Are individuals more risk and ambiguity averse in a group environment or alone? Results from an experimental study

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Abstract

Most decision-making research in economics focuses on individual decisions. Yet, we know, from psychological research in particular, that individual preferences can be sensitive to social pressures. In this paper, we study the impact of a group environment on individual preferences for risky (i.e., known probabilities) and ambiguous (i.e., unknown probabilities) prospects. In our experiment, each participant was invited to make a series of lottery-choice decisions in two different conditions. In the *Alone* condition, individuals made private choices whereas in the *Group* condition, individuals belonged to a three-person group and group-members' choices were aggregated according to either a majority or unanimity rule. This design allows us to study the impact of a group environment on individuals' attitude towards both risky and ambiguous prospects while controlling for the decision rule used in the group. Our experimental results show that when individuals are in the *Group* condition, they tend to be less risk averse and more ambiguity averse than when they are not part of a group (*Alone* condition). Our experiment also suggests that the decision rule matters as it shows that these two trends tend to be stronger when the group implements a unanimity rule. Specifically, we found that individuals who belong to a group implementing a unanimity rule are significantly less risk averse than individuals who belong to a group that relies on the majority rule. We obtained a similar – but non-significant – result under ambiguity.

Keywords: group, unanimity, majority, preferences, risk, ambiguity.

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Introduction

Most experimental research on decision-making has focused on individual decisions and individual attitudes to risk and ambiguity, and has neglected the study of social influence on these decisions and preferences (Trautman and Vieider 2011). Yet, we know from psychological research in particular, that groups can exert different types of influence on individuals and that individuals can behave differently in a group environment and in a private setting (see e.g., Ambrus et al. 2009; Trautmann and Vieider 2011 for overviews). Studying group influence on individual decisions is therefore of utmost important, not least because in many economic and business contexts, decisions are made by individuals (e.g., senior managers) who operate in a group environment (e.g., top management teams).

A growing literature in economics precisely attempts at better understanding how individuals make decisions in a group environment (Harrison et al. 2007; Masclet et al. 2009; Viscusi et al. 2011). Importantly, this literature differs from the literature on group decision making, which focuses on situations where a whole group makes a unique decision after deliberation (Blinder and Morgan 2005; Kocher et al. 2006; Baker et al. 2008; Shupp and Williams 2008; Ambrus et al. 2009; Sheremata and Zhang 2010; Deck et al. 2012; Zhang and Casari 2012). A main conclusion from the emerging body of literature on individual decisions made in a group environment is that individuals are more risk averse when they are in a group setting that when they are alone (see, e.g., Masclet et al. 2009).

However, we still know very little about the forces driving this result. Some papers suggest that a factor such as the probability of gain impacts on individual's attitude to risk. For instance, Masclet et al. (2009) reported that when the probability of gain is low,

individuals who do not belong to a group are less risk averse than individuals who belong to a group. In addition, a critical review of the existing literature suggests that the nature of the collective decision rule that the group uses to aggregate individual preferences might matter. For instance, Harrison et al. (2007) found no difference between attitudes towards risk reported by individuals who belong to a group and by individuals who do not belong to a group. This result is somewhat at odd with results from other studies, such as Masclet et al. (2009). But, in their study, Harrison et al. (2007) used a majority decision rule, whereas Masclet et al. (2009) had used a unanimity rule.

The purpose of this paper is to complement prior economic research on the impact of a group environment on individuals' decisions by testing for the effect of two variables, namely, the type of decision rule (majority vs. unanimity), and the source of uncertainty (risk vs. ambiguity). In other words, we ask the following questions: Do individuals in a group environment exhibit attitudes to risk and ambiguity that differ from the one they exhibit when they are alone? Does the decision rule used in the group matter? Our research therefore also contributes to ambiguity research (Wakker 2010), which so far has mainly focused on individuals' attitudes towards ambiguity and has neglected group influence (see Curley et al. (1986), and Trautman et al. (2008) for two noticeable exceptions).

To test for the effects of these two variables on individuals' decisions, we created an experiment in which the participants faced a series of lottery-choice decisions (under both risk and ambiguity) and had to make choices *Alone* and as part of a three-person *Group*. In both cases, the participants provided their individual choices – that we used to estimate their individual attitude to risk and ambiguity. Yet, in the group environment, the participants had to report their individual choices knowing that such choices would then be combined with the choices of the other two group-members, using either a majority or a unanimity rule. Group members received information about the other group members' choice, but they could not talk

to each other prior to making their decisions. This design thus allows focusing on the sole effect of normative influence of groups on individual decisions, and discards the possibility of any informational influence (Ambrus et al. 2009).

Our experimental results first show that a group environment decreases individuals' degree of risk aversion. We indeed found that when individuals are in a group environment (*Group* condition), they tend to be *less* risk averse than when they are not part of a group (*Alone* condition). Second, our study shows that the effect of the group environment on individual attitudes to ambiguity is different from its effect on individual attitude to risk. We indeed found that individuals in a group environment tend to be *more* ambiguity averse than individuals who are not part of a group environment. Third, our experiment shows that the decision rule (majority vs. unanimity) matters as we found that a group's influence on individuals' attitude to risk and ambiguity is stronger when the group implements a unanimity rule than when it implements a majority rule. Specifically, we found that individuals who belong to a group implementing a unanimity rule are less risk averse than individuals who belong to a group that relies on the majority rule. We obtained a similar – but non-significant – result under ambiguity.

The article is structured as follows. Section 1 describes the experiment. Section 2 is devoted to experimental results while Section 3 contains the discussion and conclusion.

1. **Experiment**

To address our research questions on the effect of a group environment on individual attitudes to risk and to ambiguity, we designed an experiment which had four main characteristics. First, in our experiment, all our participants made a series of lottery-choice decisions under two different sources of uncertainty, namely risk – where the probabilities of the lotteries are known – and ambiguity – where the probabilities of the lotteries are imprecise. Second, all our participants answered the same series of 10 risky (resp.

ambiguous) lottery choices in two different conditions: in one condition, the participants were part of a three-person group (hereafter "*Group* condition") and they received information about the other group-members choices, whereas in the other condition, the participants were not part of a group, and their decisions were thus entirely private (hereafter "*Alone* condition"). The order of presentation of this variable was randomized in order to minimize potential order effects (i.e., some participants faced the *Alone* condition first, whereas other participants faced the *Group* condition first). Third, in the *Group* condition, we introduced two treatments: some participants belonged to a group implementing a majority decision rule (hereafter *Majority group* treatment), while other participants were assigned to a group using a unanimity decision rule (hereafter *Unanimity group* treatment). Fourth and finally, when answering the series of lottery choices in the *Alone* condition, the order of presentation of the uncertain context was random (i.e., some participants started with the risky lotteries whereas other participants started with the ambiguous lotteries). In the *Group* condition, due to matching constraints, all participants started with risky prospects followed by ambiguous prospects.

1.1 Decisions under Risk: The Multiple Price List Procedure

We used the Multiple Price List (MPL) procedure of Holt and Laury (2002) to elicit attitudes towards risk. This procedure is one of the most common approaches used to elicit risk attitudes (Harrison et al. 2005; Holt and Laury 2005; Andersen et al. 2006). As Table A.1 in the Appendix shows, in this procedure, each participant is presented with ten sequential choices between two lotteries. For each binary choice, the participant has to choose between a safe lottery (option A) and a risky lottery (option B). By definition, a risk-neutral subject switches from one type of lottery to the other one when the two lotteries have the same expected value. In Table A.1, the risk neutrality threshold is 4 (i.e., risk-neutral subjects switch between the fourth and fifth choices).

Decision context (Alone vs. Group). In the *Alone* condition, the participants had to make 10 sequential choices, as explained above. This was a typical MPL task. In the *Group* condition, we randomly created three-person groups. We used a computerized procedure similar to that of Masclet et al. (2009) where each group member indicated, through the computer, his/her individual choice for each of the ten choices, to the other group members. The members of the group could not communicate prior to making their choice but once each group member had made his/her choice, these choices were made public to the other group members. The three choices were then combined according to the pre-determined rule (majority or unanimity). It is important to notice that the participants were randomly allocated to a different three-person group for each of the 10 lottery choices of the MPL procedure. Each participant therefore completed the 10 binary choices of the MPL procedure (in the same order as in the *Alone* condition) in 10 different three-person group environments. The fact that the composition of the groups changed after each binary choice is not an issue in our experiment because we compare the choices made by individuals as part of a group and alone.[1] In addition, because we focus on the normative influence of groups (Ambrus et al. 2009) – and not their informational influence as deliberation amongst group members was not possible – the identity of the group members is not at stake and what matters is the social influence that groups (whatever their composition) exert on individuals' attitude to risk. Note that the decision context is a within-subject variable, which means that all our participants were exposed to both the *Alone* and the *Group* conditions.

Decision rule (Majority vs. Unanimity). In the *Group* condition, some participants were in the *Majority group* treatment while others were in the *Unanimity group* treatment (between-subject variable). The experimental protocol is slightly different for these two

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[1]   Masclet et al. (2009) also reshuffled the groups after each binary choice in order to avoid reputational effect. If the groups are fixed for 10 choices, we cannot control for collusion or sanction.

groups of participants, in order to accommodate for the specificity of the group decision rule. In the *Majority group* treatment, because we had three-person groups, and binary options, the computer could always combine the group-members choices in order to compute the group choice. For instance, even if two group members have different preferences (i.e., one group member chooses the option A, whereas the other group member chooses the option B), whatever the decision of the third group member, the computer can compute the group choice. In the *Unanimity group* treatment, on the contrary, not all configurations of individual preferences allow the computer to implement the decision rule successfully. We therefore implemented an iterative process. For each binary choice, group members could play up to five trials. When the output of a trial is a unanimous decision – i.e., the three members chose the same option – the participants were made aware that a unanimous decision had been reached, and they were assigned to another group to address the next binary choice of the MPL procedure. If no unanimous choice was reached, each participant was made aware of the choices of the other group members, and was asked to address the same binary choice in a new trial. At the end of the fifth trial, if no unanimous decision had been reached, the computer announced that result to the group members, and each participant was assigned randomly to another group to answer the next binary choice of the MPL procedure.

It is noteworthy that there is a main difference between the two decision rules in our experiment: individuals assigned to a group implementing a unanimity rule have no guarantee that an unanimous decision will be reached (even after five trials), whereas the majority decision can always be reached in just one trial because we have three-person groups and a binary choice. The iterative process in the unanimity rule case is almost an intrinsic characteristic of this type of rule, as it would not make sense to implement such a rule without allowing the participants to iterate and perhaps converge towards a unanimous decision after a series of trials. This specificity of the unanimity rule also allows us to have a richer

understanding of group influence on individual attitudes towards risk and ambiguity, because we can study the dynamics leading towards a unanimous decision. We analyse the results associated to this methodological choice in sub-section 2.3.

Individual's risk attitude. The analysis of individual decisions under risk is composed of two parts. First, we realize a model-free analysis about individual decisions under risk. Specifically, our analysis focuses on switching points (i.e., the points when the individuals change their preferences between the gambles situated on the right and left columns). Second, we also quantify risk preferences assuming expected utility[2] with power utility (see for instance, Gollier 2011; Akay et al. 2012). More precisely, to quantify the relative risk aversion parameter of each participant's utility function, we used a Constant Relative Risk Aversion (CRRA) characterisation of risk attitudes, with $U(x) = x^{(1-r)}/(1-r)$, for $x > 0$, where $r \neq 1$ is the CRRA coefficient (see parameter r in Table 1). The switching point in the MPL list provides a direct inference of a CRRA index interval.

1.2 Decisions under ambiguity: Chakravarty and Roy's (2009) procedure

Two main types of procedure exist to elicit decision-makers' attitudes towards ambiguity: model-free procedures (Cohen et al. 2010), and procedures rooted in a specific theoretical model (Halevy 2007), such as Chakravarty and Roy's (2009) procedure, which is consistent with Klibanoff, Marinacci and Mukerji's (2005) model (hereafter KMM). In this research, we used Chakravarty and Roy's (2009) procedure (hereafter CR) because it extends Holt and Laury's (2002) procedure (MPL) to ambiguity. Specifically, CR's procedure mimics the MPL

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[2]   From its earliest days, expected utility theory has met several criticisms, leading the Prospect theory to become the best-supported alternative (Wakker 2010). However, estimation of more flexible functions requires more information and therefore more complex elicitation procedures (Abdellaoui 2000). In addition, there is also evidence showing that EUT is as good as PT to characterize behaviors (Harrison and Ruström 2009; Couture and Reynaud 2009). Finally, in the context of choice under uncertainty, expected utility theory has provided the most detailed and richest body of applications so far (Camerer 1995).

procedure in that it asks participants to make a series of 10 choices between a non-ambiguous (or risky) prospect, and an ambiguous prospect. Asking individuals to make a decision between a non-ambiguous prospect and an ambiguous prospect is the most common approach in economics to study attitude to ambiguity (see, e.g., Camerer and Weber 1992; Halevy 2007; Akay et al. 2012).

Table A.2 in the Appendix shows the series of ten sequential choices that the participants faced. Each choice consists of a non-ambiguous option (option A) and an ambiguous option (option B). In this table, an ambiguity-neutral subject is indifferent between the two options at the fifth binary choice. It is noteworthy that – as in the risky context – all the participants answered the series of ten sequential binary choices twice, once in the *Alone* condition, and once in the *Group* condition.

Decision context (Alone vs. Group) and decision rule (Majority vs. Unanimity). The procedure to create the three-person group and the system of iterations are similar to those used in the risk context (see the sections above).

Individual's ambiguity attitude. As in the risk context, the analysis of individual decisions under ambiguity is composed of two parts. First, we conducted a model-free analysis of individual decisions under ambiguity through the analysis of switching points. Second, we specified a theoretical model to further analyzed individuals' attitude to ambiguity. Specifically, we used the smooth ambiguity model of Klibanoff et al. (2005). [3] We choose this model for two reasons. First, this model introduces a simple and easily interpretable way to capture ambiguity aversion and it is popular in economics today (see e.g., Treich 2010; Gollier 2011; Brunette et al. 2012). Second, it differentiates attitudes towards risk from

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[3]   Despite the fact that there is a rich and still growing literature on modeling ambiguity attitudes, empirical evidence on the relative performance of these different models is still scarce (see e.g., Etner et al. 2012; Baillon and Bleichrodt 2013 for systematic reviews). Recent experimental studies nonetheless suggest that, despite heterogeneity of behaviour among individuals, the smooth ambiguity model of Klibanoff et al.

attitudes towards ambiguity. Specifically: $KMM(x) = E\varphi(EU(x))$, where the function U characterises the participant's attitude towards risk and the function φ characterises his/her attitude towards ambiguity. Second, Chakravarty and Roy's (2009) procedure is rooted in the KMM model – and in this procedure, the number of non-ambiguous lottery choices sets the bounds for the ambiguity aversion parameter (see the *s* parameter in Table 3).

1.3. Participants and incentives

The experiment was conducted at the Laboratory of Forest Economics in Nancy (France), in October 2009. Sixty students (31 men and 29 women; average age = 21.5 years) were recruited from different study programmes. Four sessions of 15 students were run, so that each treatment (Majority and Unanimity) contained 30 participants. The experiment was computerized and scripts were programmed using the z-tree platform (Fischbacher 2007). Each session lasted approximately two hours and ended with a short demographic survey including questions about the participants' age, sex and professional activity.

At the end of the experiment, the computer randomly selected two choices, one from the *Alone* condition and one from the *Group* condition. When the computer selected a binary choice question in the *Group* condition (with a unanimity rule) where no group choice was possible, the programme randomly selected another binary choice question up to select a binary choice question for which a group choice existed.[4] For each of these two randomly selected choices, the computer determined the participant's payoffs. The sum of the two payoffs represented the final payment of the respondent. In our experiment, the payments of subjects varied between 0 and 26 Euros with an average of 11 Euros.

(2005) is the model that best captures individual behaviors under ambiguity (e.g., Halevy 2007; Ahn et al. 2009; Andersen et al. 2009; Hayashi and Wada 2010).

[4] In Masclet et al. (2009), the computer programme randomly selected one of the two possible options. Zhang and Casari (2012) associated a zero payoff to disagreement, a procedure known as « strong unanimity ». In our experiment, we decided to adopt a different approach, and did not force agreement nor used the 'strong unanimity' approach so that the final payoff really reflects the choices the participants made.

2. Experimental results

First, we compare participants' risk and ambiguity preferences in the *Alone* condition with their risk and ambiguity preferences in the *Group* condition (within-subject variables) (Section 2.1). Second, we compare participants' attitudes to risk and ambiguity in a *Group* environment under a majority rule and under a unanimity decision rule (Section 2.2). Finally, we extend the analysis by studying the determinants of individual decisions made in group with a unanimity rule (section 2.3) and the link between risk aversion and ambiguity (section and 2.4).

2.1 Individual decisions made alone and as part of a group

Individual decisions under risk. Table 1 provides information on the choice frequencies for individual decisions made in the *Alone* and *Group* conditions. Consistent with previous works' results (see Holt and Laury 2002; Masclet et al. 2009), most players are risk averse and choose on average more than four safe options (around 77% in the *Alone* condition, and 75% in the *Group* condition). A One-sample Wilcoxon signed-rank test shows that the number of safe choices is significantly different from the neutrality threshold of 4 safe choices in both conditions ($z = 5.847$ and $p = 0.000$ in the *Alone* condition; $z = 5.937$ and $p = 0.000$ in the *Group* condition). This means that our participants exhibit risk-aversion in both the *Alone* and *Group* conditions.

INSERT TABLE 1

More, the number of safe choice is slightly lower in the *Group* condition (5.38) than in the *Alone* condition (5.67) but this difference is not statistically significant (Wilcoxon related-samples signed-rank test: $z = -1.535$ and $p = 0.125$). Figure 1 shows the proportion of safe option A for each of the ten decisions.

INSERT FIGURE 1 HERE

The dashed line shows predicted behaviour for a risk-neutral participant: s/he chooses A for the first four decisions, and subsequently B. In the *Group* condition, and for most of the decisions, participants tend to exhibit lower levels of risk aversion than in the *Alone* condition. However, a Related-Samples Friedman's Two-way analysis of variance by ranks test cannot reject the null hypothesis of equal distributions between the individual decisions in the *Alone* and *Group* conditions (p = 0.123). This result is in line with the Wilcoxon test result above, and confirms the finding that in our experiment individual attitudes to risk were not significantly impacted by the group environment.

Table 2 provides the results of a random effect probit model with the safe choice (option A) as the dependent variable.

INSERT TABLE 2 HERE

These results show that *Age* has no significant effect on the probability of choosing the safe option, which is consistent with Masclet et al. (2009). In addition, we found that being a man significantly reduces the probability of choosing the safe option (see the negative coefficient associated to *Gender*). This result is in line with past research showing that on average women are more risk averse than men (Eckel and Grossman 2008). The coefficient associated to the variable representing the group decision rule (*Rule*), is negative and significant, which means that the unanimity rule (vs. the majority rule) has a negative effect on the probability of choosing the safe option. Then, individuals who are part of a *Unanimity group* treatment are significantly less risk averse than individuals who are in the *Majority group* treatment. We also found that the probability of choosing the safe option falls as the probability of the higher payoff increases (*Prob*) and increases when individuals are in the *Group* condition (*Alone_Group*). Last, we found that the coefficient associated with the interaction variable

"*Prob*Alone_Group*" is negative and significant, showing that individuals in the *Group* condition become progressively less risk-averse as the probability of the higher payoff rises. This result may be decomposed in two effects. First, if the probability of the higher payoff increases, then the probability of choosing the safe option falls. Second, in the MPL procedure, a higher number of safe choices is associated to a higher level of risk aversion, so that, a reduction in the probability of choosing the safe option corresponds to a lower degree of risk aversion. This last result thus confirms our previous findings.

Individual decisions under ambiguity. Experimental studies have usually studied attitude to ambiguity in "private" settings and have reported that individuals are ambiguity-averse or ambiguity-neutral in the gain domain (Camerer and Weber 1992; Di Mauro and Maffioletti 2004; Chakravarty and Roy 2009; Wakker 2010). The few papers who studied individuals' attitude to ambiguity in a group environment have reported that ambiguity aversion increases because of the fear of negative evaluation by others (see, e.g., Curley et al. 1986; Trautmann et al. 2008). Our results tend to support this trend. However, in our experiment, the effect of the group environment on individual attitude to ambiguity is not always significant, as we explain below.

INSERT TABLE 3

First, we found that both in the *Alone* and *Group* conditions, the participants were significantly averse to ambiguity. As table 3 shows that the mean numbers of non-ambiguous choices are consistently greater than five – the ambiguity neutrality threshold in the CR procedure. In addition, a one-sample Wilcoxon signed-rank test confirms that ambiguity aversion is significant in both conditions (z = 3.094 and p = 0.002; z = 2.978 and p = 0.003 respectively).

Second, table 3 shows that the proportion of ambiguity averse individuals is slightly higher in the *Group* condition (46.6%) than in the *Alone* condition (43.3%), which suggests that a group environment increases ambiguity aversion, as previously reported in Trautmann et al. 2008 for instance. Figure 2, which reports the proportion of non-ambiguous choices for each of the ten decisions, gives further information about this trend. The dashed line represents predicted behaviour for an ambiguity-neutral participant: s/he chooses A for the first five decisions, and subsequently B. We can see that individuals in the *Group* condition tend to report higher levels of ambiguity aversion for most of the decisions, except for non-ambiguous lotteries with smaller payoffs. A Related-Samples Friedman's Two way analysis of variance by ranks test however, cannot reject the null hypothesis of equal distributions between the two distributions (*Alone* and *Group* conditions) (p = 0.546). More, a Wilcoxon related-samples signed-rank test reveals no significant difference between the two mean numbers of non-ambiguous choices.

INSERT FIGURE 2 HERE

Third, to complement these analyses, we ran a random effect probit model using the non-ambiguous choice (option A) as the dependent variable. Table 2 reports the results of this model. It shows that two standard demographic variables (*Age* and *Gender*) do not significantly affect the probability of choosing the non-ambiguous option. Table 2 also shows that the coefficient associated to the variable representing the collective decision rule (*Rule*), is negative but non-significant (p = 0.115), which means that individuals in the *Unanimity group* treatment tend to be less ambiguity averse than individuals in the *Majority group* treatment, but this effect − which is similar to the effect observed under risk − is not statistically significant. We also found that the probability of choosing the non-ambiguous option falls when decisions are made in groups (Alone_Group) and increases as the higher

payoff of non-ambiguous option increases (Payoff). Last, and importantly the interaction variable "Payoff*Alone_Group" has a significant and positive coefficient, showing that individuals in the *Group* condition become more ambiguity-averse as the higher payoff of non-ambiguous option increases. Two effects may explain such a result: i) if the higher payoff of the non-ambiguous option increases, then the probability of choosing the non-ambiguous option rises; and ii) in CR's procedure, an increase in the probability of choosing the non-ambiguous option is associated to a higher level of ambiguity aversion. This last result validates our conclusion.

2.2 The decision rule in the *Group* condition

In this section, we focus on the decisions that our participants made in the two treatments (Unanimity vs. Majority) that we implemented in the *Group* condition in order to unpack the effect of the decision rule on individuals' attitude to risk and ambiguity.

Individual decisions under risk. Under the *Unanimity group* treatment, individuals made on average 5.40 safe choices when they were alone and 4.97 safe choices when they were in the group environment. A Wilcoxon related-samples signed-rank test reveals that this difference is significant ($z = -2.077$ and $p = 0.038$). Under the *Majority group* treatment, individuals made on average 5.93 safe choice when they were alone, and 5.80 safe choices when they were in the group environment, but the difference is not significant (Wilcoxon related-samples signed-rank test : $z = -0.303$ and $p = 0.762$). Thus, when they are in the *Unanimity Group* treatment individuals are found to be significantly less risk-averse than when they are in the *Alone* condition, while when they are in the *Majority group* treatment, this trend is also visible, but it is not significant.

Moreover, in our experiment, individuals in the *Majority group* treatment made an average 5.80 non-risky choices, while, individuals in the *Unanimity group* treatment made

4.97 non-risky choices on average. Thus, in both treatments, most of players choose on average more than four safe options, which means that they are risk averse. A One-sample Wilcoxon signed-rank test confirms that risk aversion is significant ($z = 4.606$ and $p = 0.000$ in the *Majority group* treatment; $z = 3.796$ and $p = 0.000$ in the *Unanimity group* treatment). This result is consistent with previous works' results (see Harrison et al. 2007 for the majority rule; Masclet et al. 2009 for the unanimity rule). Importantly, a further tests also shows that participants in the *Majority group* treatment are significantly more risk averse (5.80) than participants in the *Unanimity group* treatment (4.97) (Mann-Whitney U test: $z = -2.989$ and $p = 0.003$).

Individual decisions under ambiguity. Under the *Unanimity group* treatment, individuals made on average 5.37 non-ambiguous choices when alone, and 5.20 non-ambiguous choices when in a group environment. However, a Wilcoxon related-samples signed-rank test reveals that this difference is not significant ($z = -0.340$ and $p = 0.709$). Under the *Majority group* treatment, individuals made on average 6.10 non-ambiguous choices when alone, and 5.63 non-ambiguous choices when in a group environment. Again, the difference is not significant (Wilcoxon related-samples signed-rank test: $z = -1.513$ and $p = 0.130$). Individuals in group (whatever the decision rule) thus tend to be less ambiguity-averse than individuals alone but the effect is not statistically significant.

In the *Majority group* treatment, individuals made an average of 5.63 non-ambiguous choices, which is significantly higher than the neutrality threshold of five non-ambiguous choices (One-sample Wilcoxon signed-rank test: $z = 2.863$ and $p = 0.004$). In the *Unanimity group* treatment, we observe that individuals made on average 5.20 non-ambiguous choices, which is higher than the neutrality threshold but the difference is not significant (Wilcoxon one-sample signed-rank test: $z = 1.177$ and $p = 0.239$). In other words, we found that

individuals who belong to a group tend to be ambiguity-averse but ambiguity aversion is statistically significant in the *Majority group* treatment only. This suggests that the majority rule generates more ambiguity aversion than the unanimity rule. However, a Mann-Whitney U test shows that the difference between 5.63 and 5.20 is not significant ($z = -1.301$ and $p = 0.193$).

2.3 Determinants of individual decisions made in the unanimity group treatment

In the *Unanimity group* treatment, each group had up to five iterations to reach a unanimous decision on each of the 10 binary choices. We consider the evolution of disagreements within individuals in the *Unanimity group* treatment.

Figures 3 and 4 show that both in the risk and the ambiguity contexts, individuals in the Unanimity *group* treatment reached a unanimous decision at the first iteration in decision 3 only (and also in decision 9 under ambiguity). In all the other decisions, two or more iterations were needed to reach a unanimous decision – when such a decision emerged. Interestingly, the two figures report similar percentages of disagreement across the probability range (i.e., decision number). They show, in particular, that percentages of disagreement are higher for middle probability decisions (i.e., intermediate decisions 4 to 7) than for low- and high-probability decisions (decisions 1 to 3 and 8 to 10, respectively). For example, we observed 80% of disagreements in the first iteration for decisions 5 or 6 in the risk context, and 70% of disagreements in the first iteration for decisions 5 or 7 in the ambiguity context. In contrast, the frequency of disagreement is equal to 10% in the first iteration for decision 10 in both the risk and ambiguity context.

INSERT FIGURES 3 and 4 HERE

The two figures also clearly show that the proportion of disagreement decreases with the number of iteration rounds. In most cases, the iterative process thus allowed individuals who

are part of a group to converge towards a unanimous decision. For instance, the probability of disagreement in the fifth iteration for the risky decision 5 is equal to 20%, whereas it is 80% in the first iteration. These results are similar to those of Masclet et al. (2009) who observed that for decision 7, the probability of disagreement is 75% in the first iteration and decreases to 12% in the fifth iteration. Under ambiguity, the probability of disagreement at decision 7 drops from 70% in the first iteration to 10% in the fifth iteration.

Figure 5 below gives the changes in attitudes towards risk and ambiguity in the *Alone* and *Unanimity group* conditions. It shows that almost 26.67% of the participants exhibited the same attitude towards risk in these two conditions. The same proportion exhibited more risk aversion in the *Unanimity group* condition than in the *Alone* condition. In addition, around 46.67% of the participants exhibited less risk aversion in the *Unanimity group* condition than in the *Alone* condition. This means that the *Unanimity group* condition leads to lower levels of risk aversion than the *Alone* condition. In the case of real group decision, such a result is characteristic of a "*risky shift*" (Wallach et al. 1964; Brown 1986; Aronson et al. 2005). In addition, this result extends the "other-evaluation" argument developed under ambiguity (Curley et al. 1986; Trautman et al. 2008; Keck et al. 2012) to risk: individuals, in making a choice, anticipate that others will evaluate her/his decision, and so, make the choice that is perceived to be most justifiable to others, the less risky one.

INSERT FIGURE 5 HERE

Figure 5 also our results show that 23.3% of the participants had the same attitude towards ambiguity in the *Alone* and *Unanimity group* conditions. The participants whose attitude towards ambiguity changed across tasks were evenly split: 40% were more ambiguity-averse in the *Unanimity group* condition than in the *Alone* condition, and 36.7% were less ambiguity-averse in the *Unanimity group* condition than in the *Alone* condition. This result

suggests a potential ambiguity neutrality convergence when the group adopts a unanimity rule (Curley et al. 1986; Charness et al. 2012). Overall, these observations show that individuals do not exhibit the same preferences when they belong to a unanimity group and when they are alone.

2.4 Risk aversion and ambiguity aversion

In the *Alone* condition, we find a positive correlation between the number of non-risky choices and non-ambiguous choices (Spearman coefficient = 0.407; p = 0.001). This result is consistent with those of Chakravarty and Roy (2009) who report a positive and significant correlation between individuals' attitudes towards risk and ambiguity. In the *Group* condition, we do not find any significant correlations between risk and ambiguity attitudes in either the *Majority group* treatment (Spearman coefficient = 0.138; p = 0.466) or the *Unanimity group* treatment (Spearman coefficient = -0.217; p = 0.249).

3. **Conclusion and Discussion**

In this paper, we contribute to the literature on group social influence on individual decision-making in two ways. We consider the impact of the source of uncertainty (risk or ambiguity) and we also study the impact of the decision rule (unanimity or majority). These two factors have been neglected so far.

Our experiment extends past research on the effect of a group environment on individual attitude to risk and ambiguity (Harrison et al. 2007; Masclet et al. 2009 ; Curley et al. 1986, Trautman et al. 2008, Viscusi et al. 2011). We observe that individuals who are part of a group (whatever the decision rule) are i) significantly averse to risk, but ii) tend to be *less* risk averse than when they are alone; and iii) are averse to ambiguity and iv) tend to be *more* averse to ambiguity than when they are alone. The fact that differences between attitudes to risk (resp. ambiguity) in the group environment and alone are not statistically different might

come from the fact that we did not take into account the possible effect of the decision rule, as we explain below.

In order to understand the impact of a group environment on individual attitudes to risk and to ambiguity, it is important to look at the impact of the decision rule. Our study provides important results in that respect. Our experiment first shows that if attitude to risk does not seem to be sensitive to the decision rule – i.e., we observe significant degrees of risk aversion in both the unanimity and the majority groups – attitude to ambiguity, on the contrary, seems to be sensitive to the decision rule that the group adopts. Indeed, we found that only individuals who belong to a group implementing a majority rule are significantly averse to ambiguity, while individuals who belong to a group implementing a unanimity rule are ambiguity neutral. Second, the comparison between attitudes to risk (resp. ambiguity) alone and in a group shows that only certain conditions lead to significant differences. To sum up, we found that when they belong to a group implementing a unanimity rule, individuals are *less* risk averse than when they do not belong to a group – the same effect is visible, but not significant with a majority rule. Our findings thus are at odd with Masclet et al.'s (2009) findings which report that the unanimity rule increases individual's degree of risk aversion. They are however consistent with Harrison et al. (2007) who reported no significant difference between individual attitudes to risk in a group environment and alone when a majority rule was adopted. With respect to attitude to ambiguity, we found that the majority rule tends to generate more ambiguity aversion than the unanimity rule.

This paper can be extended in several ways. For example, future research could focus on the impact of the size of the group. Most studies so far have used three-person groups (Baker et al. 2008; Masclet et al. 2009) but the size of the group could matter. Other research could also consider more naturalistic settings, where group members can discuss and interact before making a decision. In our experiment, like in Masclet et al.'s (2009) experiment,

participants did not interact with each other when making decisions in the *Group* condition. Yet, it would be interesting to implement an experiment where interaction between group members is allowed such as "cheap talk" for instance (Baker et al. 2008).

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TABLES

Table 1. Risk aversion classification based on lottery choices: Alone vs. Group conditions (in %)

Number of safe choices	Bounds for relative risk aversion $U(x)=x^{1-r}/1-r$	Classification	Alone condition	Group condition
0 and 1	r < -0.95	Highly risk-loving		
2	-0,95 < r < -0.49	Very risk-loving		
3	-0.49 < r < -0.15	Risk-loving	6.66	
4	-0.15 < r < 0.15	Risk-neutral	16.66	25
5	0.15 < r < 0.41	Slightly risk-averse	23.33	23.33
6	0.41 < r < 0.68	Risk-averse	25	38.33
7	0.68 < r < 0.97	Very risk-averse	18.33	13.33
8	0.97 < r < 1.37	Highly risk-averse	6.66	
9 and 10	1.37 < r	Stay in bed	3.33	

Table 2. Probability of safe and non-ambiguous choice: Random effects probit

	Risk	Ambiguity
	Coef.	Coef.
Age	-0.139	-0.016
	(0.076)	(0.058)
Gender	-0.622**	-0.212
	(0.322)	(0.244)
Rule	-0.547*	-0.364
	(0.304)	(0.231)
Alone_Group	2.214***	-3.235***
	(0.790)	(0.720)
Prob	-9.948***	
	(0.851)	
Prob*Alone_Group	-3.832***	
	(1.273)	
Payoff		0.619***
		(0.047)
Payoff*Alone_Group		0.375***
		(0.088)
Constant	7.051***	-4.071***
	(1.705)	(1.267)
Lnsig2u	0.016	-0.595
	(0.303)	(0.302)
Sigma_u	1.008	0.743
	(0.153)	(0.112)
Rho	0.504	0.355
	(0.076)	(0.069)
Number of observations	1173	1185
Log-likelihood	-221.3989	-287.91929

Standard errors in parenthesis
*** Significant at 1%
** Significant at 5%
* Significant at 10%

Gender is a binary variable equal to 1 for men and 0 for women.
Rule is a binary variable equal to 1 for unanimity and 0 for majority.
Alone_Group is a binary variable equal to 1 if the decision is made in the Group condition and 0 if the decision is made in the Alone condition.

**Table 3. Ambiguity aversion classification based on lottery choices: Alone vs. Group conditions (in %)**

Number of non-ambiguous choices	Bounds for ambiguity aversion $KMM(x)=E_j(EU(x))$ with $j(x)=x^s$	Classification	Alone condition	Group condition
0	$s > 1.92$	Extremely amb.-loving		
1	$1.92 \leq s < 1.59$	Highly amb.-loving		
2	$1.59 \leq s < 1.35$	Very amb.-loving		
3	$1.35 \leq s < 1.15$	Amb.-loving	5	
4	$1.15 \leq s < 1$	Slightly amb.-loving	18.33	20
5	$1 \leq s < 0.86$	Amb.-neutral	33.33	33.33
6	$0.86 \leq s < 0.75$	Slightly amb.-averse	13.33	35
7	$0.75 \leq s < 0.66$	Amb.-averse	11.66	8.33
8	$0.66 \leq s < 0.43$	Very amb.-averse	13.33	3.33
9	$0.43 \leq s < 0.30$	Highly amb.-averse		
10	$s \geq 0.30$	Extremely amb.-averse	5	

Figure 1. Proportion of safe choices for each decision: Alone vs. Group conditions

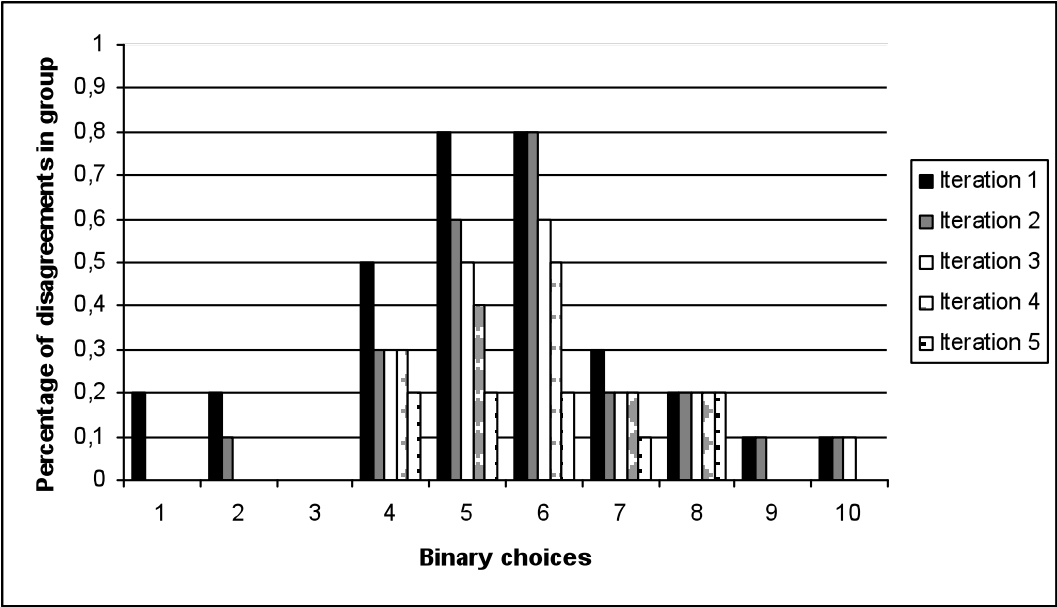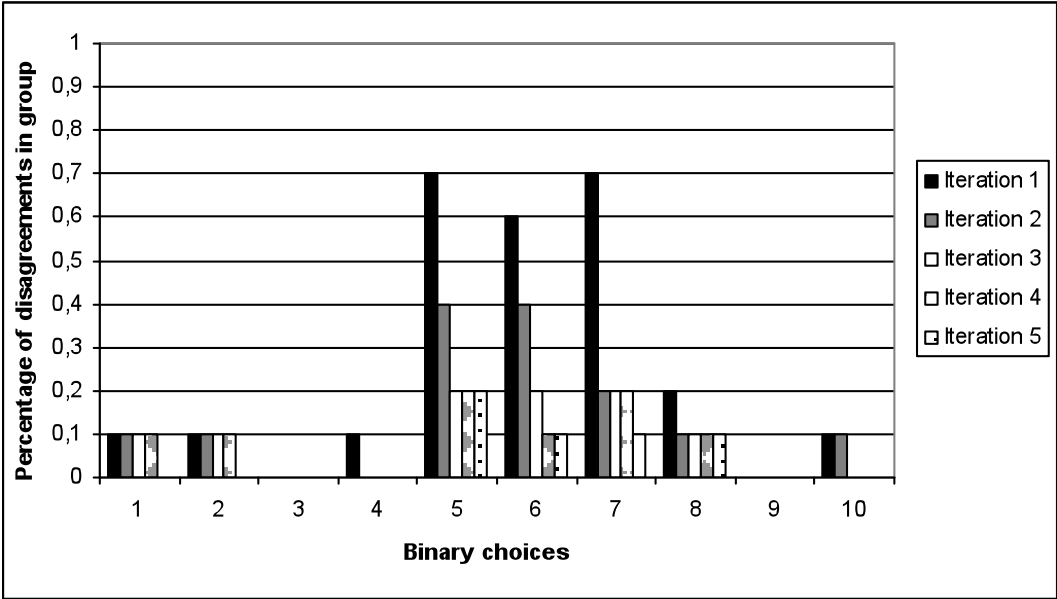Proportion of individuals choosing safe option A
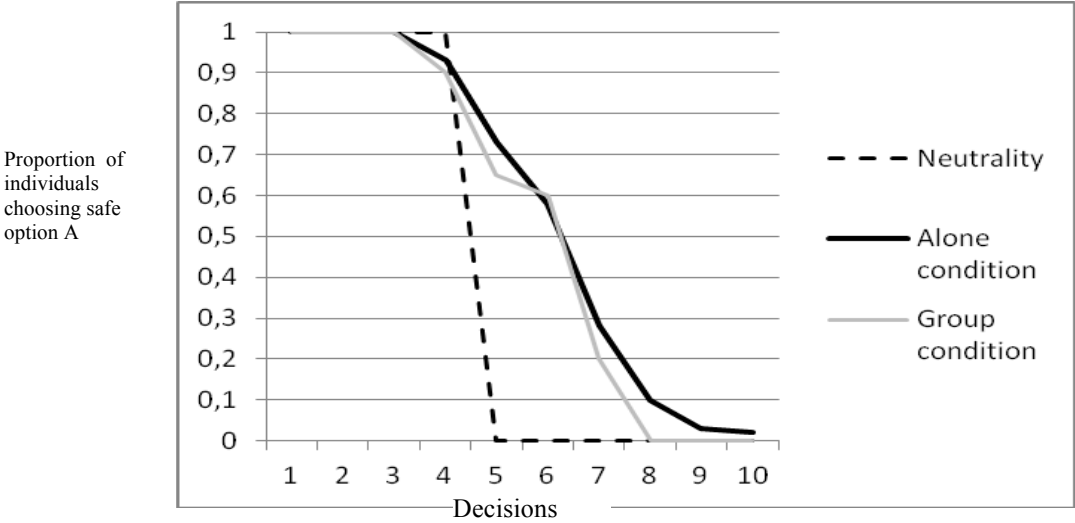
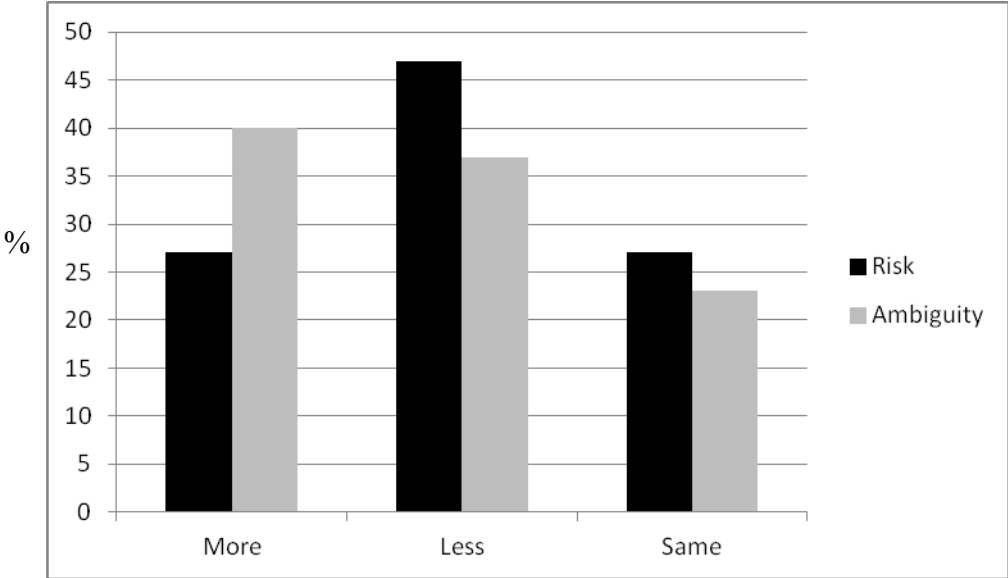**Figure 2. Proportion of non-ambiguous choices in each decision: Alone vs. Group conditions**
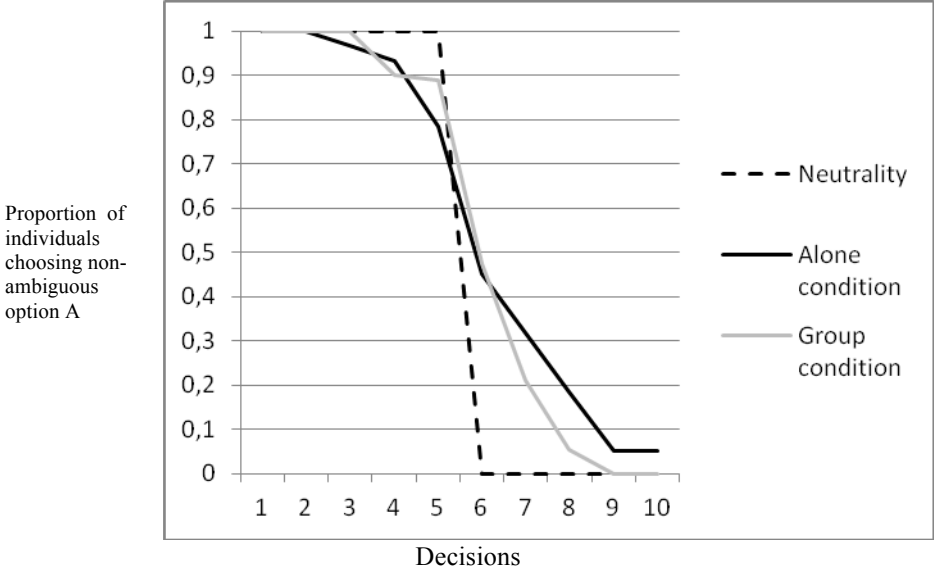
Figure 3. Frequency of disagreements for each decision: Group condition under risk

Figure 4. Frequency of disagreements for each decision: Group condition under ambiguity

Figure 5. Link between individual attitudes towards risk and ambiguity

APPENDIX

Table A1. The ten-paired lottery-choice decisions under risk (adapted from Holt and Laury, 2002)

Decisions	Option A				Option B				Choice	
	Prob. P	Gains	Prob. (1-P)	Gains	Prob. P	Gains	Prob. (1-P)	Gains		
1	10%	7 €	90%	5 €	10%	13 €	90%	0 €	A	B
2	20%	7 €	80%	5 €	20%	13 €	80%	0 €	A	B
3	30%	7 €	70%	5 €	30%	13 €	70%	0 €	A	B
4	40%	7 €	60%	5 €	40%	13 €	60%	0 €	A	B
5	50%	7 €	50%	5 €	50%	13 €	50%	0 €	A	B
6	60%	7 €	40%	5 €	60%	13 €	40%	0 €	A	B
7	70%	7 €	30%	5 €	70%	13 €	30%	0 €	A	B
8	80%	7 €	20%	5 €	80%	13 €	20%	0 €	A	B
9	90%	7 €	10%	5 €	90%	13 €	10%	0 €	A	B
10	100%	7 €	0%	5 €	100%	13 €	0%	0 €	A	B

Table A.2. The ten-paired lottery-choice decision under ambiguity (adapted from Chakravarty and Roy, 2009)

Choose a colour: BLACK ○   WHITE ○

Decisions	Option A: urn A		Option B: urn B		Choice	
	In urn A, the distribution of balls is 5 black and 5 white		In urn B, the possible distribution of balls is not known			
	The chosen colour is obtained Gains	*The chosen colour is not obtained* Gains	*The chosen colour is obtained* Gains	*The chosen colour is not obtained* Gains		
1	13 €	0 €	9 €	0 €	A	B
2	12 €	0 €	9 €	0 €	A	B
3	11 €	0 €	9 €	0 €	A	B
4	10 €	0 €	9 €	0 €	A	B
5	9 €	0 €	9 €	0 €	A	B
6	8 €	0 €	9 €	0 €	A	B
7	7 €	0 €	9 €	0 €	A	B
8	6 €	0 €	9 €	0 €	A	B
9	4 €	0 €	9 €	0 €	A	B
10	2 €	0 €	9 €	0 €	A	B