Are ambiguity preferences aligned with risk preferences?

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Abstract

Decisions under risk and ambiguity are usual and associated preferences are commonly quantified. This article deals with the relation between the individual's preferences towards risk and ambiguity. In particular, we question the correlation of the preferences and their alignment. For that purpose, we analysed experimental data measuring individual's risk and ambiguity preferences through lottery choice experiment. The results indicate that risk preferences and ambiguity preferences are positively correlated. In addition, we show that most of the subjects have preferences towards ambiguity that are aligned with those towards risk, either perfectly or weakly. Only 15% of the sample has preferences towards ambiguity that are the reversal of those towards risk.

Keywords: risk, uncertainty, ambiguity, experiments.

JEL classification numbers: C91 (Laboratory, Individual Behavior); D8 (Information, Knowledge, and Uncertainty); D9 (Micro-Based Behavioral Economics)

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1 Introduction

Many individuals' decisions in everyday life or in more specific domains, such as natural resource management in a context of climate change or health care to face pandemic risk, are not taken in a risky context but more and more in an uncertain one (Etner et al., 2012; Bühren et al., 2021). Indeed, the knowledge and quantification of the risks that individuals face are often imprecise, making the decision-making environment ambiguous. This imprecision on the existing risk is mainly due to its imperfect knowledge or to various experts' assessments. There is also a lack of precision in the knowledge and quantification of the characteristics of these uncertainties leading to a noise on the occurrence of the risk and the potential damage. As a consequence, the decision-makers evolve in a situation of ambiguity affecting their decisions.

It is widely accepted that risk preferences are a key explanatory factor of the decision-makers' choices under risk and that ambiguity preferences are a fundamental determinant of the individuals' decisions under ambiguity. In such a context, experimental economists have developed various methodologies to quantify first risk aversion (Binswanger, 1980; Holt and Laury, 2002) and then ambiguity aversion (Chakravarty and Roy, 2009). Among them, we find the Multiple Price List, Ordered Lottery Selection, Likert scale, etc.

Since ambiguity is an imprecision of risk, the question naturally arises as to whether preferences towards risk and ambiguity are linked, or even correlated or aligned (*i.e.*, same preferences under risk and ambiguity). In theoretical models that propose decision criteria integrating risk and ambiguity preferences, these two preferences are independent (Klibanoff et al., 2022). This independence means, for example, that a risk averse individuals can be ambiguity neutral, ambiguity lover or ambiguity averse. However, there is an intuition that these two preferences should be aligned given the link between them and the fact that ambiguity is characterized as regards to risk. In particular, ambiguity preferences should be aligned with risk preferences.

As clear as the separation between risk and ambiguity preferences is from a theoretical point of view, it remains unclear from an empirical point of view. Indeed, the question of the link between individual's risk and ambiguity preferences has been addressed in experimental economics with a conclusion that is not unanimous. Lauriola and Levin (2001), Chakravarty and Roy (2009) and Brunette et al. (2015) found a positive and significant correlation between risk and ambiguity preferences in the gain domain, whereas other experiments found that these two preferences are not closely related (Cohen et al., 1987; Hogarth and Einhorn, 1990; Mauro and Maffioletti, 2004; Levy et al., 2010). Many empirical and experimental papers have confirmed the risk aversion and ambiguity aversion of decision makers but without addressing the question of the link between these two types of preferences. An important unanswered question is whether the theoretical separation between risk and ambiguity preferences is verified empirically. Our paper builds on this literature and contributes to the debate about this separation and the potential link between risk and ambiguity preferences.

In this context, we examine the relationship between individual's risk and ambiguity preferences. In a first step, we elicited individual's preferences towards risk and ambiguity through a Multiple Price List elicitation method such as proposed by Holt and Laury (2002) under risk and extended to ambiguity by Chakravarty and Roy (2009). We choose to use this procedure since it is largely adopted in experimental economics to elicit preferences (Drichoutis and Lusk, 2016). In a second step, we investigate whether these preferences towards risk and ambiguity are correlated. Finally, we question their alignment. More precisely, the preferences are aligned when preferences towards ambiguity are aligned with those towards risk and weakly aligned when only one type of preferences is neutral and the other one is not. Finally, the last category presents pref-

erences that are not aligned, *i.e.* reversal of the preferences. The results indicate that risk preferences and ambiguity preferences are positively correlated. We show that preferences towards risk and ambiguity are aligned for most of the subjects, either perfectly or weakly. Indeed, only 15% of our sample has preferences that are not aligned.

The rest of the paper is structured as follows. Section 2 describes the theoretical framework in which the experiment anchors. Section 3 presents the experiment and the way preferences towards risk and ambiguity are elicited. Section 4 indicates the results. Section 5 provides a discussion of the results and concludes.

2 Theoretical insights

There are different economic theories that best represent the choices of individuals in risky situations. Expected utility theory (EUT)[1] is the traditional economic theory on decision-making under risk. Although this theory faces multiple criticisms, expected utility theory remains the most finalized and validated theory for describing such behavior. It has rapidly become a standard in decision theory. This theory, developed by Von Neumann and Morgenstern (1947), is based on the hypothesis that individuals are rational decision-makers who systematically choose the decision that provides them with the highest expected utility. This theory assumes that decision-makers have perfect information about all available decisions, the probability distribution of the different outcomes and the corresponding payoffs.

A considerable amount of empirical work has been done to evaluate the parameters necessary for this framework and to test the robustness of the underlying assumptions. The empirical calibrations and estimates of this theory assume the specification of the utility function. It is clearly accepted that a standard function used in EUT is $U(X) = X^{(1-\beta)}/(1-\beta)$, where β represents the level of constant relative risk aversion (CRRA). A seminal approach to quantify decision makers' risk aversion from an experimental perspective is the the well-known lottery choice experiment proposed by Holt and Laury (2002). In such a procedure, the decision-makers have to choose between a safe option and a risky one, and their switching point from the safe to the risky option reveals their level of risk aversion. Indeed, this switching point corresponds to an interval of values for the CRRA parameter. This value is unique for the decision maker. Empirical applications of this procedure generally obtain that decision makers are slightly risk averse and demonstrate substantial heterogeneity in risk preferences. Empirical estimates of the CRRA parameter indicate that the average value for risk aversion is around 1 (Bombardini and Trebbi, 2012). Past empirical work has also shown that risk aversion for low stakes is different from risk aversion for high stakes and that risk aversion decreases with increasing wealth (Binswanger, 1980; Rabin, 2000; Wik et al., 2004; Bombardini and Trebbi, 2012).

Many current decisions are not made in a risky situation but rather in an uncertain and often ambiguous context where information about the hazards exists but is imprecise. Indeed, a common concept in economics has emerged; it is Knightian uncertainty or ambiguity, which refers to situations where the decision-maker does not represent the hazard by a single probability distribution but by several possible probability distributions. In such a situation, decisions cannot be correctly described by the criterion of maximizing expected utility. In such a context, the decision depends strongly on the degree of ambiguity aversion of the decision maker. Thus, many theoretical and empirical works have emerged on decision under ambiguity (Etner et al., 2012; Bühren et al., 2021). It is then admitted that decision under ambiguity can be fully understood with

[1]Expected utility theory (EUT) and prospect theory (PT) are currently the two most prominent theories on decision-making under risk in (behavioral) economics.

both attitudes towards risk and attitude towards ambiguity. Many theoretical works have proposed different decision criteria integrating these two types of preferences, but two fundamental models currently emerge from the literature: the maxmin expected utility (Gilboa and Schmeidler, 1989) and the smooth ambiguity model (Klibanoff et al., 2005). The latter theoretical framework adopts the same foundations of EUT and extends it to propose a criterion under ambiguity. This criterion allows to separate the two types of preferences. Moreover, it also takes into account all the different possible probability distributions. It currently seems to be the most commonly used criterion. Therefore we will choose it. The smooth ambiguity model distinguishes ambiguity aversion, described by a specific function often noted Φ, from risk aversion, considered in a classic utility function, but it considers ambiguity aversion in a similar way to risk aversion. It consists in applying the expectation of the Φ function evaluated for expected utility. In this model, the decision criterion is then $V(f)$ for decision f defined as $V(f) = \int_\Delta \Phi(\int_S u(f)d\pi)d\nu = E_\nu\Phi(E_\pi u(f))$. u is the decision-maker's utility function representing the risk attitude, and Φ captures the decision-maker's attitude towards ambiguity. ν is the subjective prior over the set of possible probabilities Δ over the state space S, and π a probability measure. Preferences towards risk and towards ambiguity are thus considered as independent but the decision criterion under ambiguity which incorporates ambiguity aversion has as an argument the utility function which incorporates risk aversion.

As with the utility function, specifications for the Φ function have been proposed and the most common is the power function $\Phi(w) = w^\zeta$ with ζ the coefficient of ambiguity aversion. There are various literature reviews on ambiguity aversion (Camerer and Weber, 1992; Al-Najjar and Weinstein, 2009; Etner et al., 2012; Guidolin and Rinaldi, 2013; Trautmann and van de Kuilen, 2015) and the most recent one, Bühren et al. (2021), provides a bibliometric analysis of both theoretical and empirical studies on the topic. Although there is still no empirical evidence on which model better represents the decisions under ambiguity (Halevy, 2007), the smooth ambiguity model appears prevalent in empirical and experimental studies aimed at quantifying decision makers' ambiguity aversion (Chakravarty and Roy, 2009). Most experimental studies confirm the ambiguity aversion of decision makers and such experimental results are little discussed. Chakravarty and Roy (2009) propose an extension of the Holt and Laury (2002)'s procedure to quantify preferences towards ambiguity. This procedure, which is theoretically based on the smooth ambiguity model, follows the same principle: identifying the switch point between two options, one risky and the other ambiguous. As with risk aversion, the tipping point chosen by the decision-maker makes it possible to quantify her corresponding ambiguity aversion parameter. Such a procedure has become the leading approach to assess the ambiguity aversion of decision makers.

3 The experiments: measurement of risk and ambiguity preferences

We present the results of two between-subject experiments. We carried out two experiments with different individuals rather than a single within-subject experiment in order to avoid redundancy and the repetitive nature of the decisions to be taken and, above all, to limit the learning effect from one experiment to another. In each experiment, the individual's preferences towards risk and ambiguity were elicited through a Multiple Price List (MPL) method such as proposed by Chakravarty and Roy (2009). It is an extension of the MPL proposed by Holt and Laury (2002) that allows to measure both risk and ambiguity preferences. The two experiences are identical except for the amount of money at stake in the MPL procedure. In Experience 1 (low payoff), the payoff goes

from €0 to €10, one euro by one euro; whereas in Experience 2 (high payoff), the payoff goes from €0 to €20, two euros by two euros.
In each experiment, the subjects realize binary choices between two urns composed with color balls. At the beginning of the task, the subject chooses a winning color: blue or yellow. For each decision, the subject chooses their favorite urn (*i.e.*, the one they want to play with). Each individual is confronted with two contexts : risk and ambiguity.

3.1 Elicitation of the preferences towards risk

Figure 1 presents a screenshot of the Experience 2. The subject has to arbitrate between a safe option (the right one) and a risky one (the left option). The right option is safe since it corresponds to a sure amount of money from €0 to €20. The left option is risky since the probability of winning is known (1 chance in 2 of drawing the winning color) and the payoff too (€0 or €20).

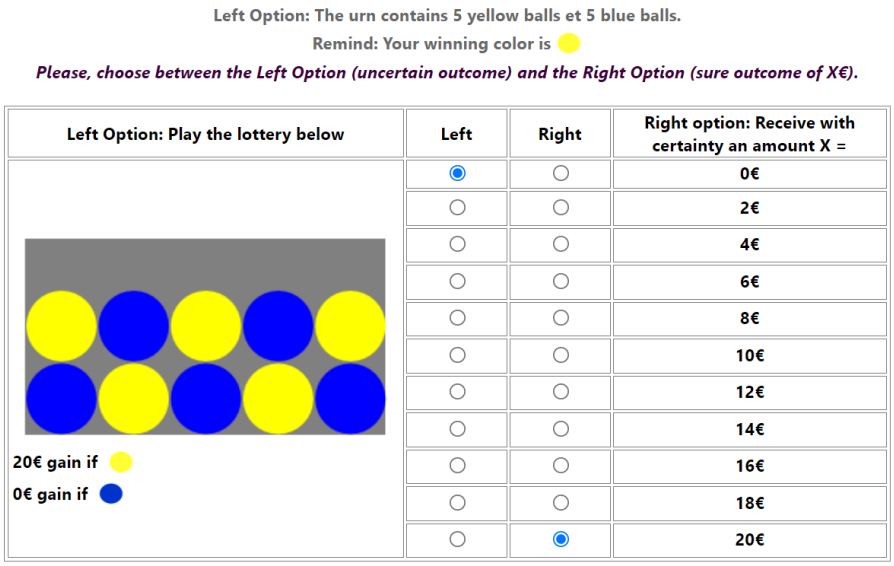

Figure 1: Elicitation of the preferences towards risk with high payoff.

The screenshot is exactly the same in Experience 1 with the payoff going from €0 to €10, one euros by one euro, rather than from €0 to €20, two euros by two euros.

The switch point between the two options is the index to measure preferences towards risk. Indeed, a switch point of 5 corresponds to risk neutrality, meaning that the individual is indifferent between the two urns. A switch point lower than 5 characterizes risk aversion and higher than 5 corresponds to risk loving. For consistency issue, and as usual in this type of elicitation procedure, we constrain the subjects to have only one switch point.

3.2 Elicitation of the preferences towards ambiguity

Under ambiguity, subjects have to arbitrate between a non-ambiguous option (right one) and an ambiguous one (left option). The right option is non-ambiguous since it offers a sure amount between €0 and €20 in Experience 2 (Figure 2) and €0 and €10 in Experience 1. The left option is ambiguous because the proportion of the balls of each color is not known, whereas the payoff is (either €0 or €10 in Experience 1 and either €0 or €20 in Experience 2).

The switch point between the two options is the index to measure preferences towards ambiguity. Indeed, a switch point of 5 corresponds to ambiguity neutrality, lower

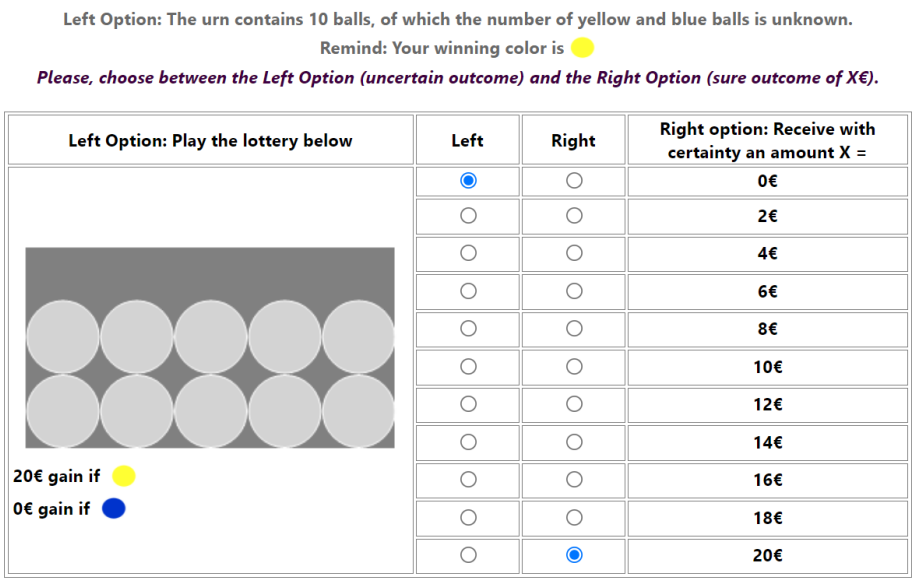

Figure 2: Elicitation of the preferences towards ambiguity with high payoff.

than 5 to ambiguity aversion and higher than 5 to ambiguity loving. We also force the uniqueness of the switch point.

3.3 The samples

The two experiences were run in November 2021 at the Laboratory of Experimental Economics of Strasbourg (LEES). The subjects were recruited in the same manner. The two experiences were also incentivized in the same manner: one decision (either under risk or ambiguity) was randomly selected and plays for real.

In Experience 1, 192 subjects completed the experiment. They have on average 21.82 years. The sample is composed with 104 women, 85 men and 3 others. Concerning their study level, 74 are in licence degree, 104 in master degree and 14 realized a PhD thesis. The study programs are distributed as follows: Law (2 students), Economics/Management (44), Exact Sciences (49), Psychology/Sociology (8), Political Sciences (8), "Other programs" (80 with Medicine, Demography, Actuarial, etc.). On average, the payoff of the subjects was €6.2.

Experience 2 was realized by 209 subjects having on average 21.25 years, and whose gender is distributed as follows: 100 women, 106 men and 3 others. In this sample, 136 subjects are in Licence degree, 70 in master degree and 3 realized a PhD thesis. These students belong to different study programs: Law (6 students), Economics/Management (73), Letter/Language (3), Exact Sciences (37), Psychology/Sociology (18), Political Sciences (15), and "Other programs" (57 with Statistics, Life sciences, Pharmacy, etc.). The subjects earn on average €13.5.

4 Results

We first present the results of the MPL procedure for risk and ambiguity in the two experiences. Second, we analyse the relation between both types of preferences. Finally, we present an another interesting issue on the comparison of self-assessment method with MPL procedure.

4.1 The preferences towards risk and ambiguity elicited through MPL

Table 1 presents the distribution of the switch points under risk and ambiguity in each experience.

	Exp. 1 (in %)		Exp. 2 (in %)	
Switch	Risk	Ambiguity	Risk	Ambiguity
1	7.3	6.3	8.1	7.7
2	0.5	2.6	1.4	3.8
3	1	7.8	3.4	19.6
4	12	24	20.1	27.3
5	34.4	34.4	31.6	19.1
6	27.1	12	23.9	9.1
7	12.5	5.7	6.7	5.7
8	2.6	2.6	2.4	3.8
9	0	1	0	0.5
10	2.6	3.6	2.4	3.4
Average switch	5.28	4.81	4.93	4.42

Table 1: Distributions of the switch points under risk and ambiguity in the two experiences.

Table 1 reveals that in both experiences, the highest proportion of individuals is risk neutral (switch point of 5), and the second one is slightly risk loving (switch point of 6). Most of the sample concentrates around the neutrality in the two experiences. The average switch point is 5.28 in Experience 1 and 4.93 in Experience 2. This means that, in Experience 1, on average, subjects are risk lover while in Experience 2, they are risk averse. The difference between the switch points under risk in Experience 1 and 2 is significant ($t = 2.027$; $p = 0.022$). This means that in Experience 2 risk aversion is higher than in Experience 1, and as the only difference between the two experiences is the level of the payoff, we can say that the increase in payoff size in the MPL procedure translates into an increase in risk aversion.

In Experience 1, the average switch point is 4.93 for ambiguity whereas for Experience 2, it is 4.42. This means that, on average, subjects are ambiguity averse in the two experiences. The difference between the switch points under ambiguity in Experience 1 and 2 is significant ($t = 2.044$; $p = 0.021$). Again, aversion is higher in Experience 2 than in Experience 1, leading to the following result:

Result 1: Risk aversion and ambiguity aversion elicited through MPL procedure increase as the payoff size in the procedure doubles.

In Table 2, we gather the subjects by category: averse, neutral or lover. This table confirms that the subjects are mainly risk lover (44.8%) and ambiguity averse (40.6%) in Experience 1. In Experience 2, the preferences towards risk are distributed almost equally between categories: 33% of the subjects are risk averse, 31.6% are risk neutral and 35.4% are risk lovers. The preferences towards ambiguity are more clear-cut since a majority of the subjects are ambiguity averse (58.4%).

	Exp. 1 (in %)		Exp. 2 (in %)	
	Risk	Ambiguity	Risk	Ambiguity
Averse	20.8	40.6	33	58.4
Neutral	34.4	34.4	31.6	19.1
Lover	44.8	25	35.4	22.5

Table 2: Percentage of the sample according to each type of preferences.

In order to deepen the analysis, we simply apply a linear regression to the individual's decisions under risk and under ambiguity with the potential explanatory variables that we have. For that purpose, we consider the two samples together (N = 192 + 209 = 401) and create a variable *Payoff* allowing to consider the difference in terms of payoff size between the two experiences. The results are presented in Table 3.

	Risk		Ambiguity	
	t	Sig.	t	Sig.
Constant	7.253***	<0.001	4.600***	<0.001
Payoff	-2.050**	0.041	-2.672**	0.008
Gender	-2.408**	0.017	-1.346	0.179
Study level	0.927	0.354	-2.039**	0.042
Eco./Manag.	1.214	0.225	0.929	0.354
Age	-0.823	0.411	1.252	0.211
Adjustment	$R^2 = 0.033$		$R^2 = 0.030$	

*** significant at 1%, ** significant at 5%.

Table 3: Determinants of the preferences towards risk and ambiguity.

These regressions confirm that the size of the payoff significantly impacts the quantification of the preferences towards risk and ambiguity, since the variable *Payoff* is the only one that affects both the preferences towards risk and ambiguity. The impact is significant and negative meaning that a higher level of payoff has a negative impact on the individual's switch point, corresponding to an increase in aversion.

We can also observe that the *Gender* has a significant and negative impact on the individual's switch point under risk. This means that on average, women are more risk averse than men, a common result in the literature (Jianakoplos and Bernasek, 1999; Eckel and Grossman, 2008; Dohmen et al., 2011). In addition, the study level seems to influence the preferences towards ambiguity.

Variables like *Age* and *Eco./Manag.* (*i.e.*, the fact to prepare a diploma in economics and/or management) are never significant.

4.2 An analysis of the link between risk and ambiguity preferences elicited through MPL

We first analyse the correlations between the preferences for the same experience and then, between experience. In a second section, we propose to categorize the preferences of the subjects as regards to the alignment (or not) of their preferences towards ambiguity and risk.

4.2.1 Intra and inter-correlations between risk and ambiguity preferences

In this section, we propose to study the link between the individuals' preferences towards risk and ambiguity. Table 4 presents the Pearson correlation coefficient between the

distribution of the switch points under risk and ambiguity for the two experiences.

		Risk_Exp1	Risk_Exp2	Amb_Exp1	Amb_Exp2
Risk_Exp1	Pearson coef.	1	-0.078	0.380***	0.009
	Sig.		0.282	< 0.001	0.900
Risk_Exp2	Pearson coef.	-	1	-0.090	0.394***
	Sig.	-		0.216	< 0.001
Amb_Exp1	Pearson coef.	-	-	1	0.002
	Sig.	-	-	-	0.979
Amb_Exp2	Pearson coef.	-	-	-	1
	Sig.	-	-	-	

Table 4: Correlations between the switch points.

We can observe that intra-correlations are significant, *i.e.*, between risk and ambiguity in the same experience. Inter-correlations are not significant, *i.e.*, between risk in both experiences and between ambiguity in both experiences. This leads us to the following result:

Result 2: The preferences towards risk and ambiguity are significantly and positively correlated inside each experience.

4.2.2 Are the preferences aligned (or not) between risk and ambiguity?

In this section, we propose a categorization of the subjects by looking the alignment of their preferences between risk and ambiguity for each experience, as presented in Table 5.

Risk	Ambiguity	Exp. 1 (in%)	Exp. 2 (in %)	Categorization
Averse	Averse	14.1	25.8	Perfectly aligned
Loving	Loving	18.2	15.3	
Neutral	Neutral	13.5	8.6	
Loving	Neutral	16.1	7.2	Weakly aligned
Neutral	Loving	4.2	3.4	
Averse	Neutral	4.2	3.4	
Neutral	Averse	16.7	19.6	
Averse	Loving	2.6	3.8	Not aligned
Loving	Averse	10.4	12.9	

Table 5: Proportion of subjects having preferences perfectly aligned, weakly aligned or not aligned in each experience.

Some subjects are averse both under risk and ambiguity, lover both under risk and ambiguity, neutral both under risk and ambiguity meaning that their preferences are perfectly aligned in both contexts. Some other subjects deviate from neutrality: from risk loving to ambiguity neutrality or the opposite; from risk aversion to ambiguity neutrality or the opposite. Their preferences are weakly aligned. Finally, some subjects completely reverse their preferences between risk and ambiguity, moving from risk aversion to ambiguity loving or from risk loving to ambiguity aversion. Their preferences are not aligned.

In Experience 1, 45.8% of the subjects has preferences towards risk and ambiguity perfectly aligned and 49.7% in Experience 2. This means that for approximately half of

the subjects, preferences towards ambiguity are perfectly in line with preferences towards risk. However, for the other sub-samples the situation is different. Indeed, in Experience 1, 41.8% of the subjects has preferences weakly aligned and 33.6% in Experience 2, whereas in Experience 1, 12.5% of the subjects has preferences not aligned and 16.7% in Experience 2.

All in all, we observe that the percentage of the subjects in each of the three categories is very close in the two experiences, meaning that the payoff size seems to be not important. Consequently, we propose the Figure 3 that allows a global overview of the distribution of the sample in each category, independently from the experience (N = 401).

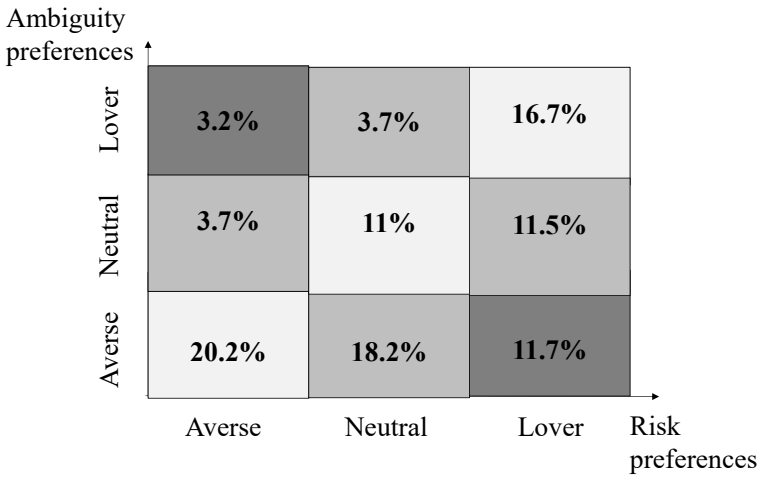

Figure 3: Schematic representation of the three categories (N = 401).
Perfect alignment in light grey, weak alignment in medium grey and not aligned in dark grey.

The diagonal in light grey represents the percentage of individuals with exactly the same preferences under risk and under ambiguity (47.9%). The boxes in medium grey correspond to individuals having preferences weakly aligned (37.1%) while the dark grey color is for preferences that are not aligned (14.9%). We thus obtain the following result:

Result 3: Most of the subjects have preferences towards ambiguity that are aligned with those towards risk, either perfectly or weakly.

This result states that only 15% of the individuals have preferences towards ambiguity that are not aligned with preferences towards risk while 85% have. The question is what can explain this difference ?

In order to answer to this question, we try to identify the determinants of the alignment (or not) of the preferences towards risk and ambiguity. We consider the data from both experiences together (N=401) and as potential explanatory variables: gender, study level, study programs, age and payoff level. Table 6 presents the results of Logit regressions realized for each category.[2]

[2]We also conduct other regressions: (i) an Ordinal Logit with 0 perfectly aligned, 1 weakly aligned and 2 not aligned and, (ii) a Logit with 1 aligned (perfectly and weakly) and 0 not aligned. None of the variables appeared significant in these two regressions.

	Perfect alignment		Weak alignment		Not aligned	
	Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Constant	1.798*	0.084	-2.370**	0.022	-1.974	0.144
	(1.041)		(1.038)		(1.352)	
Payoff	0.182	0.388	-0.411*	0.062	0.393	0.190
	(0.211)		(0.220)		(0.300)	
Female	-0.114	0.562	0.210	0.303	-0.156	0.569
	(0.196)		(0.204)		(0.274)	
Study level (2)	0.184	0.449	-0.309	0.223	0.210	0.531
	(0.243)		(0.254)		(0.335)	
Study level (3)	0.461	0.428	-0.724	0.237	0.419	0.581
	(0.582)		(0.612)		(0.759)	
Eco./Manag.	-0.142	0.542	0.306	0.202	-0.290	0.389
	(0.233)		(0.240)		(0.337)	
Age	0.092*	0.067	0.093*	0.060	0.003	0.960
	(0.050)		(0.050)		(0.065)	
Log Likelihood	550.142		519.421		335.345	

Standard error in parenthesis.
Significance computed through Wald test: ** significant at 5%, * significant at 10%.

Table 6: Determinants of the alignment (or not) of the preferences towards risk and ambiguity (N = 401).

We can easily observe that *Age* is the only variable having a significant impact at 10% on the fact to have aligned preferences. More precisely, the higher the age, the higher the alignment of individuals' preferences, either perfect or weak. The role of the age has already been found determinant to explain heterogeneity in choices under risk and uncertainty (Dohmen et al., 2011; Tymula et al., 2012). Our result seems to deepen this analysis showing that age may also explain the alignment of the preferences towards risk and ambiguity.

In Table 6, we can observe that another significant variable explains the weak alignment, the level of the *Payoff*. In particular, the higher the payoff is, the lower the weak alignment is. This variable is significant at 10%.

Remark that none of our variables significantly explain preferences that are not aligned. Further research in this direction should then be conducted.

4.3 Another interesting issue : Self-assessment *versus* lottery choice measurement

In addition to MPL procedure in both experiences, we also ask subjects to self-assess their own level of risk aversion. On a scale from 0 to 10, we ask them to indicate if "in general", they try to avoid risk or not, with 0 = always try to avoid risk and 10 = always ready to take risk. The score reflected the willingness to take risk of the subject. The higher the score, the higher the risk loving and the lower the score, the higher the risk aversion. Neutrality towards risk is supposed at 5. More precisely, subjects selecting scores from 0 to 4 are categorized as risk averse, those choosing a score of 5 are risk neutral and finally, those opting for a score higher than 5 are risk lovers. This self-assessment measure is in line with Dohmen et al. (2011). Table 7 reports the distribution of this score in the two experiences.

Score	Exp. 1 (in %)	Exp. 2 (in %)
0	0.5	0.5
1	1.6	2.9
2	3.6	4.8
3	14.6	11.5
4	19.3	12.9
5	16.7	19.6
6	16.1	16.7
7	16.1	12.4
8	9.4	11
9	0.5	3.3
10	1.6	4.3
Average score	5.18	5.45

Table 7: Distribution of the self-assessment scores of risk aversion in the two experiences.

In Experience 1, the average score is 5.18 and in Experience 2, it is 5.45. The subjects seem to be slightly risk lover. The difference between 5.18 and 5.45 is significant at the 10% level (t = -1.335, p = 0.091).

The comparison of the two elicitation procedures leads to the following table :

	Exp. 1 (in %)		Exp. 2 (in %)	
	Risk_MPL	Risk_Self-Ass.	Risk_MPL	Risk_Self-Ass.
Averse	20.8	39.6	33	32.6
Neutral	34.4	16.7	31.6	19.6
Lover	44.8	43.7	35.4	47.7

Table 8: Percentage of the sample according to each type of preferences.

In Experience 1, the two procedures lead, on average, to the same preferences, a slight risk loving (switch point of 5.28 and score of 5.18). In addition, the two distributions are significantly and positively correlated (Pearson coef. = 0.167, p = 0.021). However, when looking in details, we observe that the proportion of risk lovers is approximately the same while the proportions of neutral and averse are quite different. The percentage of risk averse subjects doubles with the self-assessment method, while the proportion of neutral is reduced by half. It seems that the self-assessment method leads to more aversion than the MPL procedure.

In Experience 2, on average, the two procedures lead to quite different results, slight risk aversion with the MPL procedure (switch point of 4.81) whereas risk loving with the self-assessment method (score of 5.45). In addition, the two distributions are not significantly correlated (Pearson coef. = 0.015, p = 0.830). However, Table 8 reveals that in this Experience 2, contrary to Experience 1, the proportions of risk averse individuals is identical between the two procedures, while the proportions of neutral and lovers change. It seems that self-assessment method leads to more risk loving than the MPL procedure.

We deepen the analysis by realizing means test comparisons for paired samples for each binary comparison between the average switch point (from the MPL procedure) and the average score (from the self-assessment scale) in each experience. It is possible since the two indicators are expressed on the same scale from 1 to 10 with the same neutrality point, at 5. The results are presented below:

	Average switch	Average score	t	Stand. error	Sig.
Experience 1	5.28	5.18	0.586	2.339	0.279
Experience 2	4.93	5.45	-2.748**	2.768	0.003

Table 9: Mean test comparisons for paired samples.

The absence of significant difference in Experience 1 confirms our results. Consequently, the following result emerges from this comparison of method to elicit risk preferences:

Result 4: The self-assessment method is a good predictor of the measurement of risk preferences in lottery choice experiment when the payoff is low.

Indeed, the only difference between Experience 1 and 2 is the size of the payoff in the lottery choice experiment. Since the self-assessment method leads to comparable result with the lottery choice in Experience 1 but not in Experience 2, this means that the predictability of the measurement or risk preferences in lottery choice experiment by the self-assessment method depends on the level of the payoff.

5 Discussion and conclusion

This article deals with the relationships between individuals' preferences towards risk and ambiguity. We present the results of two experiments where preferences towards risk and ambiguity are quantified through lottery choice experiment. The two experiences are perfectly identical except that in the lottery choice tasks, the level of the payoff is doubled in the second experience as compared to the first one. This difference allows us to analyse the impact of the level of the payoff on the individuals' preferences.

We show that risk aversion and ambiguity aversion elicited through MPL procedure increase as the payoff size in the procedure doubles (*Result 1*). This result is directly in line with others in the literature showing that the level of the payoff affects the individual's risk aversion. For example, Holt and Laury (2002) obtained that in the MPL procedure with real payoffs, risk aversion increases sharply when payoffs are scaled up by factors of 20, 50, and 90. In this article, we validate this conclusion for lower increase, a simple doubling of the payoff size. In addition, we extend this result to ambiguity aversion.

The analysis of the links between both types of preferences proves that the preferences towards risk and ambiguity are significantly and positively correlated inside each experience (*Result 2*). This result is in accordance with some articles in the literature (Lauriola and Levin, 2001; Chakravarty and Roy, 2009; Brunette et al., 2015). It also leads us to focus on the alignment or not of the individuals' preferences towards risk and ambiguity. In particular, we propose a categorization where the alignment of the preferences is associated to individuals having the same preferences towards risk and ambiguity, the weak alignment characterizes individuals that deviate from neutrality (from loving to neutrality, or the opposite; from aversion to neutrality, or the opposite) and, the preferences not aligned represent individuals who reverse their preferences (from loving to aversion, or the opposite). We classify our sample with this categorization and show that most of the subjects have preferences between risk and ambiguity that are aligned (perfectly or weakly), and only 15% of them have preferences not aligned (*Result 3*). These results indicate that the theoretical separation between risk and ambiguity preferences is not verified empirically. Indeed, the two types of preferences are correlated and in addition, the individuals' preferences towards risk and ambiguity are mainly aligned.

Finally, an additional result is presented on the capacity of self-assessment scale for risk preferences to predict the MPL quantification result. We show that the self-assessment method is a good predictor of the measurement of risk preferences in lottery choice experiment when the payoff is low (*Result 4*). The literature in experimental economics compares the consistency of individual's preferences towards risk between various elicitation procedures. Some papers compare MPL procedure with Ordered Lottery Selection one (Dave et al., 2010; Reynaud and Couture, 2012), other compared risk preferences between experiment and survey (Anderson and Mellor, 2009), or self-assessment scale and lottery question (Dohmen et al., 2011), and some compare several elicitation methods (Pedroni et al., 2017). However, whatever the methods compared, the conclusion seems to be unanimous: the measurement of preferences towards risk is procedure dependent, and the preferences are not consistent across methods. Our article contributes to this literature in two ways. First, we show that preferences may be consistent across two procedures, the MPL procedure and a self-assessment scale. Second, we show that this consistency emerge only when the payoff in the MPL procedure is low. This means that in order to have a consistency of individual's preferences, the experimenter should consider low payoff in the incentivized elicitation procedure.

Several extensions of this article may be relevant. In particular, our research question was addressed in the gain domain whereas Chakravarty and Roy (2009) show that correlations between preferences towards risk and ambiguity were domain dependent. Challenging our results in the loss domain would be then interesting. Another way to extend the research question would be to deals with the determinants of the alignment. Indeed, we have very few potential explanatory variables in our regressions and few are significant. It may be interesting to think about the potential relevant variables to explain this alignment.

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