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Risk Taking and Information Aggregation in Groups

by

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Abstract

We report an experiment examining risk taking and information aggregation in groups. Group members come to the table with an individual preference for a choice under risk, based on privately received information, and can share this information with fellow group members. They then make a decision under risk on behalf of the group using a random dictatorship mechanism, as well as an individual decision. Our analysis reveals that, while the behavior of many subjects is consistent with Bayesian rationality, a considerable number of subjects exhibited 'reverse confirmation bias': they place less weight on information from others that agrees with their private signal and more weight on conflicting information. We also observe a striking degree of consensus: in most groups all members made the same choice on behalf of the group. The pattern of individual choices after group deliberation suggests that the high degree of group consensus is due to persuasive arguments of other group members.

Keywords: Group behavior; Teams; Decision Making; Risk; Experiment

PsycINFO Classification codes: 2300, 3020

JEL Classification codes: C91, C92, D71, D80

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1. Introduction

How do groups of people make decisions under risk, and how is this affected by the way people share and process diverse information? This is an important question, since groups are often used for the assessments of economic risks – e.g. risk committees in banks, parliamentary commissions, and teams of consultants. In many cases, different group members have different information about underlying risks, and so these groups serve the dual function of aggregating information about a risky outcome and facilitating deliberation about the appropriate action to take. Previous experiments on group decision-making under risk show that when all members of a group have the same probabilistic information, groups often make decisions that differ from what their members would have decided individually. We extend this literature by focusing on a setting where each group member has private prior information about risks. In such a setting individual group members must update these priors using information conveyed through group deliberation. Previous research has shown that individuals often update priors in a way that is incompatible with rational Bayesian updating (see Camerer, 1995 for a review). Moreover, there is an extensive literature in psychology documenting important group effects in the way individuals process information obtained from group deliberation (e.g. Stoner, 1961). An important distinction between our design and this literature is that we introduce heterogeneous information in a controlled fashion.

In our experiment, we study groups of three subjects whose members come to the table with an individual preference for a choice under risk, based on privately received information. The group members then freely communicate with each other and make choices on behalf of their group and for themselves. When subjects decide on behalf of their group, we do not force them to reach a consensus with others: instead we use a random dictatorship procedure, which incentivizes subjects to reveal their own preferred level of risk-taking for the group. This procedure thus delivers easily interpretable "group choices" by individual subjects. This is in contrast to other group decision-making studies that implement voting procedures or force consensus, so that observed choices may reflect a combination of individual preferences for a particular choice and compromise among group members.[1] Because we control for the

[1] Our random dictatorship procedure may also reduce the disproportionate influence of group members with particular risk preferences or personalities that is found in other studies. For example, Ertac and Gurdal (2012) find that men who express a preference to be a group leader (decide on behalf of a group) are more risk seeking than men

information that subjects receive at various stages of the experiment, we can measure how strongly members of a group respond to probabilistic information, and whether their response depends on the source of information (a privately observed signal or information provided by a fellow group member).

The experiment is divided into four stages. In each stage, subjects make an investment decision whose outcome depends on a binary 'state of the world' variable. It is common knowledge that both states of the world, the 'good' and 'bad' state, are equally likely *ex ante*. Before the second stage of the experiment, subjects privately receive probabilistic information about the state of the world. Before the third stage of the experiment, subjects are put into groups of three in which they can share their private information and express their preferences. Subjects' investment decisions in the final two stages of the experiment are based on the same information, but the third-stage decision also affects other members of the three-person group, whereas the fourth-stage decision is taken in isolation. Using the choices from the second and fourth stage, we test whether subjects who receive identical signals from their fellow group members decide in line with Bayesian rationality, or display confirmation bias (i.e. placing more weight on information that agrees with their own private signal). Finally, we use choices from the third and fourth stage to investigate whether choices on behalf of the group reflect a concern for others' risk preferences, and to what extent individual decisions are affected by decisions taken during group deliberation.

We find that subjects generally respond intuitively to the private signals they receive. Subjects also readily share their signals with their group – there is no evidence of strategic reporting or mistrust. However, subjects do not always act in line with Bayesian rationality. Specifically, about half of the subjects who receive two conflicting signals from others in their group change their investment decision, in conflict with Bayesian rationality. Interestingly, these subjects tend to change their investments in the opposite direction to that consistent with confirmation bias: we refer to this behavior as displaying 'reverse-confirmation bias'. We also find that in the group decision-making stage the majority of the subjects make the same decision as fellow group members. This degree of consensus is remarkable given the absence of any monetary or reputational incentives for reaching consensus. In the final stage subjects

who do not. Nieboer (2013) reports that all-female groups do not take more risk than female individuals whereas all-male groups take significantly more risk than male individuals when groups decide by consensus.

tend to make the same choice that they made in the group-decision making stage. This pattern of decisions is consistent with the explanation of consensus at the group stage as driven by persuasive arguments by peer subjects, although we cannot exclude that social preferences over risk play a small role.

The remainder of the paper is organized as follows. In the following section we review related studies in psychology and economics. In section 3 we describe our experiment and in section 4 we present our results. We conclude in section 5.

2. Related Literature

Both economists and psychologists have investigated the question of how groups aggregate information. In economics, theories of information aggregation go back as least as far as the famous jury theorem of Condorcet (1785). More recently, theoretical contributions by Austen-Smith and Banks (1996) and Feddersen and Pesendorfer (1998) show that incentives to vote strategically can lead to group members voting against their private information, thus hampering efficient information aggregation. Experiments with jury decisions provide evidence that strategic voting actually occurs and lowers efficiency (Guarnaschelli et al., 2000; Ali et al., 2008), although this is less of a concern when group members can communicate (Goeree and Yariv, 2011).

In psychology, experimental evidence suggests that groups often make decisions that are extreme compared to the preferences of individual group members. Group discussion may produce choice shifts (Stoner, 1961) or group polarization (Moscovici and Zavalloni, 1969). The way in which groups aggregate information, specifically the persuasiveness of certain arguments, can play an important role in this process (Vinokur and Burstein, 1974). More recently, Glaeser and Sunstein (2009) and Sobel (2014) theoretically investigate the group polarization phenomenon in the framework of Bayesian rationality, demonstrating that both Bayesian and non-Bayesian rational behavior can explain extreme outcomes of group deliberation. These novel approaches have the advantage that they quantify the strength (in probabilistic terms) of pieces of information, which allows for more precise predictions of behavior. Our experiment also follows this approach.

Bayesian-rational models of group deliberation like Sobel's (2014) typically assume that groups efficiently aggregate probabilistic information held by their members, but Glaeser and Sunstein (2009) argue this assumption is often violated. One condition of efficient

information aggregation is that people weight information according to its strength, regardless of whether they obtained the information themselves or from others. Experimental evidence suggests that, when people possess both private and public information, they actually put more weight on their private information. McKelvey and Page (1990) present an experiment in which subjects receive private information in round one of the experiment, and in subsequent rounds they are given public information with which to update their beliefs. Although subjects do use the public information provided to adjust their beliefs, they are slow to update their beliefs away from their private information.

The results of McKelvey and Page are consistent with *confirmation bias*, defined as "seeking or interpreting of evidence in ways that are partial to existing beliefs, expectations, or a hypothesis in hand" (Nickerson, 1998). These existing beliefs are typically shaped by the source of the information (private versus public) or by the order in which information is delivered (earlier versus later). Our experimental design favors confirmation bias in both of these aspects: subjects in our experiment receive private information first, and information from others later. With regard to order, the evidence from the experimental literature is mixed. Early experimental studies suggest the existence of a *primacy effect* in line with confirmation bias: probabilistic information received earlier has a bigger impact on beliefs than information received later (Hoch, 1984; Peterson and Ducharme, 1967; Pitz, 1969). However, recent experimental evidence from outcome sampling experiments actually indicates a *recency effect*: probabilistic information received later has a bigger impact on choice than information received earlier. When subjects have to choose between two unknown distributions over monetary outcomes based on a series of draws from both distributions, they put more weight on the recent draws (Hertwig et al., 2004).

Our experiment is also related to the experimental literature on decision-making under risk in social contexts, which can be broadly divided into two strands. First, there is a growing body of laboratory research that compare decisions of groups and individuals. Results from these experiments suggest that the decisions of groups and individuals often diverge, although the evidence on direction and nature of the difference is mixed. The experiments of Sutter (2007; 2009) and subsequent replications show that groups deciding under consensus take more risk than individuals in the investment task introduced by Gneezy and Potters (1997), whether groups communicate face to face (Nieboer, 2013) or by electronic chat (Bougheas et al., 2013).

Two experimental studies that also investigate group decision by consensus but use a different risk-taking task – the multiple price list format introduced by Holt and Laury (2002) – show that group choices are more extreme than individuals' at the low end (more safe choices) and high end (more risky choices) of the probability scale (Baker et al., 2008; Shupp and Williams, 2008). Finally, three experimental studies that use a group voting mechanism and the Holt-Laury task report further mixed results. Masclet et al. (2009) find that groups, deciding by multiple-round unanimous vote, are more risk averse than individuals. Zhang and Casari (2012) use a single-round unanimous vote that is resolved by communication in case of no agreement, and report that group choices are more risk neutral than individuals' choices. Harrison et al. (2013) use a simple majority vote and find no difference between groups and individuals.

The second strand of experimental literature on choice in social contexts suggests that people are often influenced by the choices of their peers. Yechiam et al. (2008) report an experiment in which mutual real-time observation between two individuals whilst making choices under risk leads to higher risk taking. In a multi-period design with feedback on peer choices, Cooper and Rege (2011) find that subjects are significantly more likely to change their preferred level of risk taking if it deviates from the majority choice of peers. Lahno and Serra-Garcia (2012) also find evidence of peer effects on binary individual choices under risk. Finally, Bougheas et al. (2013) report significant convergence in the risk taking of individuals when they are allowed to communicate about an individual decision under risk.

3. The Experiment

We begin by describing our experimental design and procedures in section 3.1, before discussing some key features of this design and the hypotheses it enables us to address in sections 3.2 and 3.3.

3.1 Experimental Design and Procedures

The experiment was carried out at the CeDEx computer laboratory at the University of Nottingham (Nottingham, UK). Subjects were students from various disciplines, who had previously registered for participation in economic experiments and were recruited via ORSEE (Greiner, 2004). Eight sessions were conducted, with 84 subjects participating in total.

At the start of a session, subjects were randomly assigned a seat in the laboratory. They then received instructions on their computer screens, which were also read out loud by an experimenter.[2] Subjects were informed that there would be four stages and their earnings would be based on decisions in one of the four stages, to be picked at random. Similarly, subjects were informed that earnings in a stage would depend on which of two states of the world is realized. The subjects observed the random selection of the state, which was relevant for all four stages, but the selected state was not revealed to them until the end of the session. Specifically, subjects were shown two sets of cards: set A (henceforth 'the bad state') consisted of two red Aces of Hearts and one Ace of Spades while set B (henceforth 'the good state') consisted of two Aces of Spades and one Ace of Hearts. The sets were placed in identical packs which were put into an empty bag and then one of the packs was randomly selected. At the end of the experiment subjects were shown the contents of the selected set and so learned whether the state was good or bad.

Subjects then received specific instructions for each stage in turn. Throughout the experiment subjects were not allowed to communicate with one another, except in Stage III as described below, and all choices were submitted in private via the software.

In each stage subjects make an investment choice about how much of a £10 endowment to invest. In the bad state the subject loses her investment and in the good state she gets a positive return. The returns are given in Table 1.[3]

In stage I subjects choose from the options listed in Table 1, only knowing that the two states of the world are equally likely to have been selected. The amounts in the table are constructed so that the optimal investment is £5 for a risk-neutral subject, leaving room for such a subject to increase or decrease her investment as she receives information about the state of the world.

At the beginning of stage II each subject receives a private signal $s \in \{\text{good, bad}\}$, where $\Pr\{\text{good signal} \mid \text{good state}\} = \Pr\{\text{bad signal} \mid \text{bad state}\} = 2/3$. This was implemented by allowing each subject to draw a card from the selected set. A draw of a black (red) card

[2] The experimental software was programmed in z-Tree (Fischbacher, 2007). The experimental instructions are reproduced in the appendix.

[3] In the experiment we used a neutral frame that does not refer to investments, endowments, losses or gains, but simply lists the eleven options and corresponding earnings. See appendix.

corresponds to receiving a good (bad) signal. Subjects then make another choice from the options listed in Table 1.

Table 1: Investment Choices and Earnings

Investment (£)	Earnings (£)	
	good state	bad state
0	10	10
1	12.80	9
2	15.40	8
3	17.80	7
4	19.60	6
5	20.80	5
6	21.60	4
7	22.40	3
8	22.80	2
9	23.20	1
10	23.60	0

In stage III groups of three subjects are randomly formed. Subjects can then communicate freely with the other group members using an electronic chatbox on their screen. During the chat subjects can, if they want, report their individual signals to others in the group. Each subject then chooses once more from the options listed in Table 1. These decisions on behalf of the group are implemented by a 'random dictatorship' procedure: in each group one of the group members' decisions is randomly chosen to be the one that is relevant for all three group members. At the end of this stage all group members are informed of the three choices and which one is implemented.

In stage IV each subject makes a final investment decision, again by choosing from the options in Table 1. In this stage the decision is made in isolation: it is not observed by other subjects and it only affects the decision-maker.

At the end of the experiment the state of the world is revealed, the earnings-relevant stage is revealed, and subjects are paid accordingly in private. Average subject earnings were £11.35, and the average session time was 40 minutes.

3.2 Bayesian Rationality and Confirmation Bias

In stage I, subjects make individual investment choices where the state of the world is equally likely to be good or bad. Choices from this stage thus give us a measure of individual subjects' willingness to take risk.

In stages II and III, subjects receive new information about the true state of the world. In general, after receiving *g* good signals and *b* bad signals, rational Bayesian updating implies that the probability of the good state is given by $\Pr\{\text{good state} \mid b, g\} = \Pr\{b, g \mid \text{good state}\} \times \Pr\{\text{good state}\}/\Pr\{b, g\} = 1/(1 + 2^{b-g})$. Note that in our design this probability only depends on the difference between the number of bad and good signals. Thus, in stage II Bayesian updating implies that a subject receiving a good signal updates her subjective probability of the good state from 1/2 to 2/3, while a subject receiving a bad signal updates her subjective probability of the good state from 1/2 to 1/3.

Whereas in stage II subjects make individual decisions that are only informed by their private signals, in stages III and IV they may use information obtained from the group interaction in stage III. Assuming that a group efficiently aggregates all information (all group members learn the signals of all three group members), Bayesian updating implies that the subjective probability that a subject attaches to the good state is given by:

$$\Pr\{\text{good state} \mid 0 \text{ good and } 3 \text{ bad signals}\} = 1/9$$
$$\Pr\{\text{good state} \mid 1 \text{ good and } 2 \text{ bad signals}\} = 1/3$$
$$\Pr\{\text{good state} \mid 2 \text{ good and } 1 \text{ bad signals}\} = 2/3$$
$$\Pr\{\text{good state} \mid 3 \text{ good and } 0 \text{ bad signals}\} = 8/9.$$

Thus, Bayesian updating implies that a subject should not update her subjective probability of the good state if her fellow group members in stage III report conflicting signals.

If subjects are prone to confirmation bias, however, they will interpret two conflicting signals in a different way. According to confirmation bias, a subject places more weight on new evidence that confirms her own. As a consequence, a subject with a good signal who receives conflicting good and bad signal reports from her fellow group members will not regard these as cancelling out, but instead will overweight the good signal report and increase her subjective probability that the state is good. Similarly, a subject with a bad signal who receives conflicting signal reports will decrease her subjective probability that the state is good. Thus, while Bayesian updating does not predict any systematic change of behavior after receiving conflicting signals, confirmation bias does.

3.3 Group Decision Making

Recall that in stage III one group member's decision is randomly selected to be the one that is relevant for all three group members. Our use of this random dictatorship procedure implies that each group member has an incentive to truthfully reveal her preferred investment choice for the group. Note that this procedure does not force group members to compromise or reach consensus. Nor does it imply that a subject should make the same decision that she would if she were the only affected party.

However, there are two reasons why consensus might emerge in stage III. First, it may reflect that subjects have other-regarding concerns and prefer compromise rather than forcing their own preferences on others. Second, it may be that subjects may be persuaded by the discussion during the stage that a particular investment choice is the best one.

In order to see how far stage III decisions depart from the decision that an individual would make if she were making that decision in isolation (i.e. when her decision is not observed by others and does not affect others), we also have subjects make individual, isolated, decisions in stage IV. Notice that subjects now have precisely the same information as in stage III, but their decision will only affect themselves. If a subject makes different decisions in stages III and IV, especially when the tendency in stage IV is predicted by their individual risk preferences, this suggests that their stage III decisions reflect some form of social preferences over risk. Another possible effect of group deliberation is persuasion: subjects' level of risk taking in stage IV may be influenced by persuasive arguments from fellow group members in stage III, in which case subjects' individual decisions in stage IV will be shaped by the decisions made in stage III. Such a result would be in line with the

findings of Sutter (2009), who finds that deciding as part of a group leads subjects to increase their risk taking compared to individual decisions taken before group membership, without reverting to lower risk taking in individual decisions afterwards.

4. Results

4.1 Information and Individual Investments

We start by looking at decisions from the first two stages, as these provide useful information on heterogeneity in individual risk attitudes. Figure 1 shows the distribution of investment decisions in stage I (upper panel) and stage II (two bottom panels, each showing the distribution of investments conditional on the private signal received).

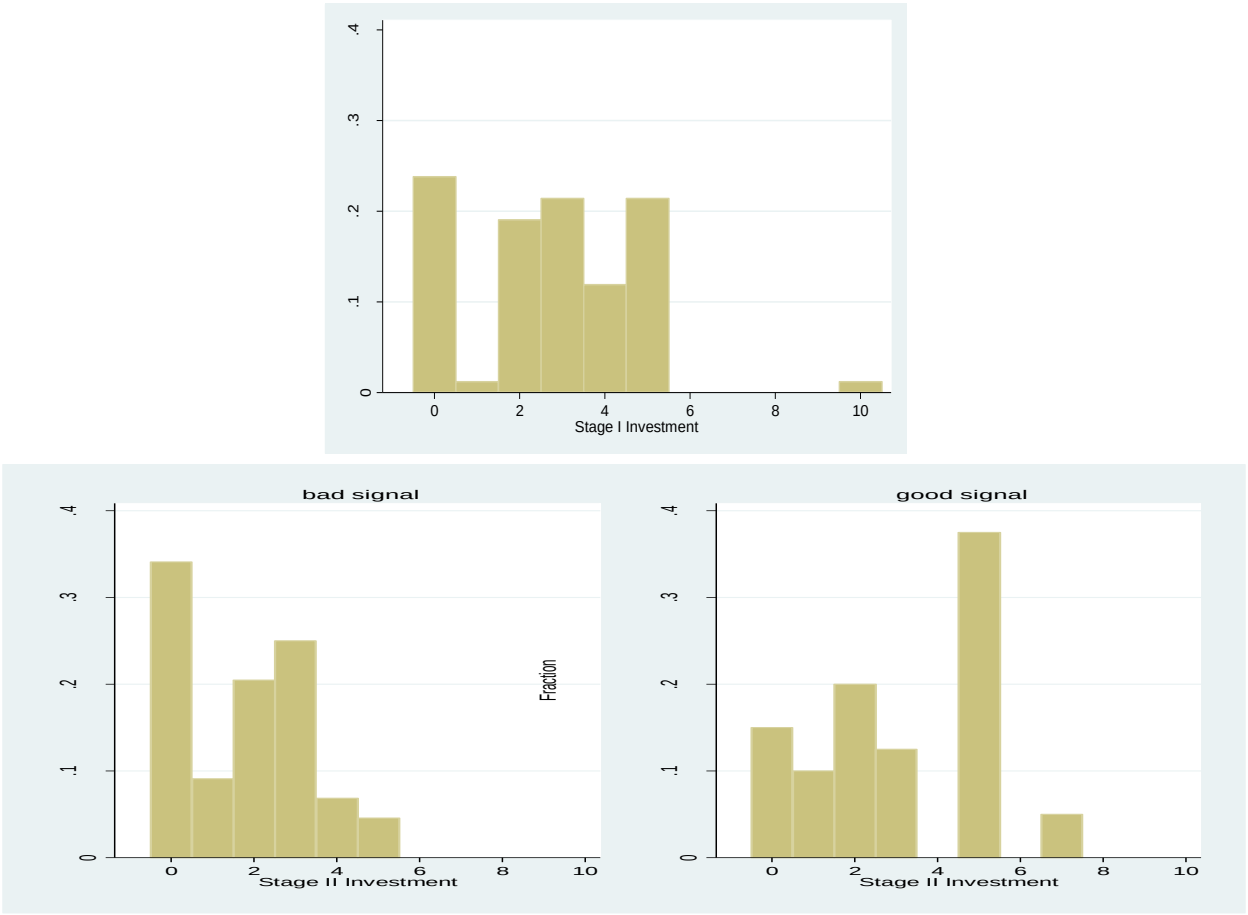

Figure 1: Distributions of individual investments in stages I and II.

In stage I, about 20% of subjects make a choice consistent with risk-neutrality and invest £5, and a similar percentage make an extremely risk averse choice investing nothing to

guarantee £10. There is considerable heterogeneity, and the majority of subjects display risk aversion. In stage II, subjects with good signals tend to invest more than subjects with bad signals, but again, for both signal types there is considerable heterogeneity.

If we look at how individuals react to their signals we see that the majority of subjects respond in an intuitive way. Figure 2 shows that subjects tend to increase their investment in response to a good signal or decrease it in response to a bad signal.[4] However, some subjects do not respond as much as Bayesian rationality would suggest. Indeed, 34 of 84 subjects did not change their investment choice. This is in line with long-standing experimental evidence that subjects are conservative in processing new information (see Edwards, 1968, and for a review see Camerer, 1995).

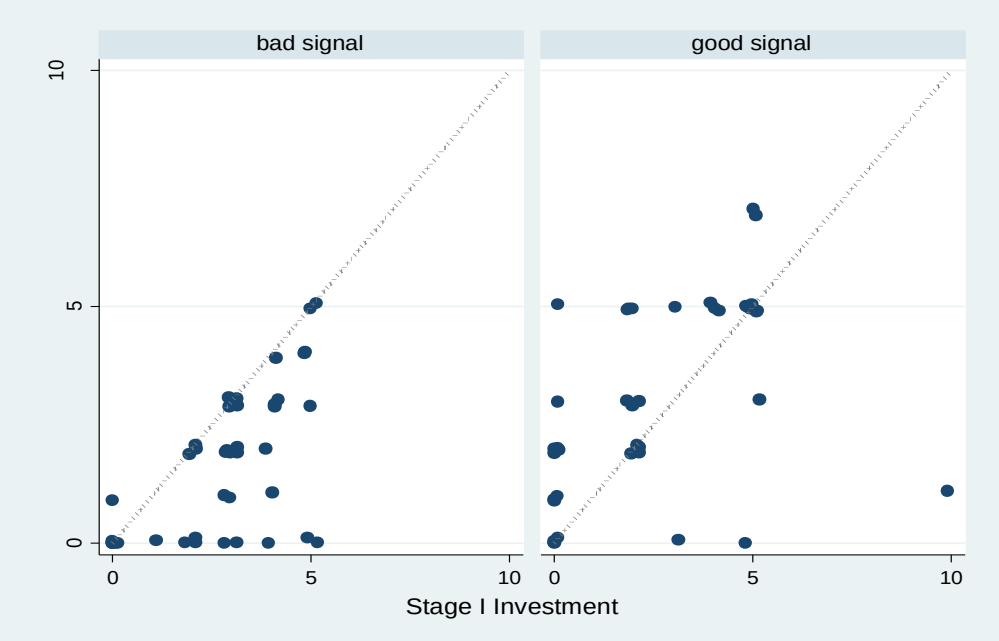

Figure 2: Stage I (pre-private signal) versus Stage II (post-private signal) investments.

Further analysis of how subjects react to new information can be based on comparing stage II and stage IV decisions, since in stage IV subjects will have new information from the stage III group interaction. Assuming that efficient information aggregation takes place, e.g. if subjects report signals truthfully and believe the reports of others, this new information gives each subject three independent signals on the state of the world. Although our design does not enforce truthful reporting and allows subjects to misreport or withhold signals, we find from

[4] Only 5 of 84 subjects modified their behaviour in the opposite way.

the stage III chat logs that all three group members revealed their signals truthfully to the other group members in 27 of 28 groups.[5] The chat logs also give no hint of any skepticism among subjects concerning the veracity of reports.

Figure 3 shows how subjects who received two new identical signals react to this new information. Twenty-seven subjects received two new bad signals: these subjects should decrease (or at least not increase) investments relative to stage II, based on a higher posterior probability of the bad state occurring. Analogously, 23 subjects received two new good signals and should increase (or at least not decrease) investments. In each category there are only three subjects who react in a contrarian manner. Thus, again, the majority of subjects react to new information in an intuitive way.

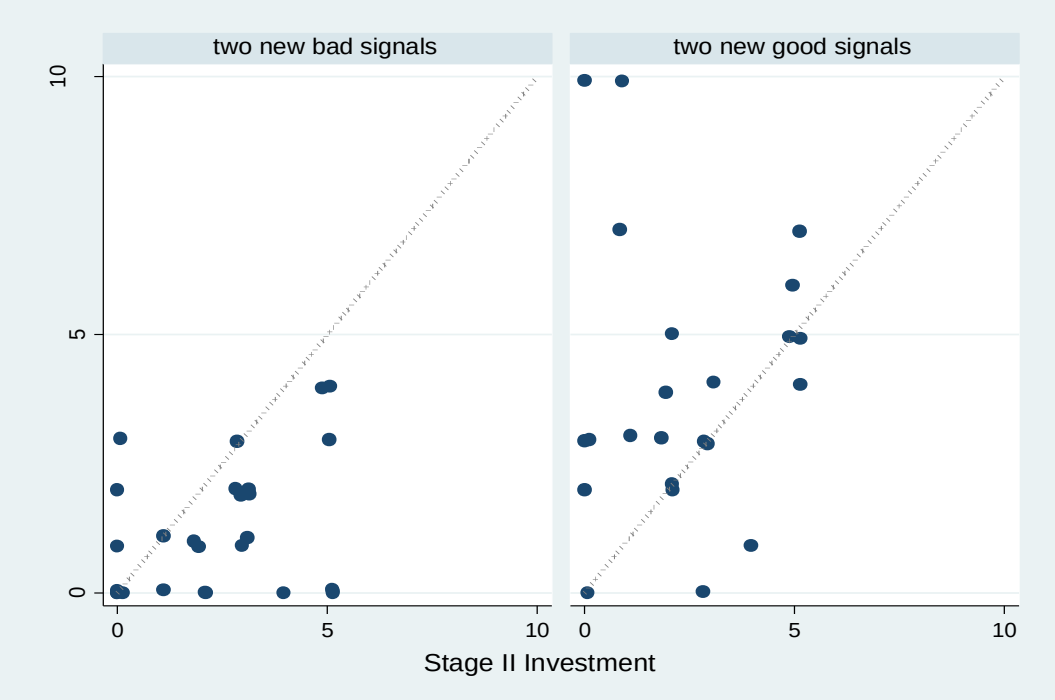

Figure 3: Stage II (pre-information sharing) versus Stage IV (post-information sharing) investments by subjects receiving two identical signals from others.

4.2 Bayesian Rationality versus Confirmation Bias

So far, we have only considered situations in which Bayesian rationality and confirmation bias cannot be separated as explanations of increasing or decreasing risk-taking across stages

[5] In the remaining group, one member claims that there is "no point discussing what clues we got because we all could have picked the same card" and the others agree. The group proceeds to discuss their decision without considering the signals. Our results are unaffected if we exclude this group.

of our experiment. But when subjects receive conflicting signals from their fellow group members, the predictions differ. According to Bayesian updating, a subject receiving one good and one bad signal should not alter her level of investment. By contrast, confirmation bias stipulates that a signal received from a fellow group member is given more weight if it confirms the subject's private signal. If our subjects display confirmation bias, we should see those with a good private signal increasing their investment in stage IV relative to stage II, and those with a bad private signal lowering their investment.

Figure 4 compares investment decisions for subjects who receive conflicting signals from their fellow group members.

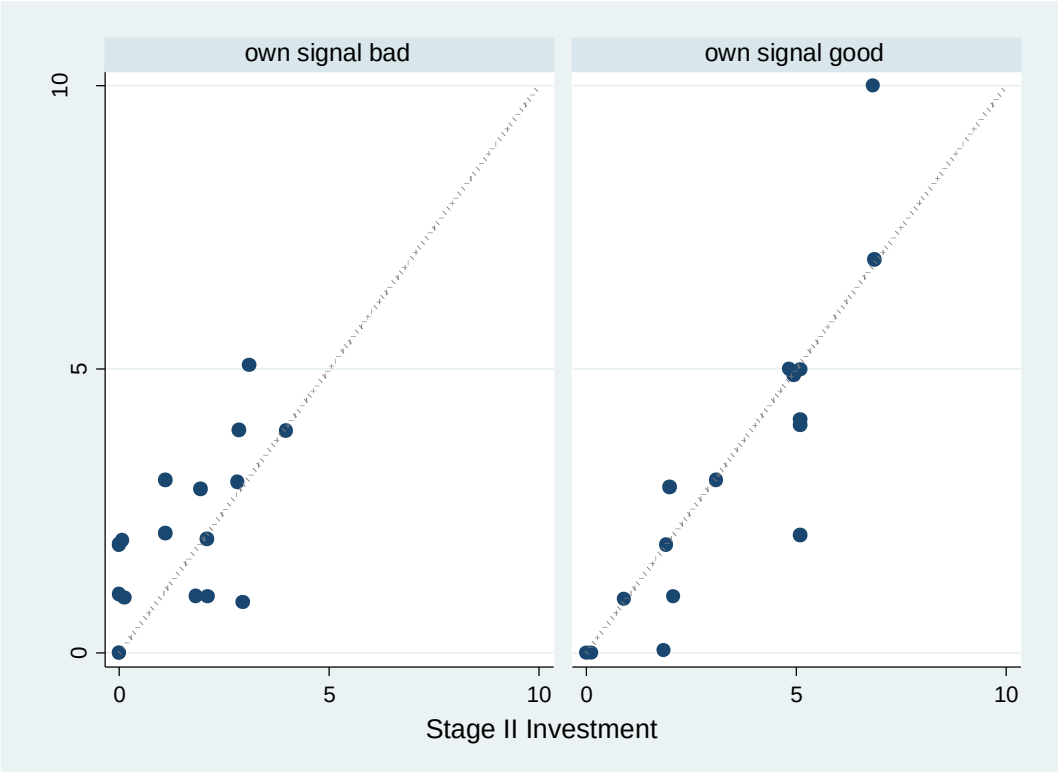

Figure 4: Stage II (pre-information sharing) versus Stage IV (post-information sharing) investments by subjects receiving two conflicting signals from others.

Out of 34 subjects 14 make the same choice in stages II and IV (5 of 18 in the left panel and 9 of 16 in the right), consistent with Bayesian rationality. However, most subjects change their investments. In the left panel, we see that those with a bad private signal tend to increase their investment, whereas in the right panel we see that those with a good private signal tend to decrease their investment. Of the 20 subjects who change investments 5 adjust

in the direction predicted by confirmation bias and 15 adjust in the opposite direction. Thus more subjects exhibit *reverse confirmation bias* than confirmation bias or Bayesian rationality.

For a formal test of whether there is a systematic change in the direction predicted by confirmation bias we measure the change in investment as the stage IV decision minus the stage II decision for subjects with good signals, and the stage II decision minus the stage IV decision for subjects with bad signals. Bayesian updating implies that these changes should be zero, whereas confirmation bias implies positive changes. A two-tailed Mann-Whitney sign-rank test of the pooled data rejects the hypothesis that the median change is zero (n=34, p=0.0286).[6] Thus there are systematic deviations from Bayesian rationality, but evidently this is because there is a tendency for negative changes, i.e. reverse confirmation bias.

4.3 Group Effects

Recall that we used a random dictatorship procedure to implement the group decision in stage III, so that each individual subject has an incentive to submit his preferred decision for the group. Now, consider subjects in groups with a given signal profile. If subjects make choices on the basis of their own risk attitudes neglecting the possible effect of their choice on the other group members one would expect their stage III decisions to be randomly distributed across groups. In fact we observe a striking degree of consensus within groups. We regressed investment decisions on group dummies for each signal profile and in all cases the group dummies are highly significant ($p < 0.01$ for all signal profiles), reflecting that the variability of individuals' investment choices about group means is substantially lower than the variability about the overall mean. Indeed in 15 out of 28 groups all three group members submitted an identical decision.

The consensus in group decision making can be explained via two alternative mechanisms. First, decisions may reflect *social preferences over risk*, whereby subjects make choices that they would not make in an individual decision-making context. For example, subjects may prefer to conform, driven by pressure from peers or a genuine concern for the

[6] The test assumes the changes in investment decisions are independent across the 34 subjects who received conflicting signals from others. However, in each mixed signal group there are two subjects with conflicting signals and it is possible that their decisions in stage IV are correlated. Thus we also ran the test using the average change for these pairs (i.e. with 17 observations). There is still systematic evidence of reverse confirmation bias (p= 0.0344).

risk preferences of other group members over the group. Second, decisions may be the result of *persuasive arguments*, whereby subjects are influenced by the group discussion and may reflect an agreement on what is the best decision. By examining decisions in stage IV we can examine the influence of these two mechanisms. If consensus in stage III decisions only reflects social preferences over risk we would expect subjects' decisions in stage III and stage IV to differ, with the individual decision in stage IV more representative of subjects' individual risk attitude (we can use stage I decisions as a proxy for the latter measure). If subjects were persuaded by fellow group members that a particular decision is best then we would expect subjects to choose similar levels of risk taking in stage III and IV.

To begin analyzing subjects' decisions in stage IV we perform a regression analysis using dummies for signal profiles as explanatory variables. This and subsequent regressions cluster standard errors at the group level to allow for correlations between choices of subjects who had interacted in stage III. The results are reported in the first column of Table 2. The signal profiles are highly significant and, not surprisingly, show that investment choices increase with the number of good signals. The information contained in signals explains around one third of the variation in investment.

This regression treats all signals within a signal profile symmetrically. That is, it does not distinguish between the choices of subjects who received different private signals but have the same signal profile. Subjects may overweight their private signal if they mistrust the signals reported by others is to see whether subjects. For example, if subjects in a group with two good and one bad signal invest more in stage IV when their own signal is good rather than bad, this would suggest that subjects put more weight on their private signal. To test for own-signal bias we re-run the regression including own signal as an additional explanatory variable. The results reported in the second column of Table 2 show no statistical evidence of own-signal bias, reinforcing our earlier observation that subjects appear to take the signal reports of others at face value.[7]

[7] Note that the test of own-signal bias is different from the test of confirmation bias, as we are now comparing decision of individuals with different signals within a given signal profile whereas the test of confirmation bias compares decisions of a given individual before and after receiving conflicting signals from others.

Table 2: Determinants of stage IV investment choices

	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	0.889**	0.889***	-0.344	-0.220	-0.385
	(0.455)	(0.280)	(0.389)	(0.214)	(0.316)
1 good signal	1.111**	0.944*	0.849**	0.257	0.718
	(0.455)	(0.478)	(0.397)	(0.311)	(0.433)
2 good signals	1.944**	1.611**	1.466**	-0.271	0.617
	(0.745)	(0.700)	(0.655)	(0.428)	(0.544)
3 good signals	4.178***	3.678***	3.776***	0.456	1.578**
	(1.019)	(1.118)	(1.044)	(0.637)	(0719)
Private signal (1 if good)		0.500	0.585	0.531	-0.176
		(0.447)	(0.450)	(0.411)	(0.497)
Stage III investment				0.803***	0.714***
				(0.069)	(0.071)
Stage I investment (risk attitude)			0.435***	0.149**	0.213**
			(0.075)	(0.059)	(0.075)
Gender (1 if male)			0.164	-0.009	-0.385
			(0.422)	(0.260)	(0.316)
Number of observations	84	84	84	84	45
R-squared	0.339	0.345	0.486	0.823	0.865

Standard errors are clustered at the group level. Standard errors in parentheses, asterisks denote significance at the 10% (*), 5% (**), 1% (***) level.

The third column reports a regression which adds controls for gender and individual risk attitudes, the latter expressed by subjects' stage I decisions. The effect of gender on stage IV investment choices is not significant in the regression. However, subjects' risk attitude is highly significant and indicates that, conditional on signal profiles, those willing to take more risk in stage I are also willing to take more risk in stage IV. This model explains about half of the variation in investment choices.

Finally, in the fourth column we report the results from including stage III investment as an additional explanatory variable. The new model explains over 80% of the variation in choices. The high explanatory power contained in stage III investment reflects the fact that

stage III and IV investments are very similar and in fact most subjects (46 out of 84) make exactly the same choice in stages III and IV. Note that once stage III investment is included the signal dummies lose significance as stage III investments already contain the information represented by these signals.

Although stage III investment explains investment beyond the information contained in the signal variables, note that subjects' risk attitude is still significant: subjects who adjust their investment in stage IV, do so in the direction of their own risk attitudes. Thus we do not conclude that social preferences play no role in consensus, since some subjects seem to eschew their individual risk preferences in stage III.

One possibility for the high degree of similarity between stage III and IV decisions is that many subjects are entering their preferred individual investment choices in both stages. This is less plausible for the case of individuals in groups that reached consensus, and so we also ran the last regression with a restricted sample of subjects belonging to groups that reached consensus. The results do not change substantively. Overall our results suggest that there is a high degree of following stage III investments in stage IV, supporting the persuasive argument rationale for consensus decision-making in stage III.

5. Conclusion

We report the results of an experiment designed to help understand how groups aggregate information that is relevant for decision-making in risky environments. By controlling for the information that subjects have at each stage of the experiment our work differs from related studies in the psychology literature. Our work is also distinct from other experiments on group decision making in the economics literature in that our subjects reveal their privately preferred group decisions whereas in other studies group members are offered strong incentives to reach consensus.

Our analysis of the experimental results produces two main findings. First, while the behavior of many subjects is consistent with Bayesian rationality, a considerable number of subjects exhibited 'reverse confirmation bias'. That is, they place less weight on information from others that agrees with their private signal and more weight on conflicting information. Second, we observe a striking degree of consensus: in most groups, all members make the same choice. Furthermore, we find that when subjects leave the group and make a decision on their own, the level of risk they take is very similar to that in the group deliberation stage. This choice

pattern suggests that the high degree of group consensus is due to persuasive arguments of other group members. Altogether, our results indicate a remarkably high level of trust in the information and opinions communicated by others.

The high level of trust placed in others may reflect certain features of our experimental design. Because our subjects have no experience with the experimental task we use, and all subjects receive the same outcome in stage III, there appears to be little incentive to act strategically. Perhaps if subjects would receive different outcomes (e.g. a smaller or greater part of their earnings was determined by the state of the world), or if subjects would play multiple rounds of the game with feedback, they would be tempted to misreport their private information and be less inclined to agree with others. Furthermore, the process of obtaining private information in our experiment was entirely transparent – if it was less clear where others' information came from subjects might be less willing to take the reports of others at face value. Varying the degree of pay-off commonality and the (perceived) quality of private information seem promising directions for further research.

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Appendix: Experimental instructions

Welcome to our experimental study of decision-making. The experiment will take about 45 minutes. The instructions for the experiment are simple, and if you follow them carefully, you can earn a considerable amount of money. The money you earn will be paid to you, privately and in cash, immediately after the experiment. You are not allowed to talk to other subjects during the experiment, and you are not allowed to look at any computer screen but your own; anyone who is found breaking these rules will be dismissed without payment.

The experiment consists of four stages. In each of the four stages, we will ask you to submit a decision. Your earnings will depend on your decision in only ONE of the four stages; the decisions in the other three stages will not affect your earnings. The experimenter will now randomly determine the stage that will count for your earnings. We have four playing cards: the ace, 2, 3 and 4 of spades - these represent the four stages of the experiment. [Experimenter shows cards to subjects.] We will shuffle them and one will be picked at random. The selected card will go back in the box and will remain here until the end of the experiment. [Randomly chosen subject blindly picks playing card in front of other subjects.] You will not know which one of the stages will count until the end. You should therefore consider your decision carefully in every stage, since, as far as you can tell, any stage could be the one that counts for your earnings.

Please raise your hand if you have any questions during the experiment. An experimenter will then come to you and privately answer your question.

Your earnings from the experiment depend on your decisions, and which of two card sets is randomly selected by the experimenter. The two sets are pictured on the whiteboard. As you can see, set A contains 2 red cards and 1 black card; set B contains 2 black cards and 1 red card. The experimenter will now select the set of cards; this selection will be relevant to all four stages of the experiment. The experimenter will not announce the selected card set to anyone until the end of the experiment. [Show card sets to subjects.] We will now put each of them in a box, and put these boxes in a bag. We will now shuffle them, and pick one of the sets at random. [Randomly chosen subject blindly picks box with card set in front of other subjects.]

Stage I

You must choose one of the 11 options in the table shown below. Your earnings will depend on

your choice and whether card set A or card set B has been selected. You make a choice by selecting a single option and pressing the ’Submit decision’ button.

You will have 5 minutes to make a decision. Keep in mind that, if this stage has been selected for pay-out, you will be paid according to the decision you are about to make. Please raise your hand if you have a question.

Stage II

Each person will now privately receive a clue about which card set has been selected. We will do this by letting you draw a card from the selected set, allowing you to see if its red or black, then putting it back in the set before the next person draws a card. Your clue is private in the sense that only you observe it. Other subjects cannot see the card you draw. Please note that we will ask you to input your clue on the computer screen immediately after your draw.

We will now go around and give each of you your private clue. Please keep your eyes in your own cubicle and wait until the experimenter comes to you, draw a card from the set, look at it, then input it on your screen. You are not allowed to observe other people’s clues.

You must choose one of the 11 options in the table shown below. Your earnings will depend on your choice and whether card set A or card set B has been selected. You make a choice by selecting a single option and pressing the ’Submit decision’ button.

You will have 5 minutes to make a decision. Keep in mind that, if this stage has been selected for pay-out, you will be paid according to the decision you are about to make. Please raise your hand if you have a question.

Stage III

In this stage you will be randomly matched with two other subjects to form a group of three. Before you make any decision, you will get 5 minutes to communicate with your fellow group members through a chat box on your screen. You are free to discuss any aspect of the experiment that you wish, as long as you follow these rules:

- You must not reveal any personal information (for example, your name, contact details or seat in the room)
- You must not make any threats, insults or use otherwise offensive language

If you violate these rules your payment will be forfeited.

After the chat you must choose one of the 11 options from the table below (which will be displayed on your screen during the chat). One of the three decisions in your group will be randomly selected and all group members will be paid according to this decision. This means that each member of your group will earn the same amount. At the end of this stage, you will be informed of each group member's decision and which one of the three group members' decisions has been selected.

You must choose one of the 11 options in the table shown below. The earnings of each member of your group will depend on which of the three group members' choices will be selected and whether card set A or card set B has been selected. You make a choice by selecting a single option and pressing the 'Submit decision' button. You will have 5 minutes to make a decision. Please raise your hand if you have a question.

One of the group members' choices will be randomly selected and implemented for the entire group. Keep in mind that, if this stage has been selected for pay-out, you will be paid according to the selected decision.

Stage IV

In this part of the experiment, you must make another decision, this time individually. You must choose one of the 11 options in the table shown below. Your earnings will depend on your choice and whether card set A or card set B has been selected. You make a choice by selecting a single option and pressing the 'Submit decision' button. You will have 5 minutes to make a decision.

Keep in mind that, if this stage has been selected for pay-out, you will be paid according to the decision you are about to make. Please raise your hand if you have a question.