions.

3 Study 2: Observational Study

3.1 Data, Setup, and Empirical Strategy

To complement the experimental results, we conduct a second study using field data from the professional sport of diving. Similar to the laboratory setup, the environment in diving is highly standardized, the task setting and performance evaluation follow clear rules, there is no interaction between task-takers, treatments and outcomes are precisely measurable, and there are few external influences. This makes data from sports such as diving a promising opportunity for studying human behavior (Balafoutas, Chowdhury, & Plessner, 2019; Bar-Eli, Krumer, & Morgulev, 2020). The field data enrich our analysis in several ways. Our data comes from a professional environment with high incentives. The agents are observed in non-artificial tasks (compare, e.g., Bardsley (2005), on the issues of artificiality) while performing their usual job (Levitt & List, 2008), and they are not aware of being part of a study (compare, e.g., Zizzo (2010), on the experimenter demand problem).

We use diving data on official contests from 2013 through 2017. We have received this data from the study by Goller and Späth (2023). Descriptive statistics can be found in Appendix B.1. In diving, professional athletes do some pre-specified task, i.e., 'dive', while jumping into the water. Every dive has an assigned difficulty level that depends on the complexity of the dive. A contest is held in several rounds, i.e., a preliminary round, sometimes a semi-final, and a final round. Each round consists of five (women) or six (men) dives that are performed sequentially. The performance of the dive is evaluated by a jury, and their numerical assessment, multiplied by the difficulty, forms a score. Based on the accumulated scores, a ranking list is formed, which is relevant for qualification to the next round or winning the contest (in the final).

In our analysis, we seek to understand how the athlete's decision on the difficulty of the dive is affected by irrelevant information. Before each contest, athletes submit a list containing which of the dives they will perform in each of the jumps. Note that the reference in this scenario is chosen by the individuals themselves, compared to the laboratory experiment, where the reference is not self-selected. If qualified for a subsequent round, the athletes are allowed to change their submitted list, e.g., they might replace one dive with another dive of higher or lower difficulty. This forms our outcome variable *Stay with reference*. The variable has the value 1 when the athlete performs a dive with the same difficulty as in the previous round; otherwise, the value is 0. About 1.7 percent of dives in our sample are changed away from the reference difficulty. Our information treatments are derived by comparing the jury evaluation of one dive to the average jury evaluation over all the individual's dives in this round. We classify a jury evaluation for one dive that is more than one rating step larger than the own rating average in the respective round as *(irrelevant) positive information*. Similarly, we classify a jury evaluation that is more than one rating step smaller than the average in the round as *(irrelevant) negative information*. All other cases are seen as *no information*.

To ensure that any potential effects can be considered a bias, we need to establish, first, the irrelevance of the information and second, that it is not rational to react to this irrelevant information. First, due to the resetting of the score from one round to the next, the information can be deemed to be irrelevant. We rely on the contest design that eliminates any relevance of the athlete's performance between rounds, the previous round is only decisive for qualifying for the next round. Second, we argue that changing away from the reference difficulty is not rational since it implies a switch to the second-best option. No rational reason is apparent why athletes should not choose their first best option in either of the rounds and consequently, in 98.3% of dives, there is no change – the athletes are well aware of their strengths and weaknesses. In line with this argument, in Appendix B.2, we show that performance (and the score) decreases following a change away from the reference difficulty. Regarding the identification of the effects, we argue that deviations occur randomly. In Appendix B.2, we show that the positive and negative signals can be considered random outliers.

Table 6 displays the predicted actions for the different archetypes. We have established that any change in the difficulty of the dive is non-optimal. Hence, rational agents will stay with their previous difficulty and show no reaction to irrelevant information. Irrational agents might react to irrelevant information by changing their difficulty. Agents prone to the gambler's fallacy would be more likely to change after positive information about the previous performance. These agents might believe that staying with the difficulty after an especially good performance will lead to worse performance. Contrarily, agents prone to the hot hand fallacy would change after negative information. These agents might believe that staying with the difficulty after an especially bad performance will lead to another bad performance.

Table 6: Predicted change in the likelihood to stay with the reference as a reaction to irrelevant information by archetype.

Information	Rational	Gambler's Fallacy	Hot Hand Fallacy
Positive vs neutral	No reaction	Decrease	(Increase)
Negative vs neutral	No reaction	(Increase)	Decrease

Note: The likelihood only increases when not already at 100% in the no information treatment.

3.2 Empirical Results

Table 7 presents the results of the observational study. Just as in our Study 1, Column (1) shows insignificant effects of the positive and negative signals on average. Likewise, Column (3) shows an insignificant effect of the positiveness of the information. As before, we code negative information as -1, neutral as 0, and positive as +1. Columns (2) and (4) exhibit that, as in Study 1, the insignificant average effect masks different reactions of the two gender groups. For men, Column (4) shows that the likelihood of staying with the reference difficulty significantly decreases with the positiveness of information. This reaction is a representation of the gambler's fallacy (compare Table 6).

For women compared to men, the likelihood to stay is significantly larger with the positiveness of information, as shown by the results in Column (4). In accordance with this, although not statistically significantly, Column (2) presents the results for the segregated information treatments. This is in line with the hot hand fallacy and replicates our experimental finding that men are prone to the gambler's fallacy while women are prone to the hot hand fallacy.

Table 7: Linear regression on stay with the reference difficulty.

Stay with reference difficulty	(1)	(2)	(3)	(4)
Positive Information	-0.006	-0.010*		
	(0.004)	(0.006)		
Positive Information x Female		0.010		
		(0.007)		
Negative Information	0.000	0.004		
	(0.004)	(0.005)		
Negative Information x Female		-0.008		
		(0.007)		
Positiveness			-0.003	-0.007**
			(0.002)	(0.003)
Positiveness x Female				0.009**
				(0.004)
Female	0.018*	0.018*	0.018*	0.018*
	(0.010)	(0.010)	(0.010)	(0.010)
N	6,730	6,730	6,730	6,730

Notes: Linear regression. Every regression includes individual fixed effects. Robust standard errors (in parentheses). *, **, and *** represents statistical significance at the 10 %, 5 %, and 1 % level, respectively.

4 Conclusion

In their decision-making processes, economic agents might irrationally react to irrelevant information about the outcome of past events. Two common representations of this behavioral bias are the gambler's fallacy and the hot hand fallacy. Understanding these fallacies is vital since they are associated with inferior economic outcomes (Dohmen et al., 2009; Filiz, Nahmer, Spiwoks, & Bizer, 2018; Goetzmann & Kumar, 2008).

With our research, we can show that women and men irrationally react to irrelevant information. The decision-making of men is in line with the gambler's fallacy, i.e., they decrease their investment into an asset with the positiveness of the previous outcome of the asset. The decision-making process of women, on the other hand, is more aptly described by the hot hand fallacy. Apparently, they increase their investment into an asset with the previous outcome's positiveness. These two gender-specific effects are masked by an average null effect. We find the two biases in a laboratory experiment (Study 1) and in a field study using sports data (Study 2), highlighting the generalizability of the findings.

Both biases cause inefficiencies in decision-making. We argue that the risk decision under the no information condition is the closest to the *true* preference of the subjects. Given positive or negative information, biased subjects choose risk levels that are too low or too high, respectively. As for the underlying mechanisms, we find that the perceived attractiveness of the reference, blurred by irrelevant information, drives part, but not all, of the effect.

Interestingly, we find the two behavioral biases despite unbiased (stated) probability perceptions. For both women and men, the irrelevant information in our experimental study does not move the (stated) perception of the probability of success of the lotteries away from the rational and correct value of 50 percent. This leaves some room for speculation. On the one hand, a biased subconscious perception might deviate from the stated rational perception. On the other hand, our results might indicate that biased decision-making consistent with the gambler´s or hot hand fallacy could be caused by something more than a mere misperception of probabilities.

Our results extend previous literature on gender differences in reactions to irrelevant information (Stöckl et al., 2015; Suetens & Tyran, 2012; Roney & Sansone, 2015) by analyzing the gambler's fallacy and the hot hand fallacy in a single framework. Exploring channels, we can explain part of the effect by the perceived attractiveness of the reference, while the (stated) perceived probability of success does not play a role. Finally, our findings relate to the common phrase, "The grass is always greener on the other side". We observe that for men, positive irrelevant information about the reference increases the feeling that the grass is greener on the other side. For women, on the other hand, positive irrelevant information increases their preference for the reference. Overall, our research highlights the gender differences in the reactions to irrelevant information.

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Appendices

A Study 1

A.1 Additional Results

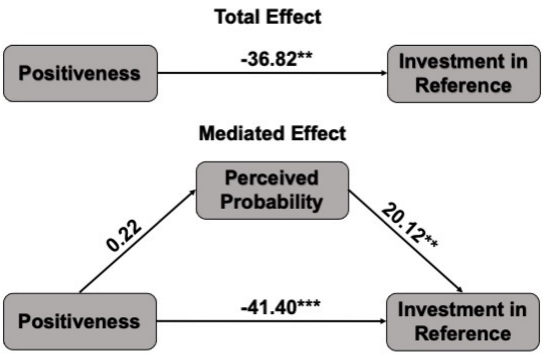

Figure 4: Male

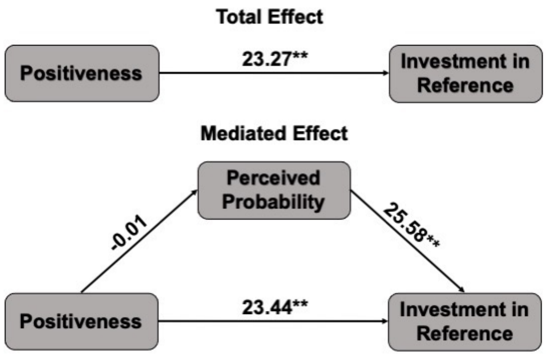

Figure 5: Female

Table 8: Mediation result male

Effect	Mean	90% CI
Mediation effect	-4.58	[-1.26 ; 12.84]
Direct effect	-41.40	[-64.64 ; -17.54]
Total effect	-36.82	[-61.30 ; -11.77]
% mediated	-0.12	[-0.35 ; -0.07]

Notes: Mediation analysis. 90% Confidence intervals (CI) based on 1000 bootstrap replications. Men, N=79.

Table 9: Mediation result female

Effect	Mean	90% CI
Mediation effect	-0.17	[-5.50 ; 4.88]
Direct effect	23.44	[6.12 ; 41.22]
Total effect	23.27	[5.43 ; 42.44]
% mediated	-0.01	[-0.02 ; -0.00]

Notes: Mediation analysis. 90% Confidence intervals (CI) based on 1000 bootstrap replications. Women, N=71.

B Study 2

B.1 Descriptive Statistics

Table 10: Descriptive statistics, stay with reference difficulty

Treatment	Mean	Median	SD	N
Negative Information	0.984	1	0.127	1,403
Neutral Information	0.986	1	0.117	3,544
Positive Information	0.976	1	0.152	1,783
Total	0.983	1	0.129	6,730

Notes: SD denotes the standard deviation. N denotes the number of observations.

B.2 Is the move away from reference difficulty in diving a fallacy?

We would like to see if the signals, i.e., positive or negative information, are rather an outlier (and thus can be treated as random noise) or some systematic deviation, such as momentum. To analyze this, we regress the signals' positive and negative information, as well as the positiveness, on the difference in performance from the signal-producing task to the subsequent (same) task. Table 11 shows a negative correlation for the positive information and a positive correlation for the negative information on subsequent performance (see column (1) for performance, and column (3) for the score, an alternative performance measure that also includes eventual difficulty changes). We can imply that both correlations move towards a 'normal' performance level. We can exemplarily interpret the positive coefficient for negative information to lead to a larger (positive) difference in performance, i.e., the performance in the later task was higher than for the signal-producing task. The interpretation of columns (2) and (4) is straightforward. The more positive the informational signal, the more negative the difference in performance.

Table 11: Momentum vs. regression-to-the-mean

	Difference Performance		Difference Score	
	(1)	(2)	(3)	(4)
Positive Information	-0.475***		-0.778**	
	(0.036)		(0.312)	
Negative Information	1.115***		2.185***	
	(0.041)		(0.358)	
Positiveness		-0.777***		-1.444***
		(0.023)		(0.198)
N	6,730	6,730	6,730	6,730

Notes: *, **, and *** represents statistical significance at the 10 %, 5 %, and 1 %, respectively. Linear regression using diving data. Individual fixed effects were used. Robust standard errors (in parentheses).

Next, we investigate if a change of difficulty away from the reference difficulty benefits the task-taker. In this case, it would imply that it is rational to move away from the reference – opposing the theoretical predictions about rational behavior.

Table 12 shows that changing away from the reference difficulty leads to decreased performance. For the difference in score, in columns (3) and (4), the coefficients indicate that parts of the decrease in the score are compensated by the increase in the difficulty (column (3)), which is multiplied by the performance for the score. The performance itself decreases independent of the subsequent difficulty (columns (1) and (2)).

Table 12: Changing away from the reference difficulty on performance

	Difference Performance		Difference Score	
	(1)	(2)	(3)	(4)
Change away from reference	-0.600***	-0.546***	-1.463	-2.673*
	(0.208)	(0.200)	(1.351)	(1.468)
Subsequent difficulty		-0.315***		7.052***
		(0.069)		(0.803)
N	6,730	6,730	6,730	6,730

Notes: *, **, and *** represents statistical significance at the 10 %, 5 %, and 1 %, respectively. Linear regression using diving data. Individual fixed effects were used. Robust standard errors (in parentheses).

Taking the combined indicative evidence in this chapter, it seems that changing away from the reference difficulty is not beneficial for the task-taker. A potential explanation for the superiority of performing the reference dive might be that the task-taker especially trains for specific dive, and they are – within a particular category of tasks – free to choose the dive they perform best. There is no reason not to choose the most familiar dive in which the task-taker is best for every contest they perform. Changing away from this is thus not rational – from an argumentation standpoint and the indicative results presented in this chapter.

Online Appendix for:

'Gender differences in investment reactions to irrelevant information'

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S.1 Timeline Study 1

1. Hypothetical investment
2. Info outcome first lottery [*Positive* and *Negative* only]
3. Elicitation of preferences and beliefs
4. Investment decision
5. Info outcome first lottery [*Noinfo* only]
6. Info outcome second lottery

S.2 Experimental Instructions Study 1 (English)

In this experiment, there are two available investment options: Project L and Project H.

Project L has a success probability of 50%.

- If the project is successful, each ECU invested in Project L will be multiplied by the factor 1.25.
- If the project is unsuccessful, each ECU invested in Project L will be multiplied by the factor 0.75.

Project H has a success probability of 50%.

- If the project is successful, each ECU invested in Project H will be multiplied by the factor 1.75.
- If the project is unsuccessful, each ECU invested in Project H will be multiplied by the factor 0.25.

The success probabilities of the two projects are completely independent of each other. This means that a random device is deciding for each of the projects separately, whether the investment into the project is multiplied by the high or the low factor. Hence, it can occur that both projects are successful at the same time, that both projects are unsuccessful, or that one project is successful while the other is unsuccessful.

The experiment consists of two steps. In step I, the program will make the investment decision for you. The investment in step I is not relevant to your payoff. The investment decision is, therefore, purely hypothetical. It is for illustration purposes. You will directly receive the information on how much was for you hypothetically invested into Project L and Project H.

-[Treatments with information:] You will learn whether the projects invested in were successful or not. Furthermore, you will learn about the hypothetical payoff from step I.

-[Treatments without information:] At the end of the experiment, you will learn whether the projects invested in were successful or not. Furthermore, you will learn about the hypothetical payoff from step I.

In step II, you will make the investment decision yourself. You will receive 400 ECU, and you will have the opportunity to allocate these freely between the projects. This decision will be payoff relevant. You can either invest in only one of the two projects, or you can divide the investment as you wish between the two projects. The 400 ECU must be fully invested. In the following, a random mechanism will decide whether Project L and Project H were successful. You will learn from both of the projects whether they were successful. Furthermore, you will be informed about your resulting experimental payoff.

Important: Step I and Step II are fully independent. In both steps, both projects will have a success probability of 50%.

S.3 Experimental Instructions Study 1 (German, Original Language)

In diesem Experiment stehen zwei Projekte zur Verfügung: Projekt L und Projekt H.

Projekt L hat eine Erfolgswahrscheinlichkeit von 50%.

- Sofern das Projekt erfolgreich ist, wird jedes in Projekt L investierte ECU mit dem Faktor 1,25 multipliziert.

- Sofern das Projekt nicht erfolgreich, wird jedes in Projekt L investierte ECU mit dem Faktor 0,75 multipliziert

Projekt H hat eine Erfolgswahrscheinlichkeit von 50%.

- Sofern das Projekt erfolgreich ist, wird jedes in Projekt H investierte ECU mit dem Faktor 1,75 multipliziert.
- Sofern das Projekt nicht erfolgreich, wird jedes in Projekt H investierte ECU mit dem Faktor 0,25 multipliziert

Die Erfolgswahrscheinlichkeiten der beiden Projekt sind vollständig unabhängig voneinander.

Das heißt, dass ein Zufallsmechanismus für beide Projekte getrennt entscheidet, ob Ihre Investition in das Projekt mit dem hohen oder dem niedrigen Faktor multipliziert wird.

Somit können sowohl beide Projekte gleichzeitig erfolgreich, beide Projekte nicht erfolgreich sowie eines erfolgreich und eines unerfolgreich enden.

Das Experiment besteht aus zwei Schritten.

In Schritt I wird die Investitionsentscheidung vom Programm für Sie getroffen.

Die Investition in Schritt I ist für Sie nicht auszahlungsrelevant. Die Investitionsentscheidung ist somit rein hypothetisch. Sie dient zur Veranschaulichung.

Sie erhalten direkt die Information, wie viel für Sie hypothetisch in Projekt L und wie viel in Projekt H investiert wurde.

-[Treatments mit Information:] Sie erfahren, ob die Projekte, in die investiert wurde, erfolgreich waren oder nicht. Zudem erfahren Sie die hypothetische Auszahlung aus Schritt I.

-[Treatments ohne Information:] Zum Abschluss des Experiments erfahren Sie, ob die Projekte, in die investiert wurde, erfolgreich waren oder nicht. Zudem erfahren Sie dann die hypothetische Auszahlung aus Schritt I.

In Schritt II treffen Sie die Investitionsentscheidung selbst.

Sie erhalten 400 ECU und können diese frei zwischen den beiden Projekten aufteilen.

Diese Entscheidung ist auszahlungsrelevant.

Sie können entweder in nur eines der beiden Projekte investieren oder aber die Investition beliebig zwischen beiden Projekten aufteilen. Die 400 ECU müssen vollständig investiert werden.

Im Anschluss an Ihre Investition entscheidet der Zufallsmechanismus, ob Projekt L und Projekt H erfolgreich waren. Sie erfahren für beide Projekte, ob diese erfolgreich waren. Außerdem werden Sie über Ihre resultierende Auszahlung in dem Experiment informiert.

Wichtig: Schritt I und Schritt II sind vollständig unabhängig. In beiden Schritten haben beide

Projekte eine Erfolgswahrscheinlichkeit von jeweils 50%.