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ESSAYS ON
GROUP DECISION MAKING
UNDER RISK

Jeroen Nieboer, M.Sc.

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for the degree of Doctor of Philosophy

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Abstract

Economic theory traditionally explains choice under risk through the preferences of the individual, yet many important economic decisions are made by groups. To increase our understanding of the implications of group decisions and enrich our theories accordingly, we need empirical and experimental evidence on groups. Although economists have conducted controlled laboratory experiments on individual choice for many decades, only recently have researchers begun to use the experimental method to study group decisions under risk. This thesis contributes to the study of group decision making under risk by providing a cross-disciplinary review of the growing literature on this topic, followed by three experiments on risk-taking by groups. The first experiment investigates the role of communication and peer effects, the second experiment investigates group composition, and the final experiment focuses on information sharing in groups.

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Chapter 1

Introduction

Controlled laboratory experiments have taught economists a lot about individual decisions under risk, but we know relatively little about the decisions of groups. Although group decisions under risk were much studied in psychology experiments in the mid to late 20th century, the difference in measurement techniques and procedures between psychology and economics experiments, notwithstanding the convergence between psychology and economics in recent decades, makes it hard to assess the importance of this evidence to modern-day economics. Economists have therefore taken to designing their own experiments on group decisions under risk, based on the tasks and procedures from the experimental literature on individual decision making. This thesis presents three such economics experiments on group influence and group decision making under risk, each comprising a chapter with a separate research question. To set the stage, the experimental chapters are preceded by a literature review that outlines the contributions of experiments to the study of group decisions.

In the literature review in chapter two, we organise the experimental evidence on group decisions under risk around three prominent empirical questions: (i) Do groups take more or less risk than individuals, (ii) Are groups more rational risk takers than individuals, and (iii) Does group interaction affect individual decisions under risk? We find that, although measurements of risk-taking by groups and individuals often differ in sequential, within-subject experimental designs, the larger body of experimental evidence

suggests there is no general tendency for group risk-taking to differ from individual risk-taking. Experiments in which risk is represented by lotteries over real monetary earnings mostly find no difference in risk-taking by groups and individuals. There are some experimental designs in which group risk-taking is persistently higher than that of individuals, however, such as the investment task used in chapters three and four of the thesis. Second, there is no evidence that groups are more rational risk takers, in the sense of being less susceptible to decision making biases and violations of Expected Utility Theory, than individuals. This finding might come as a surprise to some, as groups have been documented to out-perform individuals in intellectual decisions and strategic games (Charness & Sutter, 2012). The evidence on decisions under risk, however, indicates that these differences in ability do not necessarily imply that the actions of groups are more in keeping with Expected Utility Theory. Finally, there is ample evidence that group interaction and making decisions in a group affects subsequent individual risk-taking. This finding has implications for economists' perception of the stability of risk preferences in social contexts.

Chapter three presents an experiment that compares risk-taking by groups not only to isolated individuals, but also to individuals who can communicate ('consult') about the task with two other subjects, just like group members. The investment task used for this chapter was selected because prior studies with this design report that groups take significantly more risk than individuals, with evidence suggesting that this difference is due to greater expected earnings maximisation by groups (Sutter, 2007, 2009). We replicate the finding that groups take significantly more risk than isolated individuals. We also find that individuals who consult with others significantly affect each other's risk-taking, as evidenced by significant convergence in consultation groups. But individuals who consult take similar levels of risk as isolated individuals, which supports the notion that pay-off commonality between group members, alongside communication with others, is a distinctive feature of the group decision making process.

Chapter four presents an experiment with the same investment task as chapter three,

in which we compare risk-taking of groups with different cultural compositions. We test the prediction that groups with greater international diversity, as measured by subject nationality and familiarity with the English language, take less risk than more homogeneous groups. This prediction is based on prevalent theories of team diversity from the literature on management decision making (see Jehn et al., 1999), as well as a small body of empirical work (Watson & Kumar, 1992; Nielsen & Nielsen, 2011). Using a regression model that controls for various demographic factors, we find no differences in risk-taking between groups of different levels of international diversity. Using real incentives and a subject pool of university students, whose upbringing, education and international orientation we take to be representative of that of future global business leaders, we thus find no implications of international diversity on group risk outcomes. We do find, however, a strong and significant effect of gender composition on risk-taking: the more female group members, the more risk averse a group is. This gender effect mirrors a common demographic pattern in individual decisions under risk, and also matches the results from an experiment in a finance context (Bogan et al., 2011). Furthermore, we find that the significance and size of gender effect is independent of whether group members communicate face-to-face or by electronic chat on a computer screen. The latter finding suggests that demographic differences in individual risk preferences can explain the gender effect, but conformity to gender stereotypes does not.

Chapter five is an experimental test of group polarisation, a potential outcome of group decisions attributed to the exchange of information between group members (Vinokur & Burstein, 1974). Following recent theoretical work on group polarisation (Glaeser & Sunstein, 2009; Sobel, 2012), we conduct an experiment on group risk-taking that controls for the information that group members receive and can exchange with others. Subjects receive information in the form of private signals correlated with the probability of winning a risky lottery; signals which they can share with fellow group members. We find that, although groups aggregate information efficiently and the vast majority of subjects adjust their risk-taking in the expected direction given their signals, levels of group polarisation are low. For groups in which all members receive identical signals

and for which Bayesian updating predicts a high likelihood of group polarisation, only half of the groups polarise. The lack of group polarisation in these groups is driven by idiosyncratic actions by a single individual in the majority of cases. These findings suggest that polarisation with respect to risk-taking in small groups is highly sensitive to decisions of individual subjects. We also find that the majority of subjects display social preferences over risk by co-ordinating their decisions with fellow group members in a group choice stage, and we find significant spill-over effects of the group choice on subsequent individual choice.

Chapter 2

Group decisions under risk: a review of the experimental literature

2.1 Introduction

Evidence from experiments has greatly influenced economic thinking about decision making by individuals. But in many important settings, the decision maker is not an individual but a group. Examples abound: households planning their finances, corporate management teams deciding on business strategy, government committees involved in policy making. This observation raises the question whether the lessons learned from experiments with individuals also apply to groups. In recent years, economists have started to address the dearth of empirical evidence on group decisions by collecting data on groups in the laboratory. In this review, we focus on those experiments that look at group decisions under risk.

Economists are not the first to use experiments to investigate group decisions under risk; experimental research on groups started with the birth of social psychology in the early twentieth century (Allport, 1924). The social psychology literature on risky choice

includes the discovery of phenomena such as the *risky shift* (Stoner, 1961) and *group polarisation* (Moscovici & Zavalloni, 1969), which have inspired economics experiments in recent times. Because a review of group decisions under risk would not be complete without acknowledging these efforts, we discuss the results from psychology experiments alongside economic experiments.

The experimental evidence in this review is organised around three empirical questions: (i) Do groups take more or less risk than individuals, (ii) Are groups more rational risk takers than individuals, and (iii) Does group interaction affect individual decisions under risk? Each of these questions represents a common thread of inquiry running through part of the experimental literature, and organising the evidence in this way helps us summarise the lessons learned about group decision making so far. This review, therefore, is only comprehensive with respect to studies that contribute to a better understanding of our three questions of interest; this chapter is not an exhaustive review of all experiments on group decisions under risk.

2.1.1 Three questions about group decisions under risk

Most experiments described herein investigate whether risk-taking by groups differs from risk-taking by individuals in a systematic, perhaps even predictable, fashion. We therefore choose this as our first question of interest about group decision under risk. Broadly speaking, the null hypothesis is that groups take just as much risk as individuals, and the alternative hypothesis is that groups take more or less risk. If it were true that, at least for certain circumstances created in the laboratory, groups reliably take more or less risk than individuals, such a finding could be a promising building block for theories on risk-taking outcomes in the real world.¹ Unfortunately, the experimental evidence gathered so far does not support the existence of a simple and

¹A good example of a robust laboratory finding in decisions under risk is the gender effect: women take less risk than men (Eckel & Grossman, 2008; Croson & Gneezy, 2009). This gender effect has also been found outside of the laboratory, for example in investment portfolios held at on-line brokers (Barber & Odean, 2001).

robust pattern. The evidence is mixed, with groups taking less, as much, and more risk than individuals in different experimental settings. It appears that the choice shift paradigm from the psychology literature, in which subjects make group decisions after making individual decisions and earnings are hypothetical, often leads to differences between individual and group decisions. By contrast, most economics experiments with between-subject treatment comparisons and real incentives find no significant difference between risk-taking in groups and individuals. Experiments of the latter kind do yield some interesting findings, however, such as groups reacting more strongly to extremely low and high lottery winning probabilities (Baker et al., 2008; Shupp & Williams, 2008) and groups acting more in line with risk neutrality than individuals (Sutter, 2009). But reports of such findings has not been sufficiently widespread to properly consider them stylised facts.

The second question of interest is whether groups are more rational risk takers than individuals. The origins of this question lie in the many violations of Expected Utility Theory (EUT) detected in experiments on individual decision making under risk. In defence of EUT, some have argued that subjects in laboratory experiments are too poorly motivated or inexperienced to make the choices they would make if the outcome really mattered (see Myagkov & Plott, 1997). Providing subjects with stronger monetary incentives and putting them through practice rounds are two devices that have repeatedly been put forward as ways forcing people to think more carefully about their choices, thus reducing violations of EUT in many experimental settings. It is plausible that decision making in a group also reduces EUT violations, by making people reason about their choices with others (Bone et al., 1999). In a review of group decision making experiments with a focus on cognitive and strategic tasks, Charness & Sutter (2012) note that groups are less likely to be influenced by biases and cognitive limitations than individuals. This pattern does not seem evident in decisions under risk, however. The available evidence, although limited to tests of a handful of EUT violations, does not support the notion that groups are less prone to decisions making biases and EUT violations than individuals.

The third question addressed in this review is whether group discussion or group interaction affects subsequent individual decisions. This question is related to the first question but describes a more subtle effect: even choices not formally delegated to a group may still be shaped by consulting with a group. Decision making based on group consultation is a feature of many important settings, such as organisational decision makers discussing the pros and cons of different options with their subordinates, and politicians being assisted by teams of policy advisors. This question is of particular relevance to economic theory, since economists have traditionally modelled individual decisions under risk as arising from the risk preferences of the individual. If there is strong empirical evidence that social interaction has an effect on individual choices, this provides support for theories that take this social influence into account. The experimental evidence suggests that it is very common for group interaction to affect individual decisions: most of the reported studies find an effect. We also review some results from the growing experimental literature on peer effects, providing evidence that individual risk-taking can be affected by the choices of others choosing at the same time. Economists know little about the thought process that underlies social influence on individual choices in incentivised experiments, which offers exciting prospects for future research.

2.2 Definitions and objectives

2.2.1 What is a group decision under risk?

A group decision under risk is defined as the process by which $g > 1$ individuals in a group select one lottery l out of a set of available lotteries L . In other words, the group members' combined actions in a decision making stage will result in the implementation of lottery l by the experimenter, the outcome of which will determine each group member's earnings. Subject earnings may be real or hypothetical. For any pair of lotteries in the set L , the lottery with the higher variance is considered the riskier option.

Most experimenters design their experiments such that all lotteries in the choice set L can be ranked on riskiness according to their variance. Being able to rank all available lotteries on riskiness, the researcher can use experimental data to test null hypotheses on subjects' tendency to choose the risky over the safe option (for binary choices) or the level of riskiness of subjects' choices (for more than two levels of risk-taking). Some experimenters, such as those working with the Multiple Price List method (Holt & Laury, 2002), also use metrics like the number of safe choices or certainty equivalents for lotteries. Most of the experiments we discuss use metrics of risk-taking to compare group choices to individual choices over the same lotteries. When comparing groups to individuals in an experiment with real monetary incentives, the standard procedure is to ensure that each group member faces the same lottery outcomes as they would have faced if they had chosen the same lottery as an individual - thus avoiding wealth differences between treatments.

The above definition of group decisions under risk leaves undefined the exact link between group members' actions during the decision making stage and the selected lottery. There are, after all, various ways in which a group can arrive at a single decision, and the decision rules of the experiments reviewed here reflect this diversity. Examples of decision rules are unstructured bargaining, formal or informal opinion polls, and voting. Most experiments we review here use unstructured bargaining, and groups are expected to make a consensus decision without interference from the experimenter. Although unstructured bargaining does not permit a clean theoretical prediction of the group outcome without auxiliary assumptions on subject preferences and behaviour, this need not be a problem. We are, after all, not testing game theoretic predictions of group processes. In the context of this review, we are interested in finding stylised facts of decisions under risk in a natural group discussion setting. If and to what extent group decisions under risk are affected by the choice of decision rule is an open empirical question; the experimental evidence gathered so far does not give any clear answers.

Finally, we note that some authors in the experimental literature discussed here refer to

their groups as *teams*. For the sake of clarity and consistency, we shall stick to *groups* throughout this review. In the experimental literature on risk-taking, the terms teams and groups can be used interchangeably.²

2.2.2 A note on experimental methodology

The shared objective of controlled psychology and economic experiments with groups is to collect data that leads to a better understanding of groups in the real world. Despite this common goal, experimental designs in psychology and economics are informed by different methodological traditions. Before discussing findings from both fields, it is worth highlighting a few differences in approach.

Incentives

The use of hypothetical incentives allows researchers to investigate decisions under risk for which collecting real experimental data is too hard, expensive or unethical. But economists are typically sceptical about experimental results obtained with hypothetical incentives (Hertwig & Ortmann, 2001; Harrison & Rutström, 2008). It is unlikely, so the argument goes, that subjects will reveal their actual risk attitudes in response to hypothetical questions, especially in unfamiliar situations like life-or-death decisions or significant financial investments. There is some empirical support for such scepticism. For choices over monetary lotteries, the results of Holt & Laury (2002, 2005) provide evidence that hypothetical and real risk-taking start to diverge significantly when stakes go up, leading to unreliable hypothetical data.

Despite the oft-heard criticism of hypothetical risk attitude elicitation methods, we do

²Other disciplines and sub-fields have more or less agreed definitions that distinguish between groups and teams. An oft-cited definition of a team is Katzenbach & Smith (1992): “A team is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they are mutually accountable”. This definition captures a sense of co-operation that makes a team a more persistent and coherent unit than a group assembled for the sole purpose of making choices in a laboratory task.

discuss many experiments with hypothetical incentives here. Although doubts about the validity of hypothetical methods are certainly relevant when assessing the balance of evidence, this does not seem to justify ruling out experiments with hypothetical incentives altogether. Especially when researchers are exploring a new area of interest, experiments with hypothetical incentives can serve as an affordable way to collect exploratory data, and may inspire other researchers to develop related research questions in more controlled settings. Second, the evidence that one particular hypothetical elicitation method leads to biased data should not lead researchers to suspect all unincentivised elicitation methods. In a recent study, Dohmen et al. (2011) report strong correlations between a simple, unincentivised self-reported measure of risk tolerance and subjects' actual behaviour under risk, including paid lottery choices.

Control and artificiality

It is well documented that experimental economists are typically more concerned about control over experimental variables than psychologists (see Camerer, 1992; Lopes, 1994; Hertwig & Ortmann, 2001).³ Experimental control is seen as important because the specificity of the tested hypotheses increases with the degree of control, leading to cleaner data on the behaviour under study. But experimental control is a double-edged sword. An undue focus on control can lead to experimental designs that are artificial to the point where they no longer resemble the settings they are supposed to shed light on. Consider context as an experimental variable. In economics experiments, it is considered good practice to minimise references to context and present subjects with an abstract representation of a real world setting. This high level of abstraction is a result of economists' desire to control for confounding factors: the biases and norms that awareness of a certain context may trigger in the subjects. For example, an economist might be sceptical of measuring risk attitudes through a gambling task in a casino. Psychologists, on the other hand, have no qualms about studying behaviour in such a

³Camerer, for example, describes the methodology of experimental economics as more "fastidious" than experimental psychology (Camerer, 1992, p. 247).

heavy contextualised environment. The results of experimental studies in casinos may be context-specific and thus not very robust. But if context exerts an important influence on decisions under risk then it is plausible that abstract, context-free experiments on decisions under risk are artificial and lacking in external validity.

Experimental economists have to be prepared to defend the artificiality of their designs. So how big a problem is artificiality in the study of group decisions under risk? Following Schram (2005), we consider artificiality potentially problematic if the researcher's objective is to collect robust empirical facts, whereas it is less important if the objective is to test a theory. It follows that researchers looking to identify whether groups take more or less risk than individuals should be more concerned about producing artificial results than researchers looking to establish whether groups are more EUT rational than individuals.

Ultimately, whether an artificial design translates to a lack of external validity is an empirical question. But the same is true for generalising the results from a highly contextualised or field experiment, such as studies in a casino. When attempting to identify robust empirical facts, the gold standard is to demonstrate that a behavioural regularity exists under comparable institutions in the laboratory and the field. As we will argue in the final section of this chapter, there is a great need for field experiments to complement and inform the work that is being done in the lab. But first we look at the lessons learned from laboratory research so far.

2.3 Question one: do groups take more or less risk?

2.3.1 Choice shift experiments with hypothetical incentives

A seminal and perhaps the most famous attempt to address the question about risk-taking in groups is Stoner (1961), in which subjects' risk attitudes are measured with the Choice Dilemma Questionnaire (CDQ) developed by Wallach & Kogan (1959). The

CDQ contains twelve hypothetical dilemmas like the following:

Mr. A, an electrical engineer who is married and has one child, has been working for a large electronics corporation since graduating from college five years ago. He is assured of a lifetime job with a modest, though adequate, salary. On the other hand, it is very unlikely that his salary will increase much before he retires. While attending a convention, Mr. A is offered a job with a small, newly founded company with a highly uncertain future. The new job would pay more to start and would offer the possibility of a share in the ownership if the company survived the competition of larger firms. Imagine that you are advising Mr. A. Listed below are several probabilities or odds of the new company's proving financially sound. Please indicate the lowest probability that you would consider acceptable to make it worthwhile for Mr. A. to take the new job. (Stoner, 1961, p. 11)

Stoner asks subjects to give an individual recommendation, before putting them into groups and asking for a joint recommendation following a group discussion. It turns out that most groups recommend more risk-taking (they indicate lower acceptable probabilities) than the average of the individual members prior to discussion. This surprising finding was dubbed the *risky shift*, and has been replicated many times since (see Myers, 1982; Isenberg, 1986). But groups do not always advise higher risk-taking in hypothetical scenarios: follow-up studies by Nordhoy (1962) and Stoner (1968) reveal that some choices in the CDQ actually lead to group recommendations that are more cautious. As a result, changes of risk-taking when subjects make group choices after individual choices have come to be described by the more general term *choice shift*. The fact that choice shifts occur in both the risky and cautious directions has been attributed to prevalent social norms for certain CDQ dilemmas (Brown, 1965). Another explanation is provided by the theory of group polarisation (Moscovici & Zavalloni, 1969), according to which a group discussion serves to amplify the attitudes of the average group member.

2.3.2 Experiments with real incentives

Although the measurement of choice shifts with the CDQ has captured much of the attention, a lesser known strand of experimental psychology, its designs much closer to those of experimental economics, developed in the same decade.⁴ Experiments in this alternative strand of research represent risk by gambles over monetary outcomes, often backed up by real monetary pay-offs. And, instead of the sequential within-subject design (individual choice followed by group choice) used in the choice shift literature, these experiments measure group-individual differentials between subjects.

Hunt & Rowe (1960) compare risk-taking in three-man groups and individuals in a between-subject design. Their measure is the amount of hypothetical money invested in different investments, and they find no difference in risk-taking between groups and individuals. A similar result is found by Lonergan & Mc Clintock (1961), who let subjects bet real money on a lottery with a zero expected value and fixed winning probability in three treatments: individually in isolation, individually in the presence of others, or in a four-person group. They find that the size of bets do not differ significantly between the three treatments, and that bets converge to a common norm in both the treatment with individuals in the presence of others and the group treatment. Another experiment with incentives is Zajonc et al. (1968), who let subjects choose between two lotteries with equal expected value but different variance. The outcomes in either lottery are very small, and therefore the experiment is played for 360 rounds: subjects choose individually for 180 rounds, then either continue individually or in three-person groups for another 180 rounds. Zajonc et al. find that groups choose the lottery with lower variance significantly more often than individuals do.

Pruitt & Teger (1969) compare groups with individuals by asking subjects to invest real money in lotteries with expected values of zero. In the group treatment, groups of

⁴It has been suggested, not wholly implausibly, that CDQ experiments have received more attention because their results are more striking. “Since the CDQ has produced the more dramatic findings, it has had greater appeal, and the choice-dilemma paradigm has continued to dominate the field” (Cartwright, 1971, p. 361).

varying size (from three to five subjects) make decisions by verbally reaching consensus. The authors find that groups make significantly riskier choices than individuals. In a follow-up study, Zaleska (1974) remarks that some of the data of Pruitt & Teger (1969) suggests that subjects shift to caution as lottery stakes increase. To test whether this tendency differs between groups and individuals, Zaleska varies the expected value of lottery choice sets in her within-subject experimental design (individual choice first, then group choice). Zaleska reports that groups are more risk seeking than individuals for low expected value bets (such as the zero expected value lotteries used by Pruitt & Teger), but more become relatively more cautious as expected value increases. In other words, group membership strengthens the negative correlation between lottery expected value and risk-taking. A closer look at the data shows that this correlation is largely driven by the risk-taking differential for low value bets - there is no significant difference between group and individual behaviour for higher value bets. This result could be interpreted as evidence that risk differentials between groups and individuals disappear when monetary stakes are high enough to really matter to subjects. Such a conclusion would be in line with the rest of the experimental evidence discussed in this section - most experiments find no significant difference in risk-taking between groups and individuals. In contrast to the literature on choice shifts, measuring risk-taking over real incentives in a between-subject design does not generally reveal differences between groups and individuals. Whether this is due to the use of real monetary incentives or to the experimental decision sequence (within-subject versus between-subject) is an open empirical question.

2.3.3 Experiments with real incentives and risk-reward trade-offs

Experimental work on choice shifts and group attitudes to risk continued after the 1960s, but the main focus of this research shifted from identifying stylised facts to falsifying various theories of group effects. Although the latter objective is interesting in its own right (see Isenberg, 1986; Turner, 1991; Friedkin, 1999, for reviews), it is not the focus of this chapter. Recently, however, renewed interest in the stylised facts

of group risk-taking from economists has inspired a new wave of laboratory experiments.

Most recent experiments have employed the Multiple Price List (MPL) in the configuration used by Holt & Laury (2002).⁵ Baker et al. (2008) use the MPL to compare risk-taking in three-person groups with individuals. The authors report, when comparing risk-taking between subjects, that the number of safe choices made by groups is not significantly different from individuals. However, Baker et al. report a significant interaction effect between the lottery win percentage and group treatment: as the winning percentage increases, groups are more likely to choose the risky lottery than individuals. This result suggests that groups respond differently to outcomes with extreme probabilities: groups conform more to risk neutrality than individuals for choice pairs at the top and bottom of the MPL. Shupp & Williams (2008) also use the MPL to compare groups with individuals. To measure risk preferences, they ask subjects to submit a purchase price for each of the lotteries, rather than choose between a safe and a risky option. The purchase price for a lottery measures the subject's risk preferences - the higher the submitted price for a lottery, the higher the risk taken by the subject. If the submitted purchase price equals the lottery's expected value then the subject is acting as if risk neutral. As in the study by Baker et al. (2008), Shupp & Williams find that the choice pattern reveals a significant interaction effect between group membership and the probability of winning. For low win probabilities, groups are more risk averse than individuals; for high win probabilities, groups are more risk loving. It is remarkable that the interaction effect between group membership and probability of winning is reported by both Baker et al. (2008) and Shupp & Williams (2008). As the lottery winning percentage goes up in the MPL of Shupp & Williams (2008), group decisions

⁵The Multiple Price List is a popular tool for eliciting subjects' risk preferences. It features a list of choices between pairs of binary lotteries: a 'safe' lottery with a small difference between win and loss outcomes and a 'risky' lottery with a large difference between outcomes. Subjects are asked to choose between the safe and risky option in each of ten lottery pairs. Whilst the lottery outcomes are the same for all choices, the probability of winning goes up from 10% in the first pair to 100% in the last pair. The last lottery pair thus features a choice between two guaranteed pay-offs, of which the risky pair is the highest. Researchers use a subject's number of safe lottery choices (or the *switching point* - the pair at which the subject switches from the safe to the risky lottery) as a measure of the subject's risk preferences. In experiments with the MPL, a common finding is that the majority of subjects make more safe choices than a money maximising risk neutral decision maker would, that is to say the majority of subjects is risk averse (Holt & Laury, 2002, 2005).

approach risk neutrality faster than individual decisions. The authors conjecture that incentives play a role: "...group discussion is more likely to facilitate outcomes that are consistent with risk neutrality when the decision costs required to reach this solution are offset by a sufficiently large expected monetary gain." (Shupp & Williams, 2008, p. 274). It seems that experiments with large enough incentive differentials between risk averse and risk neutral behaviour can be used to put this hypothesis to the test.

One experiment with significantly higher incentives than usual campus experiments (average earnings of €45 for one hour and twenty minutes) is Masclet et al. (2009), which uses the MPL to compare three-person groups with individuals. The group decision making stage differs from the aforementioned papers: subjects do not communicate directly, but go through five rounds of computerised unanimity rule voting with a computer-generated random choice in case no winner emerges. Despite this institutional difference, the authors also report a significant interaction effect between group membership and probability of winning percentage, consistent with the results of Baker et al. (2008) and Shupp & Williams (2008). More surprising is the result that groups are significantly more likely to opt for the safe choice than individuals across the ten lotteries. Group decisions in Masclet et al. are more consistent with risk neutrality than individuals in the low winning percentage lotteries, but relatively less consistent with risk neutrality in the high winning percentage lotteries.

Zhang & Casari (2010) conduct a within-subjects MPL experiment (individual choice, then group choice after deliberation) in which each group member submits a preferred choice before the deliberation stage. If all three group members submit the same preference for a given lottery pair choice, then this is taken as the unanimous voting outcome. If there is disagreement, groups can communicate via an on-screen chat window to resolve their differences. Groups have a strong incentive to reach consensus: a non-decision means zero earnings for all group members. Zhang & Casari report that groups are more risk loving than individuals, but only for lotteries in which the risky option coincides with risk neutrality. Furthermore, when there is disagreement between group members'

preferred choices, the majority preference is most likely to prevail if it matches the risk neutral prediction. Lastly, the authors report that the submitted pre-deliberation preferred group choices tend to match individual choices from the first stage. This result suggests that people's choices in groups differ in predictable ways (more risk neutrality) from their individual preferences.

Not all MPL experiments report differences between group and individual risk-taking, however. Deck et al. (2010) use the number of safe choices in an MPL task as a measure of risk preferences, but find no difference between pairs and individuals. The authors report a small difference in the number of safe choices for low winning percentage lotteries (groups make more safe choices), but they cannot reject the hypothesis that the distribution of number of safe choices is the same for pairs and individuals.

Sutter (2007) uses an investment task designed by Gneezy & Potters (1997) to test for *myopic loss aversion* in groups of three subjects.⁶ Sutter finds that groups are less prone to myopic loss aversion and, more important, take significantly more risk than individuals. As a result, group choices are closer to risk neutrality and thus achieve higher expected pay-offs. In a follow-up experiment, Sutter (2009) replicates the result of higher risk-taking by groups and also for groups in which decisions are made by a single group member and communication is limited to a single message to the decision maker. Analysis of the messages sent between subjects in this treatment suggests that expected value maximisation is a major factor behind higher risk-taking in these groups. A similar result is reported in chapter three of this thesis, based on a content analysis of the logged messages of a group discussion by electronic chat.

⁶Myopic loss aversion is a prominent behavioural explanation for the equity premium puzzle, first suggested by Benartzi & Thaler (1995). It is based on the observation that investors who check the value of their investments more frequently (a myopic perspective) are more likely to sell their equity after observing a short-term loss.

2.3.4 Experiments with experienced groups

Most groups in laboratory experiments are formed by randomly allocating subjects to groups at the start of the experiment. Although ad hoc randomised assignment controls for effects arising from biased group composition, it might prevent groups from operating in an efficient manner due to a lack of familiarity between members. Many important settings in the real world feature groups that have been making decisions together for a while; it is interesting to see how decisions in these experienced groups compare to the decisions of their individual members. The experiments we discuss here have investigated the decisions of particularly experienced real world decision making groups: co-habiting and married couples.

Bateman & Munro (2005) ask married couples to make choices between risky lotteries together and individually; one of the choices is picked at random to determine subject earnings. The authors find that couples' choices are significantly more risk averse than either partner in isolation. Because these results cannot be compared to choices of ad hoc laboratory groups, these results do not tell us much about the effect of being married on joint versus individual decisions. The closest to such a comparison is the study by He et al. (2011), who visit the houses of co-habiting student couples with a MPL task to measure risk attitudes. Unlike Bateman & Munro (2005), He et al. do not find that subjects take significant less or more risk for all lotteries when making decisions as couples. In line with the results from the laboratory literature (Baker et al., 2008; Shupp & Williams, 2008), they report that decisions made by couples are more extreme at the top and the bottom of the MPL. As a result, these decisions are more in line with risk neutrality. This result supports the notion that experienced groups make choices comparable to those of ad hoc laboratory groups in simple incentivised decisions under risk. Whether decisions under risk of experienced groups deviate from those of ad hoc groups in more context-heavy settings is, to my knowledge, still an open question.

It is worth mentioning a pair of experimental studies with married couples that investi-

gate a different question: to what extent are a couple's decisions under risk influenced by either spouse? De Palma et al. (2011) let spouses make separate, individual choices between risky lotteries in six rounds, and then bring couples together to make choices between lotteries in an additional six rounds. They find that the distance between the husband's preferred risk outcome and the couple's choice increases over time, whereas the distance between the wife's preferred risk outcome and the couple's choice stays the same. The authors report this finding as suggesting that the balance of power between the spouses changes over the course of the experiment. While De Palma et al. use German couples, Carlsson et al. (2012) employ a similar experimental procedure in rural China. Carlsson et al. report that risk-taking by couples in their subject pool is skewed towards the husband's risk preferences, but that the influence of the husband is mitigated by greater household income, a greater share of the household income earned by the wife, and the wife having communist party membership.

2.4 Question two: are groups more rational risk takers?

2.4.1 Violations of Expected Utility Theory

There is ample experimental evidence that individual decisions under risk often violate the predictions of Expected Utility Theory (EUT) (see Starmer, 2000, for a review). Some scholars have described these violations as decision making errors (Savage, 1972), raising the question whether subjects' decisions can be improved by learning or experience. One way by which subjects' could reduce their error rate is by talking to other subjects, as is the case in groups. This leads to the prediction that groups violate EUT less often than individuals, as suggested by Bone et al. (1999). If the rate of EUT violations decreases when subjects decide in groups, this suggests that EUT is a more relevant model of decisions under risk than experiments with individuals alone would lead one to believe.

The typical structure of an experiment testing for EUT violations is the following. Sub-

jects face two related choices in A-or-B lottery pairs. The lottery pairs are related in the sense that for a particular choice in the first pair, EUT predicts a choice in the second pair. For example, the EUT null hypothesis would have it that choosing A in the first pair implies a preference for B in the second pair. Subjects choosing A or B in both pairs thus constitutes a violation of EUT. A particular cognitive bias or effect usually describes one particular violation (for example, choosing A in both pairs) whereas the usually less common reverse effect (choosing B in both pairs) is a violation of EUT but does not confirm the cognitive bias.

Bone et al. (1999) test for the common ratio effect in pairs of subjects by letting them choose between pairs of lotteries.⁷ The experiment has three stages: subjects first choose individually, then in a pair with another subject, then individually again. Presenting the subjects with four different choice tasks with lotteries of varying probabilities, the authors find that groups display the common ratio effect just as often as individuals do in each of the four tasks. But the data do reveal a difference in risk-taking: groups choose the risky option more often than individuals in each of the four choice tasks. This result is perhaps due to money maximising: taking more risk increases the expected earnings of subjects in every choice task. Groups therefore achieve higher expected earnings than individuals by taking more risk. Bone et al. use data from the first and third stages of their experiment to compare individual decisions before and after the group decision. They find that individuals have not learned to become more EUT-consistent after their group decisions; if anything, their EUT consistency has gone down. This is not hugely surprising, given the fact that groups are just as prone to the common ratio effect as individuals. They also note that, even when compared to the post-group individual decisions, groups still take more risk than individuals.

Bateman & Munro (2005) test for the incidence of the common ratio effect, *common*

⁷The common ratio effect describes people's tendency to prefer a safe lottery when comparing lotteries with high probabilities of winning, but switch to a risky lottery when winning probabilities of both lotteries are scaled down by the same factor (see Allais, 1953; Kahneman & Tversky, 1979).

consequence effect and failure of the betweenness property in married couples.⁸ Spouses first choose individually, then are asked to predict the other person's choices - thus encouraging further reflection on the lottery choices - and, finally, make a choice as a couple. Their results do not show any difference in EUT consistency between subjects choosing as individuals and with their partner for any of the EUT violations.

Rockenbach et al. (2007) test for the common ratio effect, preference reversals and reference point effect in an experiment with groups of three subjects.⁹ For the common ratio and preference reversal effects, they cannot reject the null hypothesis that groups are just as prone to the EUT violation as individuals. Group choices for the reference point effect lotteries, however, have a significantly higher fraction of EUT-consistent choices than individuals. The reference point effect lottery pairs were generated by giving subjects a guaranteed pre-choice endowment in the first pair, whereas the same amount of money was added to all lottery outcomes in the second lottery pair. These results therefore tell us that groups are better than individuals at integrating endowments into lottery choices, thus reducing EUT violations.

Rockenbach et al. (2007) test for preference reversals over lotteries in a controlled economics experiment, without any context. To see to what extent preference reversals affect group decisions in a contextualised setting, we must look to psychology experiments. Mowen & Gentry (1980) devise a product introduction task that features a choice and a selling price elicitation mode. They find that groups display significantly

⁸The common consequence effect is the tendency of people to change preference between lotteries when a lottery probability-outcome combination common to both lotteries is changed. The betweenness property (in EUT and other theories of choice) requires that the utility ranking for a lottery created by probabilistically mixing two other lotteries lies in between the decision maker's preference over those two lotteries.

⁹A preference reversal is the tendency for people's preference ordering over outcomes to depend on the preference elicitation procedure. The original experiments on preference reversals (Lichtenstein & Slovic, 1971) had subjects either make a choice which of two lotteries to play or to submit a selling price for each of the same two lotteries. The result, which has been replicated in many laboratory and field settings (Tversky & Thaler, 1990), is that the lottery which is more popular in the choice task is typically ranked below the other lottery in terms of submitted selling prices. The reference point effect is people's tendency to define outcomes as losses or gains depending on a particular reference point - an important building block of the loss aversion property of prospect theory (Kahneman & Tversky, 1979).

more preference reversals than individuals. Another experiment on preference reversals in groups find exactly the opposite result: Irwin & Davis (1995) report that groups display fewer preference reversals than individuals. It should be noted that the second elicitation mode in Irwin & Davis (1995) was not a selling price task but a matching task in which one attribute of a lottery outcome is adjusted to make up for another attribute.

2.4.2 Framing effects

An oft-cited criticism of EUT as a theory of choice is that it fails to take into account how the options in a decision problem are presented. For example, identical outcomes under risk can be framed in different ways depending on the decision maker's reference point. Tversky & Kahneman (1981) famously showed that subjects' preferences over identical pairs of hypothetical outcomes change, depending on whether options are framed as losses or gains relative to the status quo. These so-called framing effects have been shown to be robust in individuals, and have led researchers to ask to what extent they affect decisions by groups. McGuire et al. (1987) let subjects make individual hypothetical investment choices in loss and gain frames, before putting them in groups and asking them to make the same choices again. They find that groups are more prone to framing effects than individuals, but only if the group discusses the alternatives face-to-face. For groups communicating by electronic computer chat, the strength of the framing effect was similar to individuals. This finding echoes the results of Neale et al. (1986), who use the original framing task from Tversky & Kahneman (1981) and find that groups are more prone to the framing effect if the group members answer the question in the same frame they faced individually beforehand. Paese et al. (1993) and Yaniv (2011) replicate this finding, but also find that the susceptibility of groups to framing effects actually decreases if the groups face a frame different from the frame they saw individually. Finally, Milch et al. (2009), using a slightly modified version of the task used in the previous studies, find that groups are no more or less susceptible to framing effects than individuals. Furthermore, their result holds both for groups whose members have faced the framed questions individually before and groups

whose members see the question for the first time.

In summary, the experimental evidence reviewed here does not suggest that group decisions under risk are more EUT rational, or less susceptible to biases than individuals. None of the controlled economics experiments finds a significant difference in the number of EUT violations, and the evidence from psychology experiments is mixed. The findings discussed above show that, although groups typically perform better and more consistently in probability estimates, strategic reasoning and learning tasks (Charness & Sutter, 2012), their superiority to individuals does not imply that groups display more rational choice behaviour. Unless researchers can identify conditions under which group decisions are more rational, it seems that decision making biases from the literature on individual decision making under risk are equally relevant for group decisions.

2.5 Question three: does group interaction influence individual risk-taking?

2.5.1 Choice shift experiments with hypothetical incentives

We now turn to the final question, which concerns the effect of group interaction on individual decisions under risk, rather than group decisions themselves. Many of the psychology studies in the choice shift literature, discussed in more detail in the earlier section on group risk-taking, have addressed this question by letting subjects taking another individual decision after the group decision stage. The results from these studies indicate that the group choice shift persists in most individual post-discussion decisions (Bem et al., 1965; Wallach & Kogan, 1965; Kogan & Wallach, 1966), although not all in cases (Blank, 1968). Other studies show that active participation in a group discussion is not strictly required for individual decisions to be affected. Choice shifts arise even if subjects merely inform each other of their previous choice (Teger et al., 1970), listen to a previously recorded group decision (Kogan & Wallach, 1967), or witness a group

discussion through a one-way mirror (Lamm, 1967). In summary, the evidence indicates that, in the sequential within-subjects design of the choice shift literature, group discussion strongly affects subsequent individual decisions over hypothetical outcomes. In line with choice shifts in groups, group discussion either decreases or increases risk-taking in subsequent individual decisions.

2.5.2 Experiments with real incentives

The earlier cited paper by Baker et al. (2008) also contains a separate within-subjects treatment: individual choice first, then a three-person group choice, then individual choice again. They report that previous group membership significantly affects individual choices. Groups make more safe choices than individuals, and individual choices in the final stage are more risk averse than earlier individual choices. There is thus a clear order effect: group choice affects subsequent individual choice. Another study with a group decision order effect, but in the opposite direction, is the MPL task of Deck et al. (2010). The authors report that individuals who have already made a decision in a pair are more risk loving than individuals who have not done so. The order effect reported by Deck et al. is not entirely consistent with the theory that risk-taking in groups spills over into subsequent individual decisions, as this stage is statistically identical to first-time risk-taking by individuals in a parallel treatment.

Sutter (2009) uses a modified version of his nine-round investment task to check for order effects of group decisions on individual decisions. Subjects make individual decisions for three rounds, then in a three-person group for three rounds, then again individually for three rounds. Subjects choose significantly higher investments (taking more risk) in groups, and stay at these higher levels of investment in the last three rounds of individual choice. Because higher risk-taking by groups in this investment task has been linked to higher expected value for more risk, it is possible that individuals learn from their fellow group members about the expected return from taking more risk, and therefore choose to mirror the group decision.

2.5.3 Peer effects

A more subtle way in which individuals might be influenced by their reference groups is through so-called peer effects. Peer effects occur when people's individual decisions demonstrably move in the direction of the decisions of others in a reference group. Field studies have shown that peer effects influence people's decisions under risk, for example their demand for insurance (Gine et al., 2008; Karlan et al., 2012) or whether to invest money in a risky asset (Bursztyn et al., 2012). Because peer effects are hard to detect empirically due to confounding factors (Manski, 1993), incentivised laboratory studies are an ideal vehicle for controlled tests of peer effects.

Yechiam et al. (2008) form pairs of subjects and show each of them a real-time broadcast from the other subject's choice screen whilst both subjects are in the process of making a choice between lotteries. The authors find that subjects take significantly more risk when there is mutual observation, but that the effect disappears if only one subject can observe the other. Cooper & Rege (2011) also let their subjects make choices between risky lotteries, and show them feedback on other subjects' choices after each period. They also find evidence of peer effects: subjects are significantly more likely to change their choice of lottery if it deviates from the most popular choice among other subjects, and this social influence on risk-taking in one gamble spills over into other gambles. Similar results are reported by Viscusi et al. (2011), who let subjects observe other subjects' investment amounts in a risky gamble before they make individual decisions. Subjects invest significantly more if they observe others' decisions, and interestingly enough this risk differential does not arise for subjects who choose in groups with majority or unanimity decision rules. Viscusi et al. thus observe a risky shift for peer-observed choice, but not for group choice. This latter finding contrasts with chapter three of this thesis, in which we report significantly more risk-taking of three-person groups compared to individuals in an investment task, but no increased risk-taking by individuals who consult with and view the choices of two other subjects.

In chapter three, we do find that subjects' consultation with other subjects leads to a convergence of investment amounts in each consultation group.

In summary, there is much experimental evidence that prior interaction in groups, and social interaction more generally, has an effect on individual decisions under risk. When the prior group interaction includes an actual group decision, individual choices generally mirror the group decision. When prior group or social interaction does not include a group decision, the interaction can affect individual decisions in several ways. In some cases, prior social interaction leads to shifts in risk-taking; in other cases, social interaction leads to convergence of individual choices towards fellow group members' choices or the group members' most popular choice. Exactly why some conditions lead to choice shifts, while other settings lead to convergence of choices, is unclear. There is evidence that both convergence and choice shifts can occur in the same task: in chapter three of this thesis, we find that choice shifts towards greater risk-taking occur for groups, whereas subjects who discuss their individual decisions' without pay-off commonality display no choice shift but converge to the choices of others in their discussion group. These results show that decisions shaped by group interaction can be fundamentally different from those influenced by peers.

2.6 Discussion and conclusion

In this chapter, we have reviewed the laboratory literature on group decisions under risk with a focus on three questions of interest. The answer to the most often asked question, whether groups take more or less risk than individuals, seems to depend on the experimental design. In between-subjects designs with hypothetical incentives, commonly used in the psychology literature, group choices tend to differ significantly from individual choices. These so-called choice shifts can go either way: groups take either less or more risk than individuals. Individual decisions after group interaction often mirror choice shifts, reflecting a general tendency for experimental subjects to model their

individual decisions after what was previously decided in a group. In within-subject experiments with real incentives, however, choice shifts are rare and groups decisions are typically similar to individual decisions. It thus seems appropriate to say that choice shifts may arise in some settings, but differences between groups and individuals are not a general feature of decision making under risk in the laboratory.

If we want to explain the mixed experimental evidence, economists need to deepen their understanding of the driving forces behind group decisions. Barber et al. (2003) suggest that group decisions are based on ‘good reasons’, which in their experimental stock picking task translates to the observation that groups hold significantly more stocks of widely admired companies. The good reasons hypothesis implies that the reasons behind a group decisions are often specific to the decision context (e.g. stock markets), rather than based on universal features of decision making under risk, such as expected return or risk rates. There is some evidence from between-subjects experimental designs that groups in the laboratory are more risk-neutral than individuals, using expected return as an important decision criterion. Whether the importance of the expected return argument diminishes in more contextualised field settings, is an interesting and relevant empirical question. What the evidence to date does show, however, is that group decisions are not more in line with EUT than individual decisions. Groups display various violations of EUT at the same rate as individuals, and are equally susceptible to contextual biases like framing effects and preference reversals.

The recent literature on group decisions under risk consists mainly of experiments that compare groups and individuals. Although such comparisons are of importance to theory and interesting in their own right, the relevant practical question in many settings is how to get the best decision out of a given group of people. It may be that unstructured group discussion, often used in experiments because it seems the most natural way of letting groups communicate, leads to different outcomes than alternative decision rules. Controlled experiments on different decision making rules and institutions, such as the work on jury decision making (see Palfrey, 2009), are a useful testing ground for sug-

gested improvements to the decision making environment. Jury decision making is a field particularly suitable to experimental study, as decision quality can be evaluated by controlling for information correlated with an uncertain state of the world (the defendant being innocent or guilty). To illustrate: in experiments on jury decision making, the likelihood of a guilty verdict for innocent people is often used as the ‘loss function’ for jury choices. Proposing the relevant loss function in other domains of risk-taking is up to the researcher. For financial risk, portfolio theory suggests that expected return at a given level of risk is a good measure of decision quality. Rockenbach et al. (2007) use this criterion to compare group and individual choices over risky lotteries in their dataset, and conclude that groups are better risk takers than individuals. But other considerations, such as liquidity and a guaranteed minimum return, might (or should) also feed in to investors’ objectives. For decisions taken by management teams, it seems that the preferences and expectations of shareholders should enter into the loss function. For elected representatives, the preferences of their constituents should matter.

Another under-explored theme in the recent experimental literature is the effect of group composition on decisions. If a decision is going to be made by a group, what kind of individuals do we want the group to consist of? The empirical literature on management diversity suggests that management teams function better, and are more inclined to take risks, when team members are from similar social categories but diverse in terms of their functional background (see Van Knippenberg & Schippers, 2007; Nielsen, 2010). These empirical studies do not correct for confounds arising from company-specific factors that may simultaneously affect the riskiness of corporate strategy and the diversity of its management team. Such confounding factors can be excluded in controlled experiments on group composition, but there are few such experiments. Watson & Kumar (1992) find that cultural diversity decreases risk-taking in a series of hypothetical risk scenarios, and others find that groups with more males take more risk in an incentivised investment task (Bogan et al., 2011, see also chapter four of this thesis) . It is particularly interesting to investigate whether careful group composition can mitigate the extent to which group decisions are captured by vested interest, social norms and

prevailing wisdom. As demonstrated by the recurrent nature of asset bubbles and the financial crises that they can lead to, the decisions of groups that reason myopically and ignore the bigger picture can do great damage to their organisations and countries.

Experiments typically focus on a single function of groups, whether it be information aggregation, specialisation and task distribution, insurance, greater bargaining power, or a source of social identity and support. But groups and teams in the real world often serve multiple purposes. Indeed, popular measures of group performance typically correspond to a point-by-point evaluation of how well a group or team performs a subset of these functions. In influential work in the management literature, Katzenbach & Smith (1992); Katzenbach et al. (1993) define a taxonomy of (i) teams that recommend things, (ii) teams that make or do things, and (iii) teams that run things, and suggest that each type of team has to respond to different challenges. Furthermore, they distinguish between working groups and teams, a theme that has so far not been picked up by the experimental literature. According to their definition, working groups, like randomly assembled groups in the laboratory, are focused on individual accountability and results rather than joint responsibility. This means that working groups may make fundamentally different decisions than teams, especially when decisions have an element of risk and thus potentially negative consequences. There is a big opportunity for experimental work to identify how team risk-taking is affected by a team's official, unofficial, and perceived functions and objectives.

More generally, the multiple functions and objectives of groups in the real world pose a modelling challenge for controlled laboratory settings. If the researcher wants to test the combined effect of various supposed functions of groups on decision making, or if the researcher is interested in investigating group decisions in an environment with the greatest external validity, field experiments might yield more reliable data than laboratory work. The work on the risk preferences of married and co-habiting couples, discussed earlier, is an example of attaining greater external validity through a different subject pool (artefactual field experiments, following the taxonomy of Harrison &

List (2004)). Another way of bringing experimental research closer to reality is to use framed field experiments: subjects make contextualised decisions, like the experiments of Bogan et al. (2011) on stock investment. Field experiments that are both framed and artefactual are effectively full simulations of real decisions. But researchers can go further than simulation. In many organisations, government or business, a great number of routine decisions are taken by groups of people on a daily basis. If data on these decisions is collected in a systematic way, and confounding factors are controlled for, researchers can use such data to learn more about group decisions. For example, by varying the format and type of information supplied to teams in charge of managing risky assets, researchers can assess the effect of information on group decisions. An organisation can thus learn about how its procedures for information management affect the risk taken on behalf of the organisation, and discover ways of mitigating excessive risk-taking. Alternatively, some organisations actively encourage risk-taking by their staff in order to stimulate innovation. Many of these organisations have working groups and teams dedicated to technology and product development. Systematically monitoring the effectiveness of different group characteristics, decision rules and procedures could provide valuable insight into how groups can be encouraged to take the right kind of risks.

Chapter 3

Risk taking in social settings: group and peer effects

3.1 Introduction

The standard economic approach to the analysis of choice under uncertainty emphasises the role of individual risk preferences. In deciding how much to invest in a risky asset individuals weigh up the costs and benefits referring to these preferences. In contrast, in many important real-world settings individuals do not take choices in isolation, and the social settings within which choices are made may influence behavior. For example, individual choices may be swayed by the opinions and decisions of others. In this chapter we investigate how consultation with others and group decision making affect choices under risk in a controlled laboratory setting. There is abundant evidence from the field that people's choices are often influenced by their social networks. So-called *peer effects* have been found in a number of settings, including, in the context of choices under risk or uncertainty, investment decisions (Kelly & Grada, 2000; Hong et al., 2004; Brown et al., 2008), entrepreneurship decisions (Nanda & Sørensen, 2010; Lerner & Malmendier, 2011; Falck et al., 2012) and credit-funded consumption decisions (Sotiropoulos & D'astous, 2012).

While field studies can provide compelling evidence of correlations between pairs of individual decisions, identifying these as peer effects is complicated by confounding factors (Manski, 1993). For example, correlations may reflect an unobserved characteristic that is shared by the two individuals. Moreover, it is difficult to assess the influence of peer effects from field data, as naturally occurring control treatments where peer effects are absent but other variables are held constant are typically not available. For these reasons we use a controlled experiment to investigate the effect of social settings on choice under uncertainty. In our experiment subjects make investment decisions over multiple periods with feedback after each period. In our two *consultation* treatments subjects are allowed to freely communicate with their peers before making a decision. However, each subject's earnings depend only on his or her own choices and not on the choices of others. We use this framework because direct communication between peers is an important feature of many settings where peers may influence one another. This framework contrasts with related laboratory studies of peer effects in which subjects are informed of each other's choices and may be influenced by these, but there is no direct communication between subjects (for example, Yechiam et al., 2008; Cooper & Rege, 2011).¹ In order to control for the influence of others' choices we vary the degree of feedback we offer to subjects across the two consultation treatments. In one treatment they are fully informed about the choices of others in their group while in the other treatment they do not receive such feedback.

Our experiment is also related to experiments where subjects give and take advice (see Schotter, 2003, for a review). However, our framework departs from these studies in that we do not incentivise giving advice. Instead, the only motivations for our subjects to give or take advice are intrinsic motivations independent of financial consequences (as in many examples of peer advice in everyday life). Also, our subjects face the same task at the same time as their peers, whereas in other experiments on advice the experimental design induces differences between the experience and/or expertise of advice

¹The direct peer effects that we analyse are a special case of what Cooper & Rege (2011) call *knowledge spillovers*: subjects can share information directly with others, instead of only observing others' choices and inferring information from them.

givers and takers.

We compare our consultation treatments to two benchmark treatments, one where decisions are made by isolated individuals and one where decisions are made by groups. These benchmark treatments replicate previous findings of higher risk-taking by groups relative to isolated individuals (Sutter, 2007, 2009). Our consultation treatments enable us to assess how much of the higher risk-taking in groups can be attributed to communication between subjects. We find that consultation does not increase average investment beyond that observed among isolated individuals. Thus, direct communication alone cannot explain the higher risk-taking observed when decisions are made by groups. This result underlines the importance of common pay-offs for the divergence of individual and group decisions under risk. We do, however, find evidence of peer effects in our consultation treatments. Within consultative groups, variability in choices is significantly lower than the variability in choices between individuals from different groups. Thus, decisions in consultative groups tend to be closer together than the choices of isolated individuals. While this convergence in decisions is not necessarily surprising when subjects receive feedback about the decisions of other subjects in their group it is also observed when such feedback is absent.

Because all group and consultation communication in our experiment is mediated by an electronic chat protocol that stores all messages, we can also use content analysis to investigate what drives risk-taking in our consultation and group treatments. We find that decisions made by groups involve more discussion and more effective arguments for expected earnings maximisation compared to choices of consulting individuals. These results suggest that risk-taking in the two settings are motivated by different considerations.

3.2 Related literature

Peer effects have been observed in a wide array of choices under uncertainty, including saving and investment decisions (Kelly & Grada, 2000; Duflo & Saez, 2003; Hong et al., 2004; Brown et al., 2008), use of credit cards (Sotiropoulos & D’astous, 2012), criminal activity (Fergusson et al., 2002; Bayer et al., 2009), drug and alcohol use (Fergusson et al., 2002; Duncan et al., 2005; Powell et al., 2005; Lundborg, 2006; Clark & Lohéac, 2007). Compared to the long history of empirical and field studies, the use of laboratory experiments to identify peer effects is a recent development. Experiments have shown the existence of peer effects in labour productivity experiments (Falk & Ichino, 2006; Mas & Moretti, 2009; Bellemare et al., 2010) and effort provision in gift-exchange games (Thöni & Gächter, 2011; Gächter et al., 2012a,b).

There is also some experimental evidence of peer effects on individual decisions under risk. Yechiam et al. (2008) let subjects make binary choices under risk on a computer while looking at a real-time broadcast from another subject’s choice screen, thus exposing subjects to each other’s choices and outcomes. The authors report that mutual observation in pairs leads to higher risk-taking, but this effect is not observed if only one of the subjects in the pair observes the other. Cooper & Rege (2011) test for peer effects in a series of binary choices under risk and ambiguity, using feedback about other subjects’ choices as the channel for peer influence. They find that subjects are significantly more likely to change their response if it deviates from the majority choice of peers. Cooper & Rege also report that the peer influences of the majority opinion spills over into other gambles: if subjects observe the majority of their peers choosing the risky option in one choice, this makes them more likely to choose the risky option in other choices. Finally, the authors show that the peer effects are consistent with a model of *social regret*, the idea that obtaining a poor outcome from a gamble does not hurt as much if others have chosen the same gamble.

There are two reasons why subjects might be influenced by their peers in our experiment

(for a broader review of social influence mechanisms, see Cialdini & Goldstein (2004)). The first reason is social learning: people believe that their peers' choices are based on better information or superior cognitive appraisal of the decision to be made. The second reason is social utility: people derive positive utility from choosing the same action as their peers. Both of these mechanisms can operate at the conscious or sub-conscious level of decision making. In a field experiment facilitated by a Brazilian brokerage firm, Bursztyn et al. (2012) find that the percentage of investors participating in a certain investment increases from 42% to 71% if they learn that another investor, with whom they have been randomly paired, has expressed a wish to invest. If the investor they are paired with actually participates, this percentage increases further to 93%. Bursztyn et al. interpret their results as providing evidence that peer effects in their experiment are comprised of both social learning (knowledge that a peer investor would invest in the same asset) and social utility (knowledge that a peer investor has actually invested in the same asset).

3.2.1 Advice

Direct communication between subjects has been investigated in a number of experimental studies. Schotter (2003) reviews experiments in which subjects receive recommendations from peers that have faced the same task. He presents evidence that advice changes behaviour in ultimatum games (Schotter & Sopher, 2007), coordination games (Schotter & Sopher, 2003) and sequential guessing games (Çelen et al., 2010). The latter study also contains the striking result that subjects are more likely to follow another's recommendation rather than copy their action, although both variables have the same informational value. Chaudhuri et al. (2006) present evidence that advice leads to higher contributions and less free-riding in a public goods game. Kocher et al. (2009) find that receiving advice from peers in a beauty contest game is more effective than observational learning for improving performance. Schotter (2003) claims that advice increases efficiency or rationality because "the process of giving or receiving advice forces decision-makers to think about the problem they are facing different from the way

they would do if no advice were offered.” The possibility of our consultation treatment having such an effect is particularly intriguing. Previous experimental results with our experimental set-up have indicated that groups take more risk than individuals, and that discussion of the higher expected earnings associated with risk-taking is an important factor behind the increased risk-taking (Sutter, 2007, 2009).

The advice in the studies cited above is intergenerational and incentivised. Subjects playing in period t give advice to subjects playing in period $t+1$, and advisors receive an additional pay-off that depends on the performance of their advisee. In our experiment, we do not incentivise giving advice. There is some evidence that unincentivised peer advice works in the laboratory, but also some results that suggest that incentives matter. Charness et al. (2010) report that subjects perform significantly better in a probability reasoning task after they discuss the task with fellow subjects. In an experiment with choice under ambiguity, Keck et al. (2012) present evidence that individual choices become more ambiguity-neutral after subjects discuss the experimental task in a group. In a similar experiment, Charness et al. (2012) also find that consultation increases the percentage of ambiguity-neutral choices by individuals; the authors claim this is due to ambiguity-neutral subjects possessing a “persuasive edge” over others (Charness et al., 2012, p. 14). The authors also report that the effect of consultation on choices is stronger when subjects in a consulting pair are incentivised for each other’s choices.

3.3 The experiment

In all our treatments we use the investment task introduced by Gneezy & Potters (1997). The decision-maker receives an endowment of 100 pence and chooses how much to invest in a risky asset. With probability $2/3$ the asset bears a zero return, and the decision-maker earns that part of her endowment that was not invested. With probability $1/3$ the asset returns 3.5 times the investment, and so the decision-maker earns her endowment plus 2.5 times her investment. That is, if the decision-maker invests x her earnings in

a round are given by

- $100 - x$ pence with probability $\frac{2}{3}$
- $100 - x + 3.5x = 100 + 2.5x$ pence with probability $\frac{1}{3}$

This task is repeated over nine rounds, with the asset returns determined by independent draws at the end of each round (using a computerised random number generator).

An expected earnings maximizing (risk-neutral) decision-maker would invest the full endowment ($x = 100$), yielding expected earnings of £1.17 in every round. More generally, expected earnings are strictly increasing in x . The amount invested in the risky asset is used as a measure of risk-taking.

3.3.1 Treatments

Our experimental design comprises four treatments: one treatment where isolated individuals make choices under risk (IND), one treatment with group choices (GRP) and two treatments with individual choice after consultation (CONS1 and CONS2). Treatments IND and GRP are replications of Sutter (2009); treatments CONS1 and CONS2 are novel treatments. To allow for a faithful replication of the results of Sutter (2009), we used his instructions, software, experimental parameters and incentive structure for the IND and GRP treatments, and used these as the basis for the new consultation treatments.²

²Instructions were taken from the English translations provided in the original paper. The software was a set of a Z-Tree (Fischbacher, 2007) treatment files, downloaded from the journal website at http://www.e-aer.org/data/dec09/20080341_data.zip and translated to English. There is one technical difference between Sutter's original software implementation and ours: whereas the original experiment uses separate chat software, we use the built-in electronic chat function of Z-Tree (version 3.3.8). Regarding incentives, we effectively replace the €-sign with a £-sign for our two payment variables: the show-up fee ($\text{€}2 \rightarrow \text{£}2$) and round endowment ($\text{€}1 \rightarrow \text{£}1$). This means that incentives in our experiment are higher. Using the Economist's 'Big Mac index' (<http://www.bigmacindex.org>) as a proxy for PPP, we estimate that the purchasing power of £1 in 2012 is 25% higher than €1 in 2008.

In treatment IND subjects are not allowed to communicate with each other and they do not receive feedback about others' choices during or after the experiment. In treatment GRP, groups of three subjects are randomly formed at the start of the experiment. Group composition is fixed for the whole experiment. In each round, group members can use an on-screen electronic chat to arrive at a consensus decision for the amount x . At any point during the chat, group members can submit a consensus decision by each entering the same amount x on their decision screens. If the values of x submitted by the three members are not the same, there is no consensus choice for the round and all group members receive nothing.³

As in treatment GRP, subjects in treatments CONS1 and CONS2 are randomly assigned to groups of three subjects that stay together for the whole experiment. The decision screen in treatments CONS1 and CONS2 also features an electronic chat between the group members, but the chat is used for consultation instead of reaching a consensus. This means that subjects in the same consultation group are not required to agree with others' choices, or even participate in the chat. We thus have an individual decision-making structure, plus consultation. At the end of the round, each subject sees a feedback screen reminding them of their own choice and informing them of their own earnings (as in IND). Subjects in treatment CONS2 are also shown a second feedback screen, which displays the choices and round earnings of all three members of their consultation group. Thus the difference between consultation treatments lies in the feedback received on the choices and earnings of other members of the consultation group. CONS1 is more similar to the IND benchmark treatment, in that it gives no information on the earnings and choices of others, and simply adds consultation, while CONS2 is more like the GRP benchmark treatment, in that it gives this information about other group members, and simply removes the group consensus feature.

³The same tie-breaking rule was used in Sutter (2009), and it is very effective in motivating subjects to reach consensus. Only 6 out of 378 decisions in our treatment GRP failed to produce a consensus decision, and never more than once per group. In each of these 6 cases, two group members agreed on the group choice but the third member submitted a different value. We use the majority choice as the data point in these cases, noting that our results are not affected by excluding these observations.

3.3.2 Procedures

All experimental sessions were carried out in a computerised laboratory. We used ORSEE (Greiner, 2004) to recruit our subjects. Subjects were (mostly undergraduate) students from various disciplines, who had previously registered for participation in economic experiments. Altogether, 462 subjects took part in the experiment: 69 participated in treatment IND, 144 (48 groups of 3) participated in treatment GRP, 126 (42 groups of 3) participated in treatment CONS1 and 123 (41 groups of 3) participated in treatment CONS2.

In all treatments subjects sit at computer terminals separated by dividers and are not allowed to communicate with one another (except through the experimental software in the relevant treatments). Subjects are given instructions (reproduced in the appendix to this chapter) that are read aloud. Subjects then make decisions over nine rounds, with the results of the lottery, their resulting round earnings, and accumulated earnings up to and including the current round given in a feedback screen at the end of each round. Subjects in CONS2 also received an additional feedback screen displaying the choices and earnings of other group members at the end of each round.

To resolve the lottery we assigned each individual/group a type at the beginning of the session, with equal numbers of subjects given each of the three possible types: type 1, 2, and 3. At the end of each round subjects of one given type were successful in the lottery, depending on the realisation of a computerised random number draw. In the consultation treatments all members of a consultation group had the same type, and thus either all members of a consultation group received a zero return on their individual investments, or all members received the positive return. Thus, the consultation treatments are similar to the group treatment, except that members of consulting groups make individual decisions.

After the final round, subjects complete a questionnaire and are paid. Each subject is

Table 3.1: Percentage of endowment invested

	IND (n=69)	GRP (n=48)	CONS1 (n=42)	CONS2 (n=41)
All rounds (x_{R1-9})	39.7	51.3**	41.4	41.6
Rounds 1-3 (x_{R1-3})	39.3	48.7**	38.9	40.2
Rounds 4-6 (x_{R4-6})	42.4	51.8*	40.5	39.0
Rounds 7-9 (x_{R7-9})	37.3	53.5**	44.8*	45.4*

Asterisks denote significant differences from treatment IND at the 10% (*), 5% (**), 1% (***) level, based on two-sided Mann-Whitney U tests. For IND the unit of observation is the individual. For GRP we take the consensus decision agreed by all group members. For the consultation treatments we take the average choice of the three group members as the unit of observation.

paid their full earnings for all nine rounds, plus a show-up fee of £2. Average subject earnings (including a show-up fee) were £11.71, with an average session time of 35 minutes.

3.4 Results

3.4.1 Average investment levels

Table 3.4.1 lists average investment in all treatments, averaged over all 9 rounds and also reported in blocks of three rounds, as Sutter (2009) does for his individuals and group treatments. Pair-wise comparisons between the IND and GRP treatments reject the null hypothesis of equal distributions, whether we focus on the average across all rounds or the average in three-round blocks. This replicates Sutter’s group effect: risk-taking is higher in groups than among isolated individuals.

As noted in the previous section, CONS1 is identical to the IND treatment, except that it allows for direct communication within consultation groups. We find that the opportunity to communicate directly with others in a similar position has a very weak effect on average risk-taking, with a significant effect only in the last three rounds. As discussed above, previous experiments have shown risk-taking to be sensitive to whether subjects observed others’ choices and earnings, and so we also conducted a consultation

treatment in which an additional feedback screen informed subjects of all choices and earnings within the consultation group (CONS2). Still, we observe significant differences between average investments in IND and CONS2 only in the last three rounds. In fact, average investments are not significantly different between CONS1 and CONS2 ($p > 0.100$ in any comparison).

3.4.2 Within-group variability

By design, subjects in the IND treatment cannot influence one another's choices. Presumably their decisions reflect their own personal perceptions of the decision task and their individual risk attitudes. At the other extreme, in the GRP treatment there are strong incentives for groups to reach consensus decisions. Thus, it may not be surprising if individuals submit choices that conflict with their own risk preferences, since consensus will very likely require compromise. What about the consultation treatments? Here subjects are free to make the same kind of choices they would make were they isolated individuals, but at the same time they may be influenced by the messages sent by other subjects, or, in CONS2, by the actual choices and earnings of other members of their consultative group.

Although we find that consultation has a weak effect on the average level of risk-taking, we do find evidence that consultation influences other aspects of behavior. Taking each subject's average investment across the nine rounds as the dependent variable, we run a simple OLS regression on group dummies. The group dummies are jointly significant in both consultation treatments (CONS1: $F(41, 84) = 2.63$, $p = 0.000$; CONS2: $F(40, 82) = 1.94$, $p = 0.006$). The explanatory power of group dummies reflects the fact that the decisions of members of a consultative group are more similar than the decisions of isolated individuals.

For a non-parametric approach we apply Fisher's randomisation technique to the average within-group standard deviation of average investments. First, we compute the

within- group standard deviation (WGSD) of the individual averages for each consultation group. To illustrate the bounds for WGSD, consider a consultation group where two members invest zero in each round and a third member invests 100 in each round. The average investment in this group is 33 and the WGSD is

$$WGSD(0, 0, 100) = \sqrt{\frac{(33\frac{1}{3} - 0)^2 + (33\frac{1}{3} - 0)^2 + (33\frac{1}{3} - 100)^2}{n - 1}} = \sqrt{\frac{\frac{10000}{9} + \frac{10000}{9} + \frac{40000}{9}}{2}} \approx 57.7$$

We then took the average WGSD in our consultation treatments (19.4 in CONS1; 20.8 in CONS2) and compared it to the distribution of test statistics generated using Fisher's randomisation procedure.⁴ For both treatments we reject the null hypothesis that WGSD in the consultation groups is from the same distribution as that of randomly formed three-person groups without interaction (CONS1: $p = 0.001$; CONS2: $p = 0.000$). We thus find that consultation leads to significantly lower variability of investments between the three members of a consultation group, providing strong evidence that individuals do not choose independently of one another after consultation.

One possible mechanism behind this peer effect is that intra-group correlation develops across rounds, perhaps as a result of common shocks in the lottery outcomes.⁵ To control for this possibility we consider choices from the first round only. Since the only difference between the consultation treatments is the feedback at the end of a round, we pool the first-round data from the two treatments. Group dummies are again significant in a regression of individual investments ($F(82, 166) = 1.31, p = 0.075$), and the randomisation test again detects significant within-group correlation (average WGSD = 22.7, $p = 0.029$). If we exclude the 47 consultation groups that do not chat in round one the effect is even stronger ($F(35, 72) = 1.70, p = 0.030$; average WGSD =

⁴We drew 100,000 samples of individual averages from the empirical distribution, randomly assigning individuals to groups and counting the proportion of statistics exceeding the observed statistic. More details on the properties of this statistical procedure, as well as comparisons to commonly used parametric and non-parametric techniques, can be found in Moir (1998).

⁵Recall, in order to enhance comparability between our consultation and group treatments all consultation group members were of the same type and so the return on investment was either zero for all members of a consultation group or positive for all members.

20.8, $p = 0.001$). Thus, communication within consultation groups leads to a degree of convergence in risk-taking decisions even in the initial round.

3.4.3 Communication content analysis

Communication within groups has very different effects on levels of risk-taking in the group and consultation treatments. To gain an understanding of why this is so, we examine the messages sent via the electronic chat communication. Two trained research assistants assigned individual chat lines to one or more of the following categories:

- **Amount.** A suggestion of investment amount x (or range of values) for the current round.
- **Cautious.** A statement that signals the individual's preference to take less risk by decreasing x .
- **Emotive.** A message indicating an emotional response to events in the experiment.
- **EV.** Calculations of expected value for values of x .
- **Off-topic.** A message that does not relate to the experimental task.
- **Risky.** A statement that signals the individual's preference to take more risk by increasing x .
- **Team building.** A message referring to the group itself, individual group members, its shared strategy or group members' common fate.

Our research assistants received the same instructions but worked independently. Their assignments of statements to categories were cross-checked for validity by calculating Cohen's Kappa coefficient (Cohen, 1960) for each category. A high Kappa coefficient indicates a high proportion of agreement between the two assistants' category judgments. Following Landis & Koch (1977), we employ a threshold Kappa value of 0.41,

Table 3.2: Kappa values and average frequency (per group) for chat message categories.

Category name	Description	Cohen's Kappa			Category frequency		
		GRP	CONS1	CONS2	GRP	CONS1	CONS2
Amount	Proposal of a specific amount	0.857	0.926	0.905	17.1	3.1	2.8
Emotive	Emotive response	0.859	0.938	0.859	14.0	3.8	2.8
EV	Expected value	0.703	0.759	0.820	2.0	0.3	0.3
Cautious	Appeal to take less risk	0.695	0.903	0.651	2.8	0.8	0.3
Off-topic	Off-topic	0.898	0.904	0.847	6.9	5.3	2.9
Risky	Appeal to take more risk	0.584	0.885	0.721	3.2	0.8	0.4
Teambuilding	Reference to group identity	0.658	0.877	0.825	5.0	3.6	1.8
Average number of messages sent per group					161.0	49.6	36.7

indicating at least moderate agreement between our research assistants. Table 3.2 shows the treatment-specific Kappa values for each category, as well as the average number of times a message in the category was sent in a group. We see that all of our content categories exceed the threshold Kappa value of 0.41. For each category, we report the number of messages in that category sent per group.⁶

Note that there are considerably fewer messages sent in the consultation treatments compared to the GRP treatment. This is not too surprising given that groups had to find a consensus decision in the GRP treatment. Note also that fewer messages are sent in the CONS2 treatment than the CONS1 treatment.

To examine how the content of messages influenced average investment we use a Tobit regression where the dependent variable is the average investment in a group and with the average number of messages in each category as explanatory variables.⁷ The results are reported in Table 3.3.

Coefficients for message categories Risky and Cautious have the signs one would expect: Risky is positively correlated with investment (although not significantly in GRP or CONS1), and Cautious is negatively correlated with investment. The coefficients

⁶A chat message belongs to a category if it was coded as such by at least one of our research assistants.
⁷The regression models were also estimated with dummies for group composition demographics (age, gender, and number of economics/business students). These variables were always insignificant and do not affect our results.

Table 3.3: Tobit regression of average investment on content variables

	(GRP)	(CONS1)	(CONS2)
- amount	0.922 (1.046)	1.560 (0.934)	0.112 (0.665)
- cautious	-4.801*** (1.768)	-5.660* (2.921)	-5.650** (2.687)
- emotive	0.814* (0.484)	1.020 (0.803)	0.624 (0.474)
- ev	4.164*** (1.468)	2.004 (1.870)	6.183* (3.438)
- risky	0.617 (1.402)	0.843 (2.455)	6.722* (3.423)
- offtopic	0.443 (0.265)	0.0112 (0.152)	-0.680 (0.436)
- teambuilding	-0.739 (0.733)	-0.330 (0.713)	-1.330 (1.143)
Number of observations	48	42	41
Prob > χ^2	0.00123	0.0491	0.0303
Pseudo R^2	0.0548	0.0386	0.0437

Standard errors in parentheses, asterisks denote significance at the 10% (*), 5% (**) and 1% (***) level. Table contains Tobit model regression results (lower bound: 0, upper bound: 100) of a group (treatment GRP) or 3 consulting individuals (treatments CONS1 and CONS2) on content analysis variables. Content analysis variables represent the count of the messages in the named category exchanged between the 3 members over all rounds of the experiment.

on EV are positive and, except for CONS1, significant: more messages referring to expected value in any round are associated with higher investment. This result is in line with the hypothesis that higher investment by groups is associated with expected value maximisation, as observed in the communication data evidence presented by Sutter (2009). The lack of an effect of consultation on levels of risk-taking may be because discussion of expected value has a weaker effect than in the GRP treatment (note that the coefficient is smaller and insignificant in CONS1, and although higher in CONS2 the coefficient is significant only at the 10% significance level), or it may be simply because there is less discussion of expected value (see Table 3.2).

3.5 Discussion and conclusion

Using a simple investment task we compare choices under risk by three types of decision-maker: isolated individuals, groups, and individuals who can consult each other. In line with previous research using the same investment task (Sutter, 2009), we find that groups take more risk than individuals. When individuals can consult one another we find that communication among peers leads to significant correlation of decisions within the consultation group. However, consultation has a relatively weak effect on the level of risk-taking. Average risk-taking in our consultation treatment is similar to the average risk-taking of isolated individuals. This underlines the importance of pay-off commonality for the increased level of risk-taking observed in group decisions.

Although consultation groups can discuss the task in the same way as group decision-makers, content analysis reveals some important differences between treatments. Perhaps most importantly, subjects in the consultation treatment exchange fewer messages than in the group treatment, including messages discussing expected values. This may explain why consultation fails to increase average investment, since mentions of expected value have a strong effect on average investment in the group treatment. These results suggest that having to make a group decision under risk is quite different from

giving people the opportunity to communicate with peers. Pay-off commonality within groups leads to a different discussion and decision-making process.

Our consultation treatments were designed to isolate the effect of unincentivised communication between peers. If subjects had been financially motivated to provide others with investment advice - for example, if they had been paid a percentage of others' earnings - it is plausible that consultation would have a stronger effect on the level of investment. Similarly, we chose not to direct subjects to use communication in any particular way. If we had made it mandatory for subjects to justify their choice to their peers, this might induce them to think differently about the task (and perhaps about the expected value of their choices), and may have resulted in a higher level of investment. Thus, our finding that consultation does not translate into higher levels of investment than are made by isolated individuals may reflect particular features of our design. Nevertheless, it is notable that even in our relatively simple consultation setting subjects' decisions are influenced by their peers, as evidenced by the convergence of investment decisions within consultation groups. Further investigation of how features of the social setting influence risk-taking among peers seem a promising direction for future research.

Appendix A: Experimental instructions

Treatment IND

This experiment consists of 9 rounds. In each round you will receive an endowment of 100 pence (1 pound). You must decide which part of this endowment (between 0 pence and 100 pence) you wish to invest in a lottery. The investment will be denoted as amount X .

The outcome of the lottery is as follows:

- With probability $2/3$ (66.67%) you lose the amount X you have invested and your pay-off in the respective round is $\text{Pay-off} = 100 - X$ pence
- With probability $1/3$ (33.33%) you win two and a half times the amount X you have invested in addition to your initial endowment and your pay-off in the respective round is $\text{Pay-off} = 100 + 2.5X$ pence

The actual outcome of the lottery depends on a randomly drawn number out of the uniformly distributed interval $[0, 3]$ and on your type. There are three possible types: type 1, 2, and 3. In the first round, you will be informed about your type, which remains fixed for all 9 rounds.

- Type 1 wins if the random number in a given round is from the interval $[0, 1]$
- Type 2 wins if the random number in a given round is from the interval $(1, 2]$
- Type 3 wins if the random number in a given round is from the interval $(2, 3]$

The random number in a given round is identical for all participants in the experiment and it will be independently drawn anew in each consecutive round. After all individuals have entered their decision, you will be informed about the outcome of the random number draw, about whether you have won or lost in the respective round, about your round pay-off and your accumulated pay-off in the whole experiment. For your final

earnings, we will add up your pay-offs in all 9 rounds.

In each round, you have 3 minutes to submit your decision. Please do not communicate with other subjects at any point during the experiment. Anybody found in breach of this rule will be dismissed without payment.

Treatment GRP

At the start of this experiment, you will be randomly matched with two other individuals in the room to form a team of three. Team members will remain anonymous – no-one will find out who their fellow team members are during or after the experiment.

This experiment consists of 9 rounds. In each round your team will receive an endowment of 100 pence (1 pound). Your team must decide which part of this endowment (between 0 pence and 100 pence) you wish to invest in a lottery. The investment will be denoted as amount X . Within your team, you have to agree on a single choice of the amount X .

The outcome of the lottery is as follows:

- With probability $2/3$ (66.67%) you lose the amount X you have invested and your pay-off in the respective round is $\text{Pay-off} = 100 - X$ pence
- With probability $1/3$ (33.33%) you win two and a half times the amount X you have invested in addition to your initial endowment and your pay-off in the respective round is $\text{Pay-off} = 100 + 2.5X$ pence

The actual outcome of the lottery depends on a randomly drawn number out of the uniformly distributed interval $[0, 3]$ and on your type. There are three possible types: type 1, 2, and 3. In the first round, you will be informed about your type, which remains fixed for all 9 rounds.

- Type 1 wins if the random number in a given round is from the interval $[0, 1]$
- Type 2 wins if the random number in a given round is from the interval $(1, 2]$
- Type 3 wins if the random number in a given round is from the interval $(2, 3]$

The random number in a given round is identical for all participants in the experiment and it will be independently drawn anew in each consecutive round. After all teams have entered their decision, you will be informed about the outcome of the random number draw, about whether you have won or lost in the respective round, about your round pay-off and your accumulated pay-offs up to and including that round. For your final earnings, we will add up your pay-offs in all 9 rounds. Please note that each single member of a team will be paid the full earnings, which, of course, are identical for all team members.

Within your team, you and the other members have to agree on the amount X in each round. In order to reach agreement, you can communicate with the two other subjects via an electronic chat which will appear on your computer screen. If you have agreed on an amount X , please enter the amount on your input screen and confirm your entry. If the three members of your team do not enter the same amount X then all team members will earn zero in this round.

It is forbidden to send any message that might reveal your identity to the other team members. If you violate this rule you will not receive any payment.

Treatments CONS1 and CONS2

Note: the sentence *in italics* only applies to treatment CONS2.

At the start of this experiment, you will be randomly matched with two other individuals in the room to form a group of three. Group members will remain anonymous

no-one will find out who their fellow group members are during or after the experiment.

This experiment consists of 9 rounds. In each round you will receive an endowment of 100 pence (1 pound). You must decide which part of this endowment (between 0 pence and 100 pence) you wish to invest in a lottery. The investment will be denoted as amount X .

The outcome of the lottery is as follows:

- With probability $2/3$ (66.67%) you lose the amount X you have invested and your pay-off in the respective round is $\text{Pay-off} = 100 - X$ pence
- With probability $1/3$ (33.33%) you win two and a half times the amount X you have invested in addition to your initial endowment and your pay-off in the respective round is $\text{Pay-off} = 100 + 2.5X$ pence

The actual outcome of the lottery depends on a randomly drawn number out of the uniformly distributed interval $[0, 3]$ and on your type. There are three possible types: type 1, 2, and 3. In the first round, you will be informed about your type, which remains fixed for all 9 rounds.

- Type 1 wins if the random number in a given round is from the interval $[0, 1]$
- Type 2 wins if the random number in a given round is from the interval $(1, 2]$
- Type 3 wins if the random number in a given round is from the interval $(2, 3]$

The random number in a given round is identical for all participants in the experiment and it will be independently drawn anew in each consecutive round. After all individuals have entered their decision, you will be informed about the outcome of the random number draw, about whether you have won or lost in the respective round, about your round pay-off and your accumulated pay-offs up to and including that round. *You will also see a summary screen that shows the earnings of the other members of your group*

in the current round. For your final earnings, we will add up your pay-offs in all 9 rounds.

Within your group, each individual member can choose a different amount X in each round. Your earnings do not depend on the choices of the other group members. Before you enter your amount X , you can communicate with the two other subjects via an electronic chat which will appear on your computer screen. You are free to consult with them and discuss any aspect of the experiment. However, it is forbidden to send any message that might reveal your identity to the other group members. If you violate this rule you will not receive any payment.

Appendix B: Experimental software screenshots

Figure 3.1: Treatment IND decision screen

Time remaining [seconds]: 57

Round 1

Your endowment in pence (1 pence = £0.01) 100

Please enter how many pence (of your endowment) you want to invest in the lottery in this round (this is amount X)

OK

Figure 3.2: Treatment GRP chat and decision screen

Time remaining (seconds): 148

MEMBER 1: This is a chat
MEMBER 1: window
MEMBER 3: hi
MEMBER 2: how are you?

Round 1

Your team's type is 1. You can use the chat window on the left hand side to communicate with the other team members. Input your message in the long input box at the bottom, then press [Enter] to post. You are team **member 2** in the chat

Your endowment in pence (1 pence = £0.01) 100

Please enter how many pence (of your team's endowment) you have agreed to invest in the lottery **in this round** (this is amount X)

If the amounts entered by all three team members do not match then all team members will earn zero in this round.

Submit decision

Figure 3.3: Treatment CONS1 and CONS2 chat and decision screen

Time remaining (seconds): 96

SUBJECT 1: Hi I'm chatting
SUBJECT 3: Hi
SUBJECT 2: How are you?
SUBJECT 1: Very good
SUBJECT 1: How much should we invest?
SUBJECT 2: dont know
SUBJECT 2: about 50 maybe
SUBJECT 2: or is that too high?
SUBJECT 1: ehm
SUBJECT 1:
SUBJECT 1: a bit high, yes

Round 1

Your type is **1** (the same as the two other members of your group). You can use the chat window on the left hand side to communicate with the other group members. Input your message in the long input box at the bottom, then press [Enter] to post. You are **subject 1** in the chat

Your endowment in pence (1 pence = £0.01) 100

Please enter how many pence (of your endowment) you want to invest in the lottery in **this round** (this is amount X)

Figure 3.4: Treatment CONS2 consultation group feedback screen

Time remaining (seconds): 59

YOUR GROUP'S EARNINGS IN THIS ROUND

	Group member 1	Group member 2	Group member 3 (You)
Amount X (investment in pence)	12	2	50
Round earnings	130	105	225

N.B.: You and the other members of your group won the lottery for this round.

OK

Chapter 4

Group diversity, communication and risk taking

4.1 Introduction

Decision making groups at many levels of society are becoming increasingly diverse. Within country borders, this process is embodied by the emancipation of women and ethnic minorities, which has given these previously marginalised groups better opportunities in the labour market and greater influence in the political process. Another source of diversity is increased international cooperation and economic integration, as personified by the ubiquity of organisations with a multinational workforce. Diversity is not only viewed as a good thing in itself, but many claim it also leads to better decisions:

The problem of risk comes down to diversity (...) If you cut everybody in your own mould in the same business, then you don't have enough pressure on the questions of "Why?", "What are the benefits?" and "What are the risks?"

—Karren Brady, Executive, former UK Business Woman of the Year
(Private Business, 2011)

Empirical researchers have sought to substantiate such claims by investigating the effect of diversity on decisions of real world groups, such as management teams (Bantel & Jackson, 1989; Wiersema & Bantel, 1992; Barkema & Shvyrkov, 2007; Boeker, 1997; Nielsen & Nielsen, 2011). We complement the empirical literature on management teams by investigating the effect of group diversity on decisions under risk in a controlled, abstract lottery task. We are interested in the effect of international diversity on outcomes of face-to-face discussions, as organisational theory and empirical evidence to date suggests that more culturally diverse groups are more risk averse (Watson & Kumar, 1992; Nielsen & Nielsen, 2011). Contrary to the picture painted by the literature so far, we find no evidence that international diversity significantly changes risk-taking by groups. Furthermore, we find that the gender composition of groups is a much stronger, and statistically significant, determinant of group risk-taking. Our results are similar to those reported by Bogan et al. (2011), with the difference that risk aversion in our experimental setting is strictly increasing in the number of female group members. Finally, we find that the effect of gender composition is equally strong if subjects communicate by anonymous electronic chat. This result suggests that our gender composition effect is not caused by group members trying to live up to gender stereotypes in face-to-face encounters, but are driven by a more general tendency of groups with more female members to be more risk averse.

This chapter makes two contributions to the literature. First, we present evidence of a controlled and incentivised experimental test of the effect of international diversity on group decisions under risk. Our laboratory experiment with random group formation, in contrast to empirical studies, controls for any confounding factors that simultaneously affect group composition and its members' propensity to take risk. The fact that, contrary to the empirical literature, we find no effect of international diversity might suggest that such unobserved factors, such as company culture, play an important role in the field. Alternatively, it could be that the empirical observations of the negative relationship between cultural diversity and risk-taking depend on certain parameters of a decision problem, which are absent from our controlled laboratory setting. Finding

out which parameters moderate the effect of cultural diversity seems a promising question for further research. Second, we confirm earlier findings on the effect of gender composition on group decisions under risk in a context-free setting. Since decisions in our experimental design are not framed as representing risk-taking in a particular domain (e.g. stock market investment, international business expansion), our results cannot be explained by a gender difference in familiarity or suitability for a particular choice domain. Furthermore, we establish that the gender composition effect is robust to changes in the communication protocol used by the group.

4.2 Related literature

4.2.1 Individual demographics and risk

Experiments have shown that people's risk attitudes are correlated with various demographic characteristics, such as gender, age, and ethnicity. One of the more robust findings is the relationship between risk-taking and gender: many laboratory studies report that women are generally more risk averse than men (Eckel & Grossman, 2008; Croson & Gneezy, 2009). More specifically, Charness & Gneezy (2012) review the data from experiments with the same fundamental design as ours (based on the investment task from Gneezy & Potters, 1997) and conclude that women invest significantly lower amounts than men in a risky asset. Gender differences in risk-taking have also been found outside the laboratory: Barber & Odean (2001) find that female clients of a brokerage firm hold less risky portfolios than male clients. Second, empirical and laboratory evidence suggests a link between risk-taking and age, with a number of studies reporting that risk aversion increases as people get older (Otani et al., 1992; Grasmick et al., 1996; Gardner & Steinberg, 2005).

A number of studies suggest that risk-taking might be related to people's ethnic and cultural background. Barsky et al. (1997) report that, based on hypothetical choices on high-stakes income gambles from the 1992 US Health and Retirement Survey, white

Americans are more risk averse than other ethnicities, and that Asian and Hispanic Americans are more risk seeking than other ethnicities. Using 1992-2002 data from the Health and Retirement Survey, Sahm (2007) reports that black Americans are 28% more likely to accept a high-stake income gamble than white Americans. Furthermore, both Barsky et al. and Sahm find that hypothetical risk-taking in the survey is positively correlated with risky activities such as smoking, drinking, self-employment and stock market participation.

Other experimental studies examine differences in risk-taking between people from different cultures. Hsee & Weber (1999) find that Chinese students are more risk seeking in hypothetical scenarios than American students in the domain of stock market investment. Lau & Ranyard (2005) also report that (Hong Kong) Chinese subjects are more risk seeking than British subjects in a hypothetical gambling task, Fong & Wyer (2003) present conflicting evidence, however, with (Hong Kong) Chinese and American students being equally risk seeking in stock market investment choices, and Americans more risk seeking in the domain of academic achievement.

4.2.2 Diversity

The effect of group diversity on decisions with an element of risk has been studied extensively in the empirical literature on top management performance (see Williams & O'Reilly, 1998; Van Knippenberg & Schippers, 2007; Nielsen, 2010). Bantel & Jackson (1989) look at the effect of diversity in banks' management teams on one type of entrepreneurial risk: product innovation. They find that banks headed by managers from diverse functional backgrounds are more innovative, but that diversity in age, team tenure length and education are not correlated with innovation. Barkema & Shvyrkov (2007) find a seemingly different, but related effect of management team diversity on Dutch companies' foreign direct investment (FDI). The authors report that diversity in team tenure length is positively associated with more FDI, but note that team tenure length is also strongly related to managers' recent functional background. Finally, a

number of studies look at the effect of top management team demographics on the likelihood of a change in corporate strategy. Wiersema & Bantel (1992) report that strategic change is more likely to originate with management teams with a lower average age, shorter organisation tenure length, higher team tenure length, more educational diversity, and higher levels of education and academic training. Boeker (1997) finds that higher team tenure length and higher within-team diversity in team tenure length are associated with a higher likelihood of a change in corporate strategy.

Organisational researchers and theorists categorise sources of group diversity into informational diversity, social category diversity, and value diversity (Jehn et al., 1999). Informational diversity, which is typically measured by team members' functional or educational background, is thought to have a positive effect on group performance by widening the scope of the discussion through the provision of more task-relevant information. The studies cited above also suggest that informational diversity increases groups' propensity to take risky decisions (Bantel & Jackson, 1989; Wiersema & Bantel, 1992; Boeker, 1997; Barkema & Shvyrkov, 2007). Social category and value diversity, on the other hand, are thought to frustrate the group process by making it harder for group members to relate to each other. Our main variable of interest, international diversity, can be interpreted as both a dimension of social category diversity and of value diversity. Group diversity theory would thus predict that more internationally diverse groups are less effective at communicating with each other, and these groups might consequently feel less comfortable taking risks together. The empirical evidence collected so far is consistent with this explanation. Nielsen & Nielsen (2011) report that Swiss multi-national companies managed by more internationally diverse teams are more likely to pursue geographic expansion through joint ventures than through more risky full-control entities. In an experiment with participants from a management training course, Watson & Kumar (1992) find that culturally heterogeneous groups select less risky options than culturally homogeneous groups in hypothetical scenarios involving risk.

4.2.3 Group decisions under risk

Group decisions under risk have long been studied in experimental psychology (see Myers, 1982; Turner, 1991) but has recently seen renewed interest in the form of economic experiments. In most of these experiments, groups of subjects are presented with a list of choices between lotteries representing different levels of risk over monetary pay-offs. Groups select one lottery, and each group member is paid the same amount after this lottery is played out. The majority of these studies focus on how group risk-taking compares with individuals, instead of comparing groups to other groups.¹ To our knowledge, only one experimental study compares risk-taking over real incentives in different types of groups. Bogan et al. (2011) investigate the effect of gender composition of groups on incentivised investment decisions. In contrast to our experiment, the decisions in Bogan et al. are deliberately framed as representing the choices of an actual investment fund. The investment decisions in the experiment are presented as binary choices between stock portfolios with different levels of risk over percentage returns, the realisation of which is said to depend on actual stock price over time. Like actual investment fund managers, subjects' earnings are increasing in the realised percentage return on their portfolios. Bogan et al. find that groups' propensity to chose a risky option is increased by having a male in the group, but that risk-taking is not strictly increasing in the number of males per group. The most risk-seeking groups in their experiment are dominated by males, but not all male.

4.3 The experiment

Our experimental design contains two treatments: a treatment with group decisions (GRP) and a treatment with individual choices under risk (IND). Both treatments are

¹The experimental evidence from groups versus individual risk-taking studies is mixed, and suggests a complicated relationship (if any) between individual and group decisions. Sutter (2009) and Zhang & Casari (2010) report higher risk-taking by groups; Masclet et al. (2009) report lower risk-taking by groups; Deck et al. (2010) report no significant differences. Both Shupp & Williams (2008) and Baker et al. (2008) report that groups react more strongly than individuals to very low and very high probabilities of winning.

replications of the investment task reported in Sutter (2009), which is adapted from the ‘myopic loss aversion’ experiments of Gneezy & Potters (1997). Our experiment differs in respect of the subject pool. Whereas the subject pool in Sutter (2009) was culturally homogeneous, our subject pool is made up of students from various countries.² We use the investment task from Sutter (2009) because results show that groups consistently take more risk than individuals in this task, and effective group communication has been shown to play an important role in this process (see chapter three of this thesis). We thus consider increased risk-taking by groups as compared to individuals, controlling for other factors, as an indication of the effectiveness of group communication.

Both treatments implemented the following task, repeated over nine rounds. In round t , the decision maker (group or individual) receives an endowment of 100 pence (£1). The decision maker i can invest $x_{it} \in [0, 100]$ pence of this endowment in a lottery with winning probability $\frac{1}{3}$. If the decision maker wins the lottery in round t , earnings are $3.5x_{it}$; if the decision maker loses the lottery, earnings are zero. Any money not invested is kept, such that subject i 's earnings in round t are as follows:

- $100 - x_{it}$ pence with probability $\frac{2}{3}$
- $100 - x_{it} + 3.5x_{it} = 100 + 2.5x_{it}$ pence with probability $\frac{1}{3}$

If the decision maker is a group, these earnings are effectively multiplied by three and divided equally among the three group members. Subject earnings in each round are thus the return on a safe asset (the money kept) plus the return on a risky asset (the lottery outcome). The part x of the endowment invested in the risky asset measures risk-taking. An expected earnings maximising (risk-neutral) subject would invest the full endowment ($x = 100$), yielding expected earnings of £1.17 in every round. More generally, expected earnings are strictly increasing in x .

After subjects submit their decisions, a computerised random number generator is used

²We learned about the subject pool demographics in Sutter (2009) through private correspondence with the author.

to resolve the lottery. Subjects are then presented with the results of the lottery and their resulting round earnings on a summary screen. The summary screen also shows the subjects' accumulated earnings up to and including the current round.

After the final round, subjects are asked to complete a questionnaire. After completing the questionnaire, each subject is paid their full earnings for all nine rounds, plus a show-up fee of £2, and subsequently dismissed. To allow for a faithful replication of Sutter (2009), we used the same software, translated instructions, experimental parameters and incentive structure.³

Our main variable of analysis is the experiment average investment $\bar{x}_i = \sum_{t=1}^T x_{it}$ for a particular group or individual, which we believe to be the most stable measure of risk-taking in our task. Because x_i varies between 0 and 100 in each round, the average of this variable also corresponds to the percentage of the total endowment (9 rounds \times £1 = £9) invested in the lottery during the experiment.

We are interested in the effect of international diversity of groups of subjects on their level of risk-taking. We measure the level of risk-taking in groups of different nationality compositions, compared to baselines of strictly British nationals/native speakers. In line with group diversity theory and previous empirical results, we expect that groups with fewer British nationals/native speakers take less risk due to less effective communication. It is important to note that, in our experimental task, effective communication has been shown to significantly correlate with risk-taking: various experimental studies report that increased risk-taking is positively related to communication about the lottery's expected value (Sutter, 2009, see also chapter three of this thesis).

³The original software is available at http://www.e-aer.org/data/dec09/20080341_data.zip as a Z-Tree (Fischbacher, 2007) treatment file; our translated instructions are included in the appendix to this chapter.

4.3.1 Treatments

In treatment GRP, groups of three subjects sit together behind one computer terminal and have to submit a consensus choice of x . The experimenters provide no explicit fall-back decision mechanism in case groups fail to reach consensus, so group members have a strong incentive to agree on a common choice. Subjects can communicate with fellow group members by speaking in a low voice, but they are specifically instructed not to communicate with other groups. Groups are separated by cubicle dividers, such that subjects cannot see members of other groups in the room.

In treatment IND, subjects sit at a computer terminal by themselves and submit individual values of x . Subjects are not allowed to communicate, and subjects receive no feedback about others' choices during or after the experiment. Privacy is maintained by experimenter oversight and cubicle dividers between computer terminals.

4.3.2 Procedure

All experimental sessions were carried out at the CeDEx computer laboratory at the University of Nottingham (Nottingham, UK). We used ORSEE (Greiner, 2004) to recruit our subjects; altogether, 324 subjects participated in the experiment. Subjects were (mostly undergraduate) students from various disciplines, who had previously registered for participation in economic experiments. Average subject earnings (including a show-up fee of £2) were £11.82, with an average session time of 35 minutes. The experiment was programmed in z-Tree (Fischbacher, 2007) version 3.3.8.

4.3.3 Subject demographics and recruitment

Table 4.3.3 summarises the demographics of our subjects, including our measures of international diversity. Based on subjects' nationality, we create two measures of international diversity. The first measure is based on whether a subject is a British national;

Table 4.1: Subject pool demographics

	Treatment IND	Treatment GRP
Average age	19.9	20.0
Male / female	38 / 31	109 / 146
University degree: economics or business / other	8 / 61	62 / 193
British / international	53 / 16	177 / 78
Native speakers / non-native speakers	56 / 13	188 / 67
All-male / majority male / majority female / all-female		6 / 27 / 37 / 15
All-econ / majority econ / majority other / all-other		3 / 12 / 29 / 41
All-British / majority British / majority int'l / all-int'l		30 / 37 / 13 / 5
All-native / majority native / majority non-nat. / all-non-nat.		34 / 37 / 12 / 2
Total (groups)	69	255 (85)

Subject pool demographics for the experiment, aggregated per treatment. All measures are self-reported, with the exception of the native speaker variable.

the second measure is based on whether English is one of the official languages in the subject's country of origin (CIA World Factbook, 2009).

The subject pool in both treatments are similar in terms of non-cultural demographics, although we note that treatment GRP has more females and economics students. To test our hypotheses about risk-taking in groups, we purposely recruited a greater percentage of non-British subjects for the GRP treatment, amounting to 31% of subjects for that treatment. To avoid arousing suspicion among our subjects about targeted recruitment of international students and its intended purpose, however, we always recruited British nationals alongside international subjects for each session. To ensure we gathered enough data on optimally communicating groups, we also ran some experimental sessions with British subjects only; this explains the relatively high number of all-British groups.

4.4 Results

4.4.1 Group diversity and risk taking

To analyse group decisions for different group compositions, we estimate two Tobit models of group average investment in treatment GRP on dummy variables for international diversity, with all-British or all-native speaker groups as the baseline in the model. We also estimate versions of the model with control variables for gender and university degree (number of economics and business students) composition. We control for gender because many previous experiments have shown a correlation between risk-taking and gender, as discussed earlier. Second, because higher risk-taking in the investment task has previously been associated with group communication about lottery expected value (Sutter, 2009, see also chapter three of this thesis), it is plausible that groups with more economics and business students would be more likely to choose higher investments. We therefore include university degree dummy variables that measure the number of economics and business students in a group.

The results of our Tobit regressions are shown in table 4.2. The results in the first and third column of the table show that internationally diverse groups invest, on average, less than homogeneous groups, but that this difference is not statistically significant for any of the diverse group compositions. Furthermore, when we control for gender and degree composition, the relationship between group diversity and risk-taking remains insignificant. More important, the results show that gender composition has a much stronger (and significant) effect than international diversity. Controlling for other demographic factors, all-female groups and groups with a female majority invest around 35% less of their endowment than all-male groups. Finally, we find no evidence that the number of economics and business students in a group increases a group's willingness to take risk.

Table 4.2: Tobit regression of groups' average investment

	(1)	(2)	(3)	(4)
<i>Cultural diversity</i>				
Majority british	-5.037 (6.046)	-6.692 (5.695)		
Majority foreign	-3.571 (8.154)	0.215 (7.807)		
All foreign	-6.519 (11.85)	3.407 (12.31)		
Majority native speakers			-3.123 (5.840)	-3.816 (5.496)
Majority non-native speakers			-5.415 (8.237)	1.100 (8.099)
All non-native speakers			-13.66 (17.84)	-9.385 (16.57)
<i>Gender</i>				
Majority male		-19.50* (10.48)		-18.10* (10.45)
Majority female		-35.85*** (10.23)		-34.35*** (10.25)
All female		-36.30*** (11.25)		-36.07*** (11.29)
<i>Degree</i>				
Majority economics		-8.646 (15.22)		-4.036 (14.72)
Majority other		-1.089 (13.59)		-0.125 (13.66)
All other		5.563 (13.47)		6.136 (13.55)
Number of observations	85	85	85	85
Prob > χ^2	0.849	0.0237	0.812	0.0328
Pseudo R^2	0.00106	0.0252	0.00126	0.0239

Standard errors in parentheses, asterisks denote significance at the 10% (*), 5% (**) and 1% (***) level. Table contains Tobit model regression results (lower bound: 0, upper bound: 100) of a group's average investment over all 9 rounds on group demographic variables. Models 1 and 2 use number of British nationals in a group as a measure of international diversity (dummy baseline: all British groups). Models 3 and 4 use number of native speakers of the English language in a group as a measure of international diversity (dummy baseline: all native speaker groups). Models 2 and 4 include controls for gender composition (dummy baseline: all male groups) and university degree composition (dummy baseline: all economics/business studies groups).

4.4.2 Demographics and individual risk-taking

To learn more about the interaction between individual characteristics and group membership, we investigate how demographic characteristics are correlated with individuals' choices under risk in our task. Table 4.3 contains the results of a series of Tobit regressions of individual average investment on dummy variables for non-British nationality, East Asian nationality, non-native speaker, gender (female) and degree (economics/business or other). The variable for East Asian nationality is to test for a commonly held perception that Eastern cultures differ from Western cultures in their perception of risk (Weber & Hsee, 1998; Hsee & Weber, 1999).

The regression results in table 4.3 show that women invest significantly less than men in treatment IND, a result consistent with other studies with similar experimental designs (Charness & Gneezy, 2012) and the literature on individual risk-taking at large (Eckel & Grossman, 2008; Croson & Gneezy, 2009). Controlling for differences in cultural background and degree, women invest about 18% less of their endowment than men. The coefficients on the interaction terms suggest that this effect is stronger for international or East Asian subjects, but this is not significant. Furthermore, we find no evidence of different levels of risk-taking in non-British subjects, East Asians or non-native speakers. We also find no evidence of differences in individual subjects' risk-taking due to differences in culture or language ability.

Gender is significantly correlated with risk-taking in both individuals and groups, but a comparison between tables 4.2 and 4.3 shows that the effect leads to a bigger risk-taking differential in groups. At the most extreme end of the scale, we find that all male groups invest almost twice as much as all female groups in the risky asset (see figure 4.1). The greater differential between groups could indicate polarisation of risk attitudes: women become more risk-averse in the company of other women, and men become more risk seeking in the company of other men. Such polarisation could cast doubt on the findings that groups consistently invest more than individuals in the in-

Table 4.3: Tobit regression of individuals' average investment

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Demographic variables</i>						
Foreign nationality (non-British)	-7.785 (8.375)	0.194 (11.24)				
Non-native speaker					-0.479 (9.342)	-0.803 (11.41)
East Asian nationality			0.0794 (11.65)	3.571 (15.17)		
Female	-18.41*** (6.727)	-14.73* (7.528)	-18.60*** (6.766)	-17.81** (7.108)	-18.57*** (6.790)	-19.32 (16.69)
Other degree (non-economics/business)	10.80 (11.18)	13.09 (11.32)	14.46 (11.21)	14.64 (11.20)	14.67 (11.52)	14.73 (11.58)
<i>Interaction terms</i>						
Foreign \times Female		-16.91 (16.04)				
Eastern \times Female				-7.956 (22.17)		
Non-native \times Female						0.901 (18.22)
Number of observations	69	69	69	69	69	69
Prob $> \chi^2$	0.0296	0.0391	0.0437	0.0830	0.0436	0.0873
Pseudo R^2	0.0143	0.0161	0.0129	0.0132	0.0130	0.0130

Standard errors in parentheses, asterisks denote significance at the 10% (*), 5% (**) and 1% (***) level. Table contains Tobit model regression results (lower bound: 0, upper bound: 100) of a subject's average investment over all 9 rounds on demographic variables. Models 1 and 2 test for differences due to not having British nationality, models 3 and 4 differences due to not being a native speaker, model 5 and 6 test for differences due to being East Asian. All models include controls for gender and university degree. Models 2, 4 and 6 include interaction terms between gender and measures of nationality and native language.

vestment task (Sutter, 2009, see also chapter three of this thesis). But our data on gender composition, summarised in figure 4.1, actually shows that the result of higher investment by groups still holds. All-female groups invest on average more of their endowment (38.3%) than individual females (30.7%), although this difference is not statistically significant (two-tailed Mann-Whitney U test, $p > 0.1$). All-male groups invest more (70%) than individual males (47%) - a difference significant at the 10% level (two-tailed Mann-Whitney U test, $p < 0.1$). We thus find that the result of higher investment by groups reported in Sutter (2009) applies regardless of gender, and this effect is particularly strong in all-male groups.

Figure 4.1: Average investment by gender (composition)

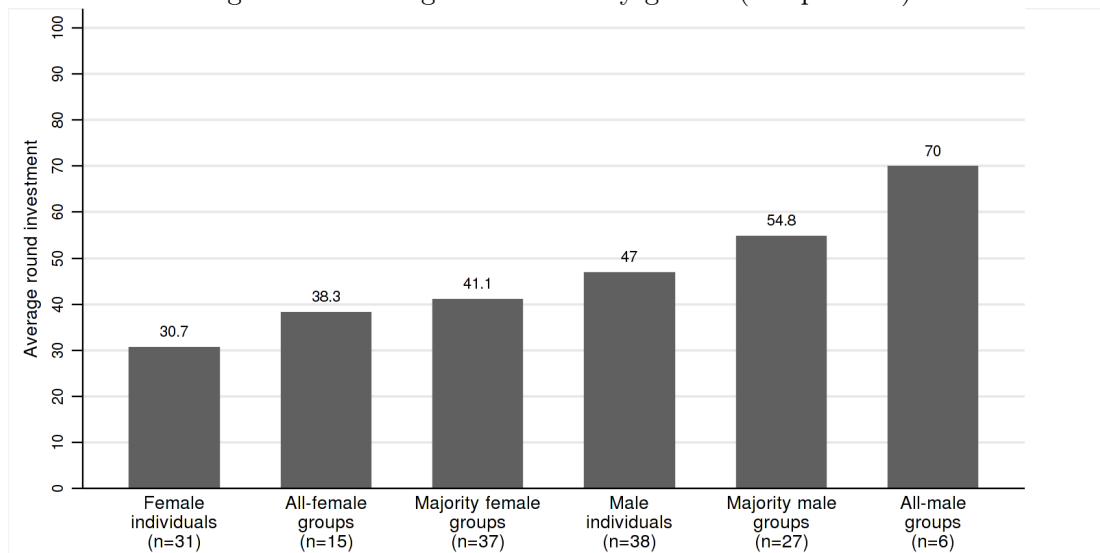


Figure shows the average investment over all nine rounds of individuals (males and females separately) and groups in the GRP treatment (grouped by gender composition).

4.4.3 Communication and group risk taking

As part of a related study on the same investment task (reported in chapter three of this thesis), we carried out a group treatment in which subjects communicated by electronic chat before making a choice (henceforth GRP-CHAT, $n = 48$). In the electronic chat, group members were not allowed to reveal any personal information to fellow group members. By comparing the data from treatment GRP-CHAT to treatment GRP, we

Table 4.4: Tobit regression of average investment in different group treatments

	(1)	(2)	(3)
<i>Gender composition</i>			
Majority male	-24.18*** (7.911)	-24.30*** (7.937)	-19.08* (11.41)
Majority female	-36.44*** (7.797)	-36.65*** (7.872)	-34.42*** (11.15)
All female	-35.66*** (9.028)	-35.76*** (9.043)	-35.60*** (12.31)
<i>Cultural diversity</i>			
Majority native speakers	-4.313 (4.820)	-4.727 (5.278)	-4.458 (5.271)
Majority non-native speakers	-1.217 (8.029)	-1.789 (8.559)	-1.133 (8.605)
All non-native speakers	-10.77 (17.81)	-11.33 (18.05)	-12.28 (17.94)
<i>Degree composition</i>			
Majority economics	-4.228 (15.52)	-3.920 (15.60)	-2.429 (15.55)
Majority other	0.842 (14.70)	1.140 (14.78)	2.899 (14.76)
All other	1.524 (14.67)	1.764 (14.72)	3.284 (14.68)
<i>Treatment variables and interaction terms</i>			
Subjects use electronic chat		-0.985 (5.112)	3.869 (14.12)
Chat × Majority male			-11.14 (15.80)
Chat × Majority female			-3.284 (15.65)
Chat × All-Female			3.593 (18.31)
Number of observations	133	133	133
Prob > χ^2	0.00272	0.00485	0.0139
Pseudo R^2	0.0211	0.0211	0.0222

Standard errors in parentheses, asterisks denote significance at the 10% (*), 5% (**) and 1% (***) level. Table contains Tobit model regression results (lower bound: 0, upper bound: 100) of a group's average investment over all 9 rounds on group demographic variables, for pooled data from the GRP and GRP-CHAT treatments. All models use the number of native speakers of the English language in a group as a measure of international diversity (dummy baseline: all native speaker groups), and further control for gender composition (dummy baseline: all male groups) and university degree composition (dummy baseline: all economics/business studies groups). Model 2 measures the pure treatment effect from using electronic chat instead of face-to-face communication; model 3 also includes interaction terms between gender composition and electronic chat communication.

can thus estimate the joint effect of anonymity and electronic chat as a communication medium (as compared to face-to-face communication). This allows us to check for certain stereotype effects. It could be, for example, that predominantly male groups in treatment GRP feel a pressure to conform to the stereotype of the risk-taking male; this would not occur in GRP-CHAT as subjects do not know each other's gender. There is a large psychology literature on gender stereotypes and risk, and experimental studies suggest that people typically predict that men are more risk-taking (Daruvalla, 2007), sometimes even over-estimating male risk attitudes and under-estimating female risk attitudes (Siegrist et al., 2002; Roszkowski & Grable, 2005).

It might also be the case that subjects feel less comfortable taking risk in groups with greater social distance between subjects. Experiments have found that communication media with greater social distance (video conference, face-to-face conversation) generally lead to lower levels of cooperation in public goods games (Frohlich & Oppenheimer, 1998; Brosig et al., 2003; Bochet et al., 2006). Cooperation in public goods games depends on subjects exposing themselves to risk: the social risk of being exploited by free riders. The results in public goods games could therefore point to a more general relationship between social distance and risk-taking: people are less willing to take risk when social distance is greater. To look for evidence of the above hypotheses, we combine data from treatments GRP and GRP-CHAT to estimate a Tobit regression model of average investment on dummy variables for electronic chat, native speaker composition, gender composition and degree composition.

Table 4.4 shows the results of the Tobit regressions for communication medium effects, the third column also containing includes interaction terms between the communication medium and gender composition. As before, gender composition coefficients show that majority female and all-female groups take significantly less risk than all-male groups. Also similar to the results presented earlier, international diversity and university degree composition do not affect risk-taking. More important, the results show that (i) the communication medium does not affect risk-taking, and (ii) the gender effect is per-

sistently significant and unaffected by the communication medium. This is confirmed by an F-test of the model in the first versus the third column, as the variable for electronic chat and its interaction terms with gender composition are jointly insignificant ($F(4, 114) = 0.59, p > 0.1$). These results suggest that the differences in risk-taking in groups with different gender compositions are driven by a combination of subjects' risk attitudes and group communication, regardless of whether subjects know each other's gender. This evidence contradicts the notion that group decisions in our experiment are driven by gender stereotypes, such as the view that men should take more risk than women.

4.5 Discussion and conclusion

We use a controlled experiment to investigate incentivised risk-taking by small groups with varying degrees of international diversity. Contrary to evidence from empirical studies on top management teams (Nielsen & Nielsen, 2011) and unincentivised experiments with hypothetical choices (Watson & Kumar, 1992), we find that a group's international diversity does not affect its risk-taking. Because higher risk-taking in our investment task has previously been associated with discussion about achieving higher expected value (Sutter, 2009, chapter three of this thesis), our results suggest that our internationally diverse groups are just as effective as homogeneous groups in increasing their expected earnings through more risk-taking. We do, however, find a strong effect of groups' gender composition: the more females in a group, the more risk averse the group decision. Compared to all female groups, all male groups invest almost twice as much of their endowment in a risky asset.

The lack of an international diversity effect should be viewed in the context of our experiment. Our investment task is easy to comprehend and the arguments used to convince fellow group members are arguably far simpler than those used in more complex group decisions in the real world. It could be that a more difficult task would have presented

our internationally diverse groups with more problems. Second, our subject pool consists of university students that have all passed a language test to study at the University of Nottingham. Perhaps groups with greater cultural and language barriers would have operated differently. On a related note, we would like to suggest another way of interpreting our results: barriers to cross-cultural communication will be less important in the future than they are today. Our subject pool is comprised of students who study and live in an environment with people of many nationalities, which presumably leads to greater awareness of international diversity. If today's students are better prepared for culture and language differences, and if these differences are smaller due to students' upbringing, education and common life experiences, communication will be more effective.

The direction of our gender composition effect is in line with the literature on gender in individual risk-taking and the only other experimental study that looks at the effect of diversity on group decisions (Bogan et al., 2011). The relationship between gender composition and risk-taking in our data is straightforward: risk-taking strictly increases in the number of males in a group, with all-male groups the most risk seeking and all-female groups the most risk averse. Furthermore, we find that the effect of gender composition is of the same magnitude when groups communicate by anonymous electronic chat through computer terminals. This result suggests that group decisions are independent of the communication medium and are driven by group members' own risk attitudes, rather than stereotypical behaviour based on subjects' perceptions of what degree of risk-taking is appropriate for their gender.

Appendix A: Experimental instructions

Treatment IND

This experiment consists of 9 rounds. In each round you will receive an endowment of 100 pence (1 pound). You must decide which part of this endowment (between 0 pence and 100 pence) you wish to invest in a lottery. The investment will be denoted as amount X .

The outcome of the lottery is as follows:

- With probability $2/3$ (66.67%) you lose the amount X you have invested and your pay-off in the respective round is $\text{Pay-off} = 100 - X$ pence
- With probability $1/3$ (33.33%) you win two and a half times the amount X you have invested in addition to your initial endowment and your pay-off in the respective round is $\text{Pay-off} = 100 + 2.5X$ pence

The actual outcome of the lottery depends on a randomly drawn number out of the uniformly distributed interval $[0, 3]$ and on your type. There are three possible types: type 1, 2, and 3. In the first round, you will be informed about your type, which remains fixed for all 9 rounds.

- Type 1 wins if the random number in a given round is from the interval $[0, 1]$
- Type 2 wins if the random number in a given round is from the interval $(1, 2]$
- Type 3 wins if the random number in a given round is from the interval $(2, 3]$

The random number in a given round is identical for all participants in the experiment and it will be independently drawn anew in each consecutive round. After all individuals have entered their decision, you will be informed about the outcome of the random number draw, about whether you have won or lost in the respective round, about your round pay-off and your accumulated pay-off in the whole experiment. For your final

earnings, we will add up your pay-offs in all 9 rounds.

In each round, you have 3 minutes to submit your decision. Please do not communicate with other subjects at any point during the experiment. Anybody found in breach of this rule will be dismissed without payment.

Treatment GRP

This experiment consists of 9 rounds. In each round your team will receive an endowment of 100 pence (1 pound). Your team must decide which part of this endowment (between 0 pence and 100 pence) you wish to invest in a lottery. The investment will be denoted as amount X . Within your team, you have to agree on a single choice of the amount X .

The outcome of the lottery is as follows:

- With probability $2/3$ (66.67%) you lose the amount X you have invested and your pay-off in the respective round is $\text{Pay-off} = 100 - X$ pence
- With probability $1/3$ (33.33%) you win two and a half times the amount X you have invested in addition to your initial endowment and your pay-off in the respective round is $\text{Pay-off} = 100 + 2.5X$ pence

The actual outcome of the lottery depends on a randomly drawn number out of the uniformly distributed interval $[0, 3]$ and on your type. There are three possible types: type 1, 2, and 3. In the first round, you will be informed about your type, which remains fixed for all 9 rounds.

- Type 1 wins if the random number in a given round is from the interval $[0, 1]$
- Type 2 wins if the random number in a given round is from the interval $(1, 2]$
- Type 3 wins if the random number in a given round is from the interval $(2, 3]$

After all teams have entered their decision, you will be informed about the outcome of the random number draw, about whether you have won or lost in the respective round, about your round payoff and your accumulated payoff in the whole experiment. For your final earnings, we will add up your payoffs in all 9 rounds. Please note that each single member of a team will be paid the full earnings, which, of course, are identical for all team members.

Prior to making your decision, you have 3 minutes to talk to your fellow team members in a low voice. You are allowed to discuss any aspect of the experiment, as long as you do not make any threats, insults or use otherwise offensive language. Please do not speak loudly or communicate with other teams. Anybody found in breach of these rule will be dismissed without payment.

Treatment GRP-CHAT

At the start of this experiment, you will be randomly matched with two other individuals in the room to form a team of three. Team members will remain anonymous – no-one will find out who their fellow team members are during or after the experiment.

This experiment consists of 9 rounds. In each round your team will receive an endowment of 100 pence (1 pound). Your team must decide which part of this endowment (between 0 pence and 100 pence) you wish to invest in a lottery. The investment will be denoted as amount X . Within your team, you have to agree on a single choice of the amount X .

The outcome of the lottery is as follows:

- With probability $2/3$ (66.67%) you lose the amount X you have invested and your pay-off in the respective round is $\text{Pay-off} = 100 - X$ pence
- With probability $1/3$ (33.33%) you win two and a half times the amount X you have invested in addition to your initial endowment and your pay-off in the re-

spective round is $\text{Pay-off} = 100 + 2.5X$ pence

The actual outcome of the lottery depends on a randomly drawn number out of the uniformly distributed interval $[0, 3]$ and on your type. There are three possible types: type 1, 2, and 3. In the first round, you will be informed about your type, which remains fixed for all 9 rounds.

- Type 1 wins if the random number in a given round is from the interval $[0, 1]$
- Type 2 wins if the random number in a given round is from the interval $(1, 2]$
- Type 3 wins if the random number in a given round is from the interval $(2, 3]$

The random number in a given round is identical for all participants in the experiment and it will be independently drawn anew in each consecutive round. After all teams have entered their decision, you will be informed about the outcome of the random number draw, about whether you have won or lost in the respective round, about your round payoff and your accumulated payoffs up to and including that round. For your final earnings, we will add up your payoffs in all 9 rounds. Please note that each single member of a team will be paid the full earnings, which, of course, are identical for all team members.

Within your team, you and the other members have to agree on the amount X in each round. In order to reach agreement, you can communicate with the two other subjects via an electronic chat which will appear on your computer screen. If you have agreed on an amount X , please enter the amount on your input screen and confirm your entry. If the three members of your team do not enter the same amount X then all team members will earn zero in this round.

It is forbidden to send any message that might reveal your identity to the other team members. If you violate this rule you will not receive any payment.

Appendix B: Experimental software screenshots

Figure 4.2: Treatment GRP and IND decision screen

The screenshot shows a decision screen for Round 1. At the top right, a timer indicates "Time remaining [seconds]: 57". The screen is titled "Round 1" in the center. Below the title, it states "Your endowment in pence (1 pence = £0.01) 100". The instruction reads: "Please enter how many pence (of your endowment) you want to invest in the lottery in this round (this is amount X)". To the right of this instruction is a blue input field containing the number "1". In the bottom right corner, there is a red "OK" button.

Figure 4.3: Treatment GRP-CHAT chat and decision screen

Time remaining (seconds): 148

MEMBER 1: This is a chat
MEMBER 1: window
MEMBER 3: hi
MEMBER 2: how are you?

Round 1

Your team's type is 1. You can use the chat window on the left hand side to communicate with the other team members. Input your message in the long input box at the bottom, then press [Enter] to post. You are team **member 2** in the chat

Your endowment in pence (1 pence = £0.01) 100

Please enter how many pence (of your team's endowment) you have agreed to invest in the lottery **in this round** (this is amount X)

If the amounts entered by all three team members do not match then all team members will earn zero in this round.

Submit decision

Chapter 5

Testing for group polarisation in decisions under risk

5.1 Introduction

How do people arrive at radically different points of view on an issue when they have, at least in theory, access to the same information? Psychological research since the 1960s has sought to explain radical opinions and decisions by theories of group processes. One of the most influential of these is *group polarisation* theory (Moscovici & Zavalloni, 1969), which holds that group discussion will bias group members' opinions in the direction of their pre-discussion average opinion. One of the mechanisms through which polarisation can take place is information aggregation: each group member individually possesses a piece of information that leads to a slight bias in one direction, and when these pieces of information are combined in a group discussion the bias becomes stronger. For example, a discussion between investors with a slightly positive average personal track record of stock market investments might lead to a strong collective agreement that active investment in the stock market is a profitable enterprise. This information-based perspective on group polarisation is called *persuasive arguments theory*, and was first advanced by Vinokur & Burstein (1974) in response to a body of experimental evidence suggesting that group polarisation is driven by information ex-

change instead of social factors (Kogan & Wallach, 1967; Teger et al., 1970; Lamm, 1967).

Recent theoretical contributions in economics show that group polarisation due to information exchange can be explained by rational Bayesian updating (Glaeser & Sunstein, 2009; Sobel, 2012; Roux & Sobel, 2012). Group polarisation as such is thus no evidence of subject irrationality, but rather a natural outcome of information aggregation in groups. We aim to complement these predictions with an experimental test of group polarisation in terms of risk-taking. In a typical economics experiment with choices under risk, we investigate whether group polarisation occurs as a result of information sharing in groups of three subjects. Information is controlled for by giving subjects private signals on an earnings-relevant state of the world, and subjects are given the opportunity to share these signals in a group. Polarisation is measured in different ways, to account for the lack of an obvious neutral reference point with respect to subjects' risk attitudes.

We find that group polarisation of risk-taking occurs in 30% of groups. Of the groups in which group members receive mixed signals, 18% polarise; when all group members receive identical private signals, 50% of groups polarise. These results suggest that group polarisation is not a universal feature of group decisions under risk. For the groups with identical private signals, Bayesian updating suggests that polarisation should occur, and it is surprising that only half of these groups shows polarisation. The low rate of group polarisation does not seem to be caused by poor information aggregation, however. None of our subjects misreports their private signal to fellow group members, and very few subjects take actions that go against the information contained in the private signals they receive. By comparing decisions in groups with a random dictator decision rule to individual decisions with the same information, we find evidence that many subjects consciously coordinate their level of risk-taking with fellow group members when their decision may affect fellow group members' earnings. Furthermore, in keeping with other results in the literature, group decisions have a spill-over effect on

subsequent individual decisions.

5.2 Related literature

5.2.1 Choice shifts and group polarisation

Experimental psychologists have long recognised the effect of social context on individual decisions. In one of the first experimental demonstrations of social influence, Allport (1924) reported that the presence of others significantly influences individuals' reported opinions and task performance. The famous conformity experiments of Asch (1956) showed that subjects' judgements can be influenced by others even if an objective criterion shows that the influencers are wrong. These and other seminal studies of behaviour in social contexts (see Sherif, 1935; Lewin, 1947; Festinger, 1954) have shaped the field of social psychology, which concerns itself with how "the thought, feeling and behaviour of individuals are influenced by the actual, imagined or implied presence of others" (Allport, 1985).

A hypothetical choice experiment by Stoner (1961) provides evidence that social context also affects behaviour under risk. Furthermore, the results from the experiment suggest that this influence takes the form of increased risk seeking. In the experiment, subjects have to advise a hypothetical protagonist in a risky choice scenario. Subjects make individual recommendations first, then make a group recommendation after a discussion with other subjects. Stoner found that groups' judgements of the acceptable level of risk were significantly higher than those of group members choosing as individuals, a phenomenon since called the *risky shift*. The risky shift was replicated by various authors (see Myers, 1982; Isenberg, 1986, for a review) but others found that in some situations the group shifts to caution rather than risk (Nordhoy, 1962; Stoner, 1968). As a result, the literature has since adopted the more general term *choice shifts*.

The co-existence of choice shifts to risk and caution presented researchers with a the-

oretical challenge. One of the most prominent candidate explanations is the group polarisation theory of Moscovici & Zavalloni (1969), which was subsequently extended by other scholars. According to the persuasive arguments explanation of group polarisation (Vinokur & Burstein, 1974), the group acts as a forum in which people share information in the form of arguments and opinions exchanged during discussion. The processing of this information by the group leads to the amplification of the average group members' attitude, away from a neutral reference point to a more extreme position. In the case of risk seeking, the theory predicts that combining a collection of individuals that is slightly risk seeking will lead to a group that is more risk seeking than the average of its individual members.

5.2.2 Information aggregation

If group polarisation occurs due to the exchange of information, information has to be aggregated efficiently. In other words, subjects must be willing to share relevant information with fellow group members, who in turn must believe this information. That these assumptions are not always warranted, is demonstrated in theoretical contributions by Austen-Smith & Banks (1996) and Feddersen & Pesendorfer (1998). These two papers demonstrate that, in some group decision settings, group members have an incentive to strategically vote against their private information. These challenges to efficient information aggregation are not just a theoretical objection. Recent experiments on jury decision making (Guarnaschelli et al., 2000; Ali et al., 2008) present evidence of strategic voting as predicted by the theoretical literature. Other experimental designs have also shown that subjects often mis-report information to others when they have a financial incentive to do so (Cain et al., 2005; Gneezy, 2005; Hurkens & Kartik, 2009).

5.2.3 Group risk taking and social preferences over risk

The last two stages of the experiment see subjects make two decisions under risk based on the same probabilistic information: once in a group (random dictator decision rule¹) and once individually. A comparison of decisions in these two stages thus measures the effect of having to make a decision that also affects others. Although our main focus is on how strong group polarisation is under each of these conditions, it is worth noting that these stages bear a close resemblance to the nascent experimental literature on group decisions under risk. This literature aims to characterise group decisions by contrasting them with individual decisions, testing for systematic differences between the two conditions. The evidence on individual and group risk-taking in these experiments is mixed. Groups may take more (Zhang & Casari, 2010), less (Masclot et al., 2009) or as much risk (Deck et al., 2010) as individuals, with little robust evidence as to why these differences may or may not emerge in a particular experiment.

An interesting empirical pattern, especially in the context of measuring group polarisation, is that groups in some experiments seem to be more sensitive to probabilistic information than individuals. Experimental studies by Baker et al. (2008) and Shupp & Williams (2008) report that groups take more risk than individuals for lotteries with a high probability of winning, and less risk for lotteries with a low probability of winning. The experiment by Baker et al. also presents another finding relevant to our experiment: individual decisions in the final stage of the experiment are strongly correlated with the group decision that precedes it.

¹The random dictator decision rule has each of the three group members submitting an individual decision, with one of the three decisions randomly selected to determine the earnings of all group members. Under this decision rule, subjects without social preferences over risk have an incentive to submit their own preferred decision. But some subjects might display social risk preferences, given that their decision in stage III does not only affect their own earnings but also their fellow group members' earnings.

Table 5.1: Lottery choice table

Option	$S = 1$ (win)	$S = -1$ (loss)	EV($p=1/9$)	EV($p=1/3$)	EV($p=1/2$)	EV($p=2/3$)	EV($p=8/9$)
#1	£10	£10	£10	£10	£10	£10	£10
#2	£12.80	£9	£9.42	£10.27	£10.90	£11.53	£12.38
#3	£15.40	£8	£8.82	£10.47	£11.70	£12.93	£14.58
#4	£17.80	£7	£8.20	£10.60	£12.40	£14.20	£16.60
#5	£19.60	£6	£7.51	£10.53	£12.80	£15.07	£18.09
#6	£20.80	£5	£6.76	£10.27	£12.90	£15.53	£19.04
#7	£21.60	£4	£5.96	£9.87	£12.80	£15.73	£19.64
#8	£22.40	£3	£5.16	£9.47	£12.70	£15.93	£20.24
#9	£22.80	£2	£4.31	£8.93	£12.40	£15.87	£20.49
#10	£23.20	£1	£3.47	£8.40	£12.10	£15.80	£20.73
#11	£23.60	£0	£2.62	£7.88	£11.80	£15.73	£20.98

Subjects' lottery choice table for all stages of the experiment. For each lottery, column 2 and 3 show the subject's pay-off for either realisation of the state of the world variable S . Columns 4-8 show the expected value of each option under different probabilities that the positive state of the world $S = 1$ obtains. Subjects only saw columns 1-3 during the experiment.

5.3 The experiment

5.3.1 Experimental design

We measure risk-taking by individuals through four stages of an experiment, in which subjects accumulate probabilistic information on the realisation of a set of lotteries over monetary earnings. In each stage, a subject chooses one of the eleven options listed in table 5.3.1: a certain pay-off of £10, or one of ten binary lotteries with increasing levels of return and risk. The win/lose realisation of each lottery depends on a state of the world variable $S \in \{-1, 1\}$. The second column of table 5.3.1 indicates the earnings from a particular lottery if the subject wins the lottery ($S = 1$ or the *positive state*); the third column indicates the earnings from the lottery if the subject loses ($S = -1$ or the *negative state*). The state of the world is determined at the beginning of the experiment and its value is valid for all stages, subjects and lotteries.

Let probability p be the likelihood of the positive state of the world with value $S = 1$ (a lottery win). In stage I, subjects only know that one of the two states of the world has been selected with equal probability ($p = 1/2$). Before stage II, each subject privately receives an i.i.d. signal s that is equal to the actual state of the world S with probability $\frac{2}{3}$. After receiving a private signal, a rational Bayesian subject will update her belief in

the positive state of the world in the following way:

$$p(S = 1|s = 1) = p(S = -1|s = -1) = \frac{2}{3}$$

$$p(S = 1|s = -1) = p(S = -1|s = 1) = \frac{1}{3}$$

Thus, if the private signal is positive ($s = 1$) the probability $p(S = 1)$ increases to $2/3$; if the private signal is negative ($s = -1$) the probability $p(S = 1)$ decreases to $1/3$. Although approximately one in every three subjects will receive a signal that does not correspond to the actual state of the world, the average subject is better informed in stage II than in stage I.

In stage III, subjects can use an electronic chat on their screen to communicate freely with two other subjects. Groups of three subjects are randomly formed at the start of the experiment, and thus we control for group polarisation due to subjects with similar risk preferences being grouped together. Random allocation of subjects to groups also means that group composition does not depend on received signals or the subjects' decisions during the experiment. During the electronic chat, subjects can share their individual signals with others in the group. In stage III, then, the average subject is even better informed than in stage II. Assuming that a group efficiently aggregates all information (all group members report their signals truthfully), Bayes' rule gives the following probabilities for the states of the world in a group with members A , B and C :

$$p(S = 1|s_A = 1, s_B = 1, s_C = 1) = \frac{8}{9}$$

$$p(S = 1|s_A = -1, s_B = 1, s_C = 1) = \frac{2}{3}$$

$$p(S = 1|s_A = -1, s_B = -1, s_C = 1) = \frac{1}{3}$$

$$p(S = 1 | s_A = -1, s_B = -1, s_C = -1) = \frac{1}{9}$$

It should be noted that these probabilities are independent of the order of the signals in the signal profile s_A, s_B, s_C .

To avoid strategic reporting of information, we opt for group decisions by random dictatorship (Myerson, 1984). Under random dictatorship, each subject submits a decision for the group and one of these decisions is implemented with equal probability. This rule allows subjects to deviate as much, or as little, from their individual preference as they want. But even under this decision rule, there is no guarantee that subjects will honestly report their private information to others. For example, an extremely risk seeking subject might refrain from sharing information that would limit his fellow group members' desire for risk. We can use the chat logs from the electronic chat between subjects to find out if subjects misreport their signals to fellow group members during the experiment.

In stage IV, subjects make an individual decision, as in stages I and II. Since the state of the world S is valid for all stages, individual subjects can make use of the information contained in the signals received in the previous stages. Because decisions in stage IV only apply to the individual subject, comparing this decision to that in stage III indicates the difference between a subject's decision that only applies to herself, and a decisions that affects fellow group members as well. Under the assumption of no learning and no order effects, we interpret this difference as a measure of the impact of pay-off commonality. In related experimental settings, pay-off commonality in small groups has been shown to affect the aggregate level of risk-taking (Sutter, 2009), or intensify subjects' responses to extreme probabilities (Shupp & Williams, 2008; Baker et al., 2008).

5.3.2 Measuring polarisation

Moscovici & Zavalloni (1969) claim that “group consensus seems to induce (...) a change of attitudes in which subjects are likely to adopt a more extreme position” (Moscovici & Zavalloni, 1969, p. 130). Measuring polarisation thus inevitably starts with the selection of a neutral point with respect to which the extremity of subjects’ attitudes can be measured. Most researchers (including Moscovici & Zavalloni) have solved this problem by measuring attitudes on a scale with a zero score as neutral reference point in the middle. Although this approach works for hypothetically measured attitudes, in which subjects can self-calibrate with respect to the subjective neutral reference point, it is not feasible for incentivised decisions under risk. The reason is that there is no neutral reference point for risk attitudes that would apply to all subjects. The middle option in our choice set (#6) coincides with the risk neutral choice in stage I and thus seems a logical starting point, but this ignores the fact that the typical subject in experiments with monetary rewards is usually risk averse (Holt & Laury, 2002) and thus the pre-deliberation bias will be negative for the majority of subjects. Experimental procedures to induce risk neutrality in subjects have met with controversy and we choose to steer clear of them (Selten et al., 1999).

We solve the problem of measuring polarisation by controlling for information, starting with taking ‘zero information’ measurements of individual risk-taking in the first stage of the experiment. In subsequent stages of the experiment, we control for the earnings-relevant information that subjects receive. This approach is inspired by a theoretical treatment of group polarisation by Sobel (2012), who demonstrates how polarisation can arise as a result of rational aggregation of private information held by individual members of a group. We thus proceed under the assumptions that (i) subjects recognise that all task-relevant information is contained in the signals they receive during the experiment, (ii) subjects’ utility functions are monotonic and (iii) subjects understand that the probability of the good state of the world is increasing in the signal balance (the number of good signals received minus the number of bad signals received).

We thus use the decisions of subjects in stage I as a subjective neutral reference point. This neutral point controls for subjects' individual risk attitudes, provided that the measure of polarisation used is the difference between individual decisions in stages II and IV (instead of decisions in stage III, which may be affected by social preferences over risk). We thus define risk polarisation *at the individual level* as the number of subjects whose change in risk-taking from stage II to IV is in the same direction as the change from stage I to II. Depending on the information contained in individual signal s and the group's signal profile, polarisation at the individual level can be in line with subjects' information sets, or not. For example, it would be considered irrational for an individual subject to choose a riskier option compared to the previous individual decision if the information received since then has objectively decreased the probability p of a lottery win.

Defining risk polarisation *at the group level* is more difficult. If we consider the £10 sure pay-off at the top of table 5.3.1 as the subject's *endowment* in the experiment, we can view the options further down the table as representing a percentage of their endowment invested in an increasingly risky lottery. The mean value of a group's choices, then, expresses the average percentage of the endowment invested in the lottery by the group members. This average, measured in stages I, II and III, is our first measure of polarisation at the group level. This definition of polarisation comprises many complex patterns of behaviour. Consider a group in which all members invest 50% in stage I. In stage II, member 1 invests 45%, member 2 invests 50% and member 3 invests 60%. In stage IV, member 1 invests 65%, member 2 invests 50% and member 3 invests 45%. The individual behaviours of these group members do not confirm to the common conception of polarisation - rather, they are a combination of idiosyncratic shifts without a common direction. But, according to our definition of polarisation as a group behaviour measured at the mean of group choices, the group has polarised. A second point worth noting is that there is no value in making normative judgements about the response of the group average choice to a combination of signals, unless all subjects receive iden-

tical signals and should therefore update their beliefs in the same direction. We will therefore not define any behaviour at the group level as irrational - such behaviour is better assessed at the individual level.

As a second measure of polarisation at the group level, we follow the recommendation of some authors and take the median choice of the three subjects.² Again, stage I is the neutral point, stage II is the pre-deliberation measurement and stage IV the post-deliberation measurement. As in the case of mean group choice, defining polarisation by median group choice comprises many complex patterns of behaviour, and will not be used to judge subject's rationality in responding to probabilistic information. The advantage of using the median instead of the mean in a group of three subjects is that it is not sensitive to a single outlier - it is not possible for one group member to act as the 'polariser' of the whole group.

5.3.3 Procedure

All experimental sessions were carried out at the CeDEx computer laboratory at the University of Nottingham (Nottingham, UK). We used ORSEE (Greiner, 2004) to recruit our subjects. Our 84 subjects were (mostly undergraduate) students from various disciplines, who had previously registered for participation in economic experiments. Average subject earnings were £11.35, and the average session time was 40 minutes. The experimental software was programmed in z-Tree (Fischbacher, 2007) version 3.3.8.

At the start of the experiment, subjects were randomly assigned a seat in the laboratory. First, subjects were read instructions by the experimenter, explaining the two states of the world and their representation by two sets of three playing cards. The positive state of the world ($S = 1$) was represented by two black cards and one red card (referred to as *set A*); the negative state ($S = -1$) was represented by two red cards and

²As Abelson (1973) argues quite convincingly, using the median rather than the mean is a more robust measure of choice shifts, as the median is not affected by skewness in the distribution of individual preferred options.

one black card (*set B*).³ Both card sets were shown to the subjects and subsequently put in identical card packs. The card packs were put in an opaque bag, after which a volunteer subject blindly selected one of them from the bag. The selected pack was put on a shelf in a prominent position in the room and subjects were told its contents would be revealed at the end of the experiment.

In stage I, subjects were asked to pick one of the eleven options listed in table 5.3.1. Next, before stage II commenced, subjects were informed they would receive a single card draw with replacement (referred to as a *clue*) from the selected card pack that represented the state of the world. This draw was their private signal. An assistant experimenter visited each subject's cubicle, asked them to pick one card from the set and input its colour on the computer screen (black being $s = 1$ or the *positive signal*, red being $s = -1$ or the *negative signal*). The assistant experimenter then shuffled the card set before the next subject drew a card. During the signal draws, the main experimenter oversaw the room to ensure that subjects would only observe their own private signal. After all subjects had drawn their signal, subjects made a choice from the same eleven options in the pay-off table.

Stage III started with an explanation of the group setting, the rules of the on-screen chat and the random dictator mechanism. After the subjects had been given the opportunity to ask questions, they entered a computer chat session of 5 minutes. Subjects were identified as *subject #1*, *subject #2* and *subject #3* in the chat box, and they could communicate by entering free-form text messages on their keyboard. After the chat stage, subjects were presented with the decision screen similar to the previous stages, with the added reminder that one of the group members' decisions would be chosen at random to apply to the whole group. When all the subjects had submitted their decision, one of the decisions was chosen at random by the experimental software. The final computer screen of this stage showed subjects (i) the decisions that each of

³All the playing cards in sets A and B were aces of either hearts or clubs; this was common knowledge among the subjects.

the group members had made and (ii) which one of these would be implemented as a group decision.

Finally, stage IV presented the subjects with another choice from the 11 options in table 5.3.1. Although subjects could use the information they received from fellow group members in the previous stage, their decision in stage IV applied only to themselves. After stage IV, the experimenter publicly revealed the selected stage for pay-out and the state of the world. At the end of the experiment, all subjects completed a short questionnaire with demographic data and questions about the experiment.

5.4 Results

5.4.1 Private signals

Of our 84 subjects, 39 receive signals under state of the world $S = 1$ and 45 subjects under $S = -1$. Under the null hypothesis of unbiased signals with $Pr(s = S) = 2/3$, the expected signal frequencies are 13/26 for $S = -1$ and 30/15 for $S = 1$. The observed frequencies in our experiment are 11/28 and 33/12, and we cannot reject the null of unbiased signals for either state (Chi square goodness of fit test, both $p > 0.1$).

First, we look at how subjects respond to the private signals they receive. Of the subjects that receive the positive signal ($s = 1$), 4 out of 40 decrease their investment in stage II relative to stage I; of the subjects that receive the negative signal ($s = -1$), only 1 subject out of 44 increases her investment in stage II relative to stage I. If we assume that subjects choose according to true, stable risk preferences and understand that $s = 1$ ($s = -1$) signals a greater (smaller) chance of winning the lottery, these five subjects can be said to have acted irrationally. What is more likely, however, is that these subjects were simply trying to correct for an uncharacteristic level of risk-taking in stage I.⁴ Furthermore, the majority of the 84 subjects either adjust their risk-taking

⁴It is plausible that these five subjects thought they had taken too much risk in stage I and wanted

in stage II in the direction suggested by their private signal (45 subjects) or do not change their risk-taking from stage I to stage II (34 subjects). There is therefore no convincing evidence of irrational behaviour or misunderstandings of the relationship between private signals and the state of the world in the first stages of the experiment.

5.4.2 Information aggregation

We find no evidence of subjects misreporting their signal values. Apart from a single group, who seem to collectively misunderstand the informational value of pooling signals and are therefore excluded from subsequent data analysis, all subjects report their signals truthfully in the group chat.⁵ For the remaining 27 groups, signal profiles were distributed as follows: 5 uniformly positive groups, 8 mixed positive groups (two positive and one negative signals), 9 mixed negative groups (one positive and two negative signals) and 6 uniformly negative groups.

A second component of efficient information aggregation is that subjects trust the signals they receive from others. Trust in reported signals cannot be measured directly, but we can check for actions of subjects that contradict the signals they receive in the group chat. For example, if a subject learns that her fellow group members received two positive signals and she believes this to be true, she should revise the probability of winning the lottery upwards and increase (or keep constant) risk-taking relative to stage II. We find some evidence of subjects going against their group members' signals. Out of the 20 subjects whose two fellow group members receive positive signals, 3 subjects take less risk in stage IV; out of the 27 subjects whose two fellow group members receive negative signals, 3 subjects increase their risk-taking in stage IV. Although the

to correct for this by choosing a safer option in stage II. After all, there is no practice round before subjects make their first decision in stage I. Supporting this conjecture is the fact that all 4 'irrational' subjects took more risk than the average subject in stage I. The same reasoning could apply to the subject with a negative private signal who went against her signal by increasing her risk-taking from option 0 in stage I (below the stage average) to option 1 in stage II.

⁵In the group chat, one member of the excluded group 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.

majority of subjects responded to the signals by altering their risk-taking in the direction predicted by the information content of the signals (29 out of 47) or by keeping risk-taking constant (12 out of 47), a small part of the subjects acts in a way at odds with efficient information aggregation in their group.

Perhaps a lack of information aggregation will manifest itself in more subtle ways than subjects explicitly going against signals reported by others. We therefore check if, for a given group signal vector, subjects put more weight on their own signal than others. For example, if subjects in a mixed positive signal group (two positive and one negative signal) took more risk in stage IV when their own signal is positive rather than negative, this suggests that subjects put more weight on their own signal. It turns out, however, that there is no statistical evidence of such behaviour. We cannot reject the null of an equal distribution of stage IV choices for different private signals, both for mixed positive signal groups and mixed negative signal groups (two-tailed Mann-Whitney U tests, both $p > 0.1$).

5.4.3 Polarisation

First, we look at subjects whose risk-taking gets more extreme throughout the three individual choice stages (stages I, II and IV) of the experiment. In total, there are 6 subjects who take more risk in each subsequent individual stage (positive polarisers) and 7 subjects who take less risk in each subsequent individual stage (negative polarisers). Of the positive polarisers, 5 subjects are in groups with uniformly positive private signals and 1 subject has a positive private signal and is in a group with a mixed positive signal profile. Of the negative polarisers, 4 subjects are in groups with uniformly negative private signals, 2 subjects have negative private signals and are in groups with a mixed negative signal profile, and 1 subject is one of the subjects identified earlier as decreasing risk-taking after learning about two positive signals from his fellow group members. Out of the 13 polarising individuals, then, only one subject's polarisation is at odds with the information received from others in the group discussion.

Next, we consider polarisation at the group level using the group mean choice as the measure of group choice. Note that we still use choices from stage IV to measure the shift in risk-taking after stage II.⁶ Out of the 27 groups in the sample, there are 5 groups that polarise in the negative, risk averse direction, and 3 groups that polarise in the positive, risk seeking direction. Most of these groups have uniformly positive (2 out of 3 groups) or uniformly negative (3 out of 5 groups) private member signals. If the group median choice is used to measure polarisation, we find even less polarisation: 3 positively polarising group and 3 negatively polarising groups.

Of the 4 (6) groups with uniformly positive (negative) signal vectors, 2 (3) groups polarise, according to the more generous definition of group polarisation by group mean choice. This is exactly 50% of the groups with uniform signal profiles in the experiment. This figure is quite low, given that each subject in these groups first receives a private signal that should lead them to update their beliefs in favour of a particular state of the world, then receives even stronger evidence in favour of said state of the world in the form of two more identical signals from fellow group members. Why does the average group shift of choices between stages I-II and II-IV not confirm to polarisation? Of the 5 groups that did not polarise, some group averages fail to shift in the predicted direction after receiving the private signals in stage II, and other group averages fail to shift in the predicted direction after the information aggregation in stage III and IV. When we look at these averages in more detail, we find that the lack of polarisation is driven by inertia in 1 group (none of the subjects change their choice between stage I and II) and driven by an erratic choice of a single group member in the 4 other groups.

⁶The results reported in this section remain unchanged if we use choices from stage III. This is due to the high similarity between stage III and stage IV choices, which is discussed in the section on group effects.

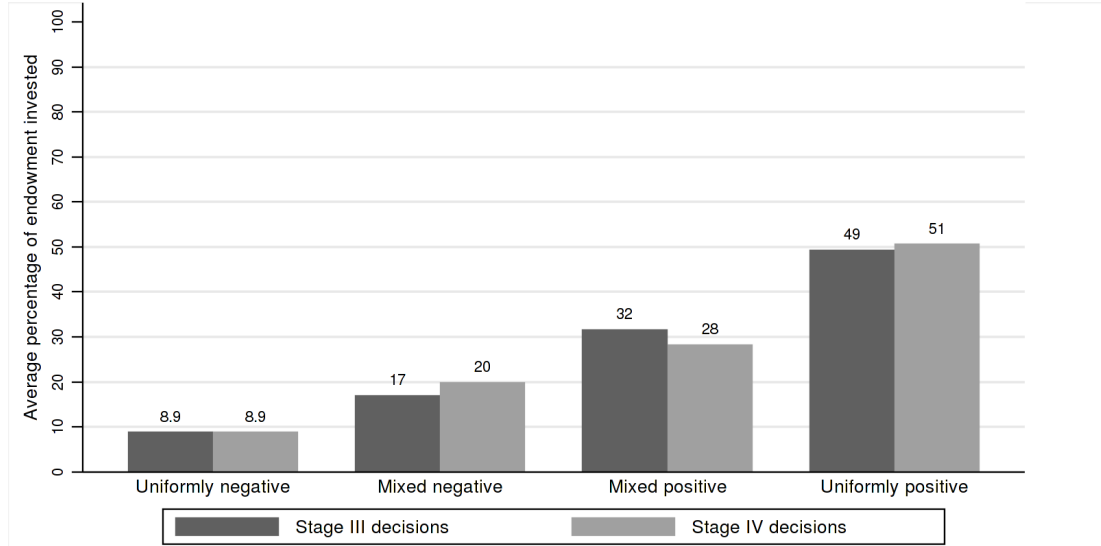
5.4.4 Group effects

Finally, we consider whether decisions made under the random dictator mechanism in stage III are different from individual decisions in stage IV. Subjects submit an individual choice in both stages but in stage III their choice, if randomly selected, will apply to two other group members as well. First, we note that the results on individual and group polarisation reported in the previous section are virtually unchanged when, instead of stage IV, stage III is used to measure post-deliberation choice. The only change in the previously reported numbers is the number of negatively polarising groups if polarisation is measured by group average (up to 6 from 5).

About half of the subjects (43 out of 81) submit the same choice in stages III and IV. This could be explained by subjects simply submitting their individual preference as their input for the random dictator mechanism, without considering the preferences of the other group members. But selfishness does not fully explain this behaviour, as 25 of these 43 subjects submit the exact same choice in stage III as their fellow group members. It seems that many subjects care about other group members' preferences, and use the electronic chat in stage III to coordinate choices and thereby resolve any uncertainty stemming from the random dictator mechanism. In all, 17 out of 27 groups agree on a consensus decision in stage III. The high degree of similarity of choices between stages III and IV thus indicates that choices under risk in the group context spill over into the subsequent individual choice. These spill-over effects are in line with findings in within-subjects experiments on decisions under risk (Baker et al., 2008).

Figure 5.1 shows the average choice (as expressed as a percentage of the £10 endowment) in stages III and IV, grouped by group signal profile (uniformly negative, mixed negative, mixed positive, uniformly positive). For groups with mixed signals, an interesting pattern emerges: investment in stage III is more extreme, in the direction of the probability indicated by the signal vector, than in stage IV. For groups with all negative signals, average investment is identical (8.9% in both stages). For groups with

Figure 5.1: Stage III and IV choices averaged by group signal profile, measured as a percentage of endowment invested. Uniformly negative groups are groups in which members only receive negative ($s = -1$) signals; Uniformly positive groups are groups in which members only receive positive ($s = 1$) signals. Mixed negative groups are groups with two negative and one positive signals; mixed positive groups are groups with two positive and one negative signals.



all positive signals, average investment is slightly higher in stage IV (55.8%) than in stage III (54.2%). None of the per signal profile differences between stages III and IV are statistically significant (two-tailed Wilcoxon signed ranks test, all $p > 0.1$).

5.5 Discussion and conclusion

We present an experimental test of the prediction of group polarisation in incentivised decisions under risk, by controlling for the information received by the subjects. Contrary to the predictions, we find that many groups in our experiment do not polarise. The rate of polarisation is 50% for groups in which all subjects receive the same information; a low figure given that subjects in these groups receive increasingly stronger information on the probability of a lottery win or loss. The lack of group polarisation is mostly due to an erratic choice by a single group member. It is surprising that an erratic choice by a single group member can prevent group polarisation, when the information

sets of all group members greatly favour polarisation. It is hard to pin-point the exact cause of this influence, although the fact that many subjects do not change their risk-taking very much is likely to have increased the influence of outliers on the mean choice in a group. The vast majority of choices in all stages were in the 0-50% range (options #1 to #6 in the choice table), even for groups that received three positive signals (2 out of 3 choices in stage IV). Perhaps an experimental design that leads subject to respond more uniformly and stronger to changes in the probability of winning would have lead to more group polarisation.

It could be that randomly allocating subjects to groups and trying to induce changes in risk preferences with signals is too artificial a context for group polarisation. It could be that the reported ubiquity of polarisation in the real world is largely due to self-selection into groups: people are not looking for groups to exchange information in, but for groups of like-minded individuals. The rational, information-based explanation of group polarisation does not capture such psychological motivations, and perhaps this is why its predictions perform so poorly in our experiment. To test this alternative explanation of group polarisation, an experimenter could seek to allocate subjects to groups based on their risk preferences, instead of randomly allocating them to groups. Self-selection into like-minded groups seems a promising avenue for future research on the social determinants of risk-taking. Another explanation of the lack of group polarisation in our experiment is that group polarisation is more prevalent in opinions about risky decisions than risky decisions themselves.

A striking result in our data is the high number of groups that reach a consensus in the group decisions with random dictatorship. Since this decision rule gives purely self-ish subjects an incentive to submit their own preferred option, it seems plausible that the majority of our subjects has risk preferences that are either (i) easily influenced by other group members or (ii) comprised of an individual and a social component, in that subjects care about risk borne by others as a result of their decision. Another explanation is that subjects do not like probabilistic risk (the lottery) compounded by

social risk (who will be the random dictator, i.e. whose choice will be implemented) and are eager to coordinate with others to remove one of these sources of risk. Very little experimental work has been done on the origins of, and conditions for, the emergence of group consensus on decisions under risk. Recent work on committee voting (Guarnaschelli et al., 2000; Ali et al., 2008) is a promising starting point.

Appendix A: Experimental instructions

Before stage I: 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 stage that will count for your earnings will now be randomly determined by the experimenter.

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.

Before stage II: Before continuing to stage 2, each person will 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.

Stage II: 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.

Note: 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.

Appendix B: Experimental software screenshots

Figure 5.2: Stage I decision screen

Time remaining [sec]: 297

Stage 1

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.

	Earnings in £ if set A was selected	Earnings in £ if set B was selected
<input type="radio"/> 1	10.00	10.00
<input type="radio"/> 2	9.00	12.80
<input type="radio"/> 3	8.00	15.40
<input type="radio"/> 4	7.00	17.80
<input type="radio"/> 5	6.00	19.60
<input type="radio"/> 6	5.00	20.80
<input type="radio"/> 7	4.00	21.60
<input type="radio"/> 8	3.00	22.40
<input type="radio"/> 9	2.00	22.80
<input type="radio"/> 10	1.00	23.20
<input type="radio"/> 11	0.00	23.60

Figure 5.3: The private signal input screen before stage II

NOTE: Please DO NOT SELECT OR CLICK anything on this screen until an experimenter tells you to.

Before continuing to stage 2, each person will 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.

Your clue Red
 Black

Figure 5.4: Stage II decision screen

Time remaining [sec]: 273

Stage 2:
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.

Your clue was: Red

	Earnings in £ if set A was selected	Earnings in £ if set B was selected
<input type="radio"/> 1	10.00	10.00
<input type="radio"/> 2	9.00	12.80
<input type="radio"/> 3	8.00	15.40
<input type="radio"/> 4	7.00	17.80
<input type="radio"/> 5	6.00	19.60
<input type="radio"/> 6	5.00	20.80
<input type="radio"/> 7	4.00	21.80
<input type="radio"/> 8	3.00	22.40
<input type="radio"/> 9	2.00	22.80
<input type="radio"/> 10	1.00	23.20
<input type="radio"/> 11	0.00	23.60

Figure 5.5: Stage III group chat screen

Time remaining [sec]: 267

Stage 3:

You can use the chat box on the left of your screen to communicate with the other group members for the next 5 minutes. On the screen after the chat you must choose one of the 11 options from the table on the right of your screen. One of your group members' three decisions will be randomly selected - this selection will determine the earnings of all group members for this stage.

You are group member: 2
Your clue was: Red

Member #2: My clue is red
Member #2: yours?

	Earnings in £ if set A was selected	Earnings in £ if set B was selected
1	10.00	10.00
2	9.00	12.80
3	8.00	15.40
4	7.00	17.80
5	6.00	19.60
6	5.00	20.80
7	4.00	21.60
8	3.00	22.40
9	2.00	22.80
10	1.00	23.20
11	0.00	23.60

Figure 5.6: Stage III decision screen

Time remaining [sec]: 297

Stage 3:
 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.

Your clue was: Red

	Earnings in £ if set A was selected	Earnings in £ if set B was selected
<input type="radio"/> 1	10.00	10.00
<input type="radio"/> 2	9.00	12.80
<input type="radio"/> 3	8.00	15.40
<input type="radio"/> 4	7.00	17.80
<input type="radio"/> 5	6.00	19.60
<input type="radio"/> 6	5.00	20.80
<input type="radio"/> 7	4.00	21.60
<input type="radio"/> 8	3.00	22.40
<input type="radio"/> 9	2.00	22.80
<input type="radio"/> 10	1.00	23.20
<input type="radio"/> 11	0.00	23.60

Note
 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.

Figure 5.7: Stage IV decision screen

Time remaining [sec]: 289

Stage 4
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.

Your clue was: Red

	Earnings in £ if set A was selected	Earnings in £ if set B was selected
<input type="radio"/> 1	10.00	10.00
<input type="radio"/> 2	9.00	12.80
<input type="radio"/> 3	8.00	15.40
<input type="radio"/> 4	7.00	17.80
<input type="radio"/> 5	6.00	19.60
<input type="radio"/> 6	5.00	20.80
<input type="radio"/> 7	4.00	21.80
<input type="radio"/> 8	3.00	22.40
<input type="radio"/> 9	2.00	22.80
<input type="radio"/> 10	1.00	23.20
<input type="radio"/> 11	0.00	23.60

Chapter 6

Conclusion

This thesis contributes to the literature on group decision making under risk with three novel experiments and a literature review that combines a previously unlinked body of cross-disciplinary evidence. The results presented in the preceding chapters thus increase our understanding of how groups make decisions under risk from the perspective of the experimental economist, with risk-taking measured over real incentives in a controlled setting, without ignoring the field's strong ties to the psychology literature.

The three experiments shed light on the role of group communication, group composition and information sharing for risk-taking by groups. In chapter three, we present evidence of peer effects on risk-taking after subjects consult with each other, although these peer effects are of a different nature than the choices made by groups. These results suggest that different types of peer influence may exist between subjects in the same experimental design, and that pay-off commonality between group members is an important part of what defines a group's decision.

In chapter four, we show that international diversity of group members does not affect risk-taking by groups in an abstract investment task, and we suggest various reasons why this finding is at odds with the existing theoretical literature and small body of empirical results on team diversity. We also find a strong effect of gender composition: groups with more females are more risk averse. The gender composition effect appears

to be driven by the interaction of group discussion with an underlying demographic effect on risk preferences, as it is equally strong in a treatment with discussion by on-screen computer chat.

In chapter five, we test the theoretical prediction that group polarisation arises after subjects receive private information and share this information with fellow group members. Rates of polarisation are low - only half of the the groups strongly predicted to display polarisation actually polarise - and the lack of polarisation is mainly due to idiosyncratic decisions by a single group member. The group discussion stage of the experiment has a big effect on decisions - many subjects display social preferences over risk by co-ordinating their choices under a random dictator group decision rule with fellow group members. Furthermore, group stage decisions have a strong effect on subsequent individual decisions, in line with other results from the experimental literature reviewed in chapter two.

Group decision making under risk has been an active field of research in recent years, and we think it will continue to offer exciting opportunities for future research. In the concluding remarks of chapter two, we propose that researchers go beyond comparisons between individuals and groups, and suggest that group institutions and group composition are two important variables that merit further investigation. With an eye on practical applications, we think that field research can be especially valuable. Another opportunity for further research lies in the design of theories of group decision making in accord with the experimental findings we have reviewed and presented.

Finally, we note that the experimental studies in this thesis could be extended in various ways. The process of ‘consultation’ introduced in chapter two has many different implementations - an obvious manipulation would be incentivise subjects to give each other profitable advice, thereby introducing a measure of pay-off commonality. Another interpretation of consultation is professional advice, in which the consultant is not a peer of the consultee, but a supposedly independent party paid to provide expert advice. Some

work has already been done on this topic, with a focus on financial advice. Second, the experiment on group composition in chapter three could be repeated in other settings. One possibility is more context-heavy or complex settings, in which efficient communication is key to understanding the risks involved; it is possible that certain degrees of diversity or unfamiliarity between group members would affect risk-taking in such settings. An alternative interpretation of our results on group composition is that students educated at internationally focused universities have better cross-cultural communication skills than older generations - this is an hypothesis that can be tested. Third, more work can be done on the importance of the group polarisation phenomenon in decisions under risk. Our results suggest that extreme risk-taking or caution in groups is not widespread, even when Bayesian updating suggests it should be. Perhaps endogenous group formation or a more context-heavy setting would bring out more polarisation in groups. Alternatively, we do not exclude the possibility that group polarisation is more prevalent in opinions about risky decisions than risky decisions themselves.

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