Theory and Decision
https://doi.org/10.1007/s11238-019-09742-3

Decision making under uncertainty: the relation between economic preferences and psychological personality traits

David Schröder[1] · Gail Gilboa Freedman[2]

Abstract
Both economists and psychologists are interested in understanding decision making under uncertainty. Yet, they rely on different concepts to analyse human behaviour: economists use economic preference parameters rooted in utility theory, while psychologists use personality traits to describe responses to uncertain situations. Using a large sample of university students, this study examines and contrasts five economic preference parameters and six psychological personality traits that are commonly used to study individuals' attitudes towards uncertainty. A novelty of this paper is including both the economic concept of ambiguity aversion as well as the personality trait of ambiguity intolerance. We find that standard economic preference measures based on incentivized choice tasks seem to capture rather different characteristics than psychological personality traits. In contrast, economic preference measures obtained from self-assessment questions appear more related to personality traits, especially ambiguity intolerance.

Keywords Decision making · Uncertainty · Preferences · Personality traits · Ambiguity intolerance · Ambiguity aversion · Risk aversion

1 Introduction

Uncertainty is a fact of life. People constantly have to take decisions in uncertain environments. Examples include consumption, savings and investment decisions, as well as education and employment choices. To better understand the important topic

A1 ✉ David Schröder
A2 d.schroeder@bbk.ac.uk
A3 Gail Gilboa Freedman
A4 gail.gilboa@idc.ac.il
A5 [1] Birkbeck College, University of London, Malet Street, Bloomsbury, London WC1E 7HX, UK
A6 [2] IDC Herzliya, Kanfei Nesharim St, 4610101 Herzliya, Israel

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

of decision making under uncertainty, both economists and psychologists have developed concepts that identify key determinants of human behaviour in such situations.

The workhorse model in economics is decision theory, which is usually built on some form of utility maximization. Utility theory combines information on various possible outcomes in uncertain situations with individual economic preference parameters, such as risk (Savage 1954) or ambiguity preferences (Gilboa and Schmeidler 1989). Whereas the concept of risk denotes a situation with an uncertain outcome where the probabilities for each of the outcomes are known, the absence of precise information on probabilities is known as ambiguity (Ellsberg 1961).

Psychologists, in contrast, have developed personality traits to assess human behaviour in various domains of life. Besides the general and well-known Big Five personality traits, which go back to Allport and Odbert (1936), more specific psychological constructs have been proposed to assess individual responses to uncertain situations. One of the most important of these personality traits is the concept of ambiguity intolerance (Frenkel-Brunswik 1949). Although similar in spirit to the notion of ambiguity aversion used in economics, the concept of ambiguity intolerance is far more general. While ambiguity intolerance comprises the idea of aversion to imprecise probabilities, the concept also refers to aversion to complexity, novelty and insolubility (Budner 1962).

With a few exceptions, the concepts used by economists and psychologists to explain human behaviour under uncertainty have been studied and applied separately so far. The objective of this paper is therefore to analyse and compare economic preference measures and psychological personality traits that are designed to capture human attitudes towards uncertainty. To our knowledge, this is the first study that considers and compares both the economic concept of ambiguity aversion as well as the personality trait of ambiguity intolerance.

The analysis is based on an experimental data set of university students in London. Economic preferences towards uncertainty are captured by risk and ambiguity preferences. Following the tradition in experimental economics, these two preferences are measured using standard decision tasks with monetary incentives. In addition we measure these preferences with the help of self-assessment questionnaires. Personality traits are measured with computer-based versions of the usual pencil-and-paper questionnaires used in personality psychology. For each subject, the concept of ambiguity intolerance is assessed using a set of standard self-assessment scales. Besides, we measure other important personality measures, such as optimism, self-esteem and cognitive skills.

The results of this study show that economic preference parameters inferred from incentivized decision tasks are little related to psychological personality traits. Ambiguity aversion and ambiguity intolerance in particular seem to capture different human characteristics. Rather than being substitutes, they can hence be considered distinct concepts.

This paper builds on the emerging literature that examines the relation between economic preferences and personality traits. The first comprehensive reviews in this area of research are by Borghans et al. (2008) and Almlund et al. (2011). These general works look at the stability of economic and psychological preference

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

measures over time and explore how the insights of personality psychology might be used to improve existing decision theoretic models in economics. More specific analyses are by Borghans et al. (2009), Daly et al. (2009) and Dohmen et al. (2010). Borghans et al. (2009) show that risk preferences are related to most personality traits of the Big Five, while this is not the case for ambiguity preferences. Daly et al. (2009) find that time preferences are related to the traits of conscientiousness and extraversion. Dohmen et al. (2010) show that risk and time preferences are systematically related to cognitive skills.

Most closely related to this paper are the studies by Becker et al. (2012), Rustichini et al. (2016) and Lönnqvist et al. (2015). Becker et al. (2012) examine the relation between six key economic preference parameters, the personality traits captured by the Big Five and the locus of control (Rotter 1966). Using various data sets from the German population, they find that economic preferences obtained from incentivized tasks and psychological personality traits are little related to each other, similar to the findings of this paper. They conclude that the two concepts are rather complementary to each other. Rustichini et al. (2016) use a large data set of US truck drivers to analyse the relation between risk and time preferences and personality traits. While they find some strong association between cognitive skills and both time and risk preferences, the relation between economic preferences and the personality traits of the Big Five is rather weak. Lönnqvist et al. (2015) compare different elicitation methods for risk preferences. They find that risk preferences obtained from self-assessment questionnaires are more connected to personality traits than economic preference parameters obtained from standard choice tasks.

The present study contributes to this literature by examining economic preference parameters and personality traits that specifically aim to capture human attitudes towards uncertainty. A special focus of this paper is on the concepts of ambiguity aversion and ambiguity intolerance. While Becker et al. (2012) and Rustichini et al. (2016) consider a variety of economic and psychological measures, they do not include ambiguity preferences or ambiguity tolerance. To our knowledge, Tanaka et al. (2015) is the only study that explicitly compares these two concepts, albeit from neuroeconomic perspective. Similar to this paper, they do not find any relation between ambiguity aversion and ambiguity intolerance.

This paper proceeds as follows. The next section presents the research design in detail. The experimental procedure is explained in Sect. 3. Section 4 then describes the economic preference parameters and psychological personality traits obtained from the data. Section 5 analyses the relation between economic preferences and personality traits that aim to capture individual attitudes towards uncertainty. Section 6 provides some discussion and conclusions.

2 Research question and hypotheses

The objective of this study is to analyse the relation between economic preferences and psychological personality traits that aim to measure human attitudes towards uncertainty. In economic terms, this analysis allows understanding whether economic preferences and personality traits are closely linked to each other—or

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

whether they are independent concepts. In psychometrics, such an analysis is known as a test of construct validity, i.e. the extent to which a measure quantifies what it is supposed to be measuring.

We consider the two most important economic preferences that measure individual attitudes towards uncertainty: risk and ambiguity preferences. While the notion of *risk* refers to a situation with an uncertain outcome where the probabilities for each of the outcomes are known to the decision maker, the absence of accurate information on probabilities is known as *ambiguity*. Following the tradition in experimental economics, we measure these two preferences using standard choice tasks with monetary incentives. In addition to these incentivized tasks, also called behavioural measures of economic preferences (Mata et al. 2018), we also assess risk and ambiguity preferences using non-incentivized self-assessment questionnaires using Likert scales.

In terms of personality traits, this study considers six different measures. One of the most prominent psychological personality traits to measure attitudes towards uncertain situations is the concept of ambiguity intolerance (Frenkel-Brunswik 1949; Bochner 1965). While similar in spirit to the notion of ambiguity aversion used in economics, the concept of ambiguity intolerance is more general. In addition to ambiguity intolerance, we also measure other important personality traits that have been shown to capture attitudes towards uncertainty, including optimism, self-esteem, reasoning and cognitive skills.

We examine the relation between economic preferences and personality traits using correlation analysis. Sizable and significant correlations between their empirical measures suggest that economic and psychologic measures essentially capture similar human characteristics. This would also imply that there is some substitutability between these concepts when it comes to explaining heterogeneity in behaviour. In contrast, small and insignificant correlations mean that economic preferences and personality traits are distinct concepts. This, in turn, might imply some complementarity when explaining actual life outcomes.

In addition, we expect that any empirical relation between economic preferences and personality traits to be stronger when measuring economic preferences using self-assessment questions relative to incentivized choice tasks, for two reasons. First, self-assessment questions measure economic preferences using the same elicitation method as psychology questionnaires, i.e. a predefined set of answers using Likert scales. Second, self-assessment questions use language to evoke responses to uncertain situations, which is similar to the standard scales used in personality psychology.

A particular focus of this study is to compare the economic concept of ambiguity aversion with the personality trait of ambiguity intolerance. Both concepts have been increasingly (and simultaneously) used to measure attitudes towards uncertainty going beyond what is known as risk aversion. Yet, although ambiguity intolerance comprises the idea of aversion to vague outcome probabilities (similar to ambiguity aversion), it also refers to aversion to complexity, novelty and insolubility (Budner 1962). Aversion to situations with unclear structure (i.e. where there is no obvious solution) is an indication of ambiguity intolerance. For example, the scales used to measure ambiguity intolerance contain statements such as

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

"Practically every problem has a solution". From an economics perspective, ambiguity intolerance might therefore be conceived to denote not only aversion to ambiguous probabilities, but also aversion to ambiguous outcomes (Du and Budescu 2005). If psychologists and economists essentially aim to capture an identical underlying concept of ambiguity, we expect their empirical measures to be significantly correlated. Such a relation would effectively mirror previous evidence showing that the notion of 'risk' is not too different in economics and psychology (Frey et al. 2017). In contrast, if that ambiguity aversion and ambiguity intolerance measure different aspects of human attitudes towards uncertainty, we expect no significant correlation between the two.

3 Experimental design

3.1 Economic preferences measures

The experimental economics literature has proposed various designs to measure risk preferences. This study uses an incentivized binary choice list by Chakravarty and Roy (2009), which is a simplified version of the well-known Holt and Laury (2002) design. In this list, subjects are presented a decision table with ten choices between a low-risk and a high-risk lottery. The lotteries are presented in the form of two-colour urns. As the list proceeds, the low-risk urn remains identical, while the expected payoff of the high-risk urn increases monotonically. The task is presented in detail in Appendix 1. The point at which subjects switch from the low-risk urn to the high-risk urn indicates the subjects' risk preferences.

Ambiguity preferences are measured using another incentivized binary choice list, involving 11 sequential decisions between a risky and an ambiguous lottery. The lotteries are presented again in the form of two-colour urns, similar to Ellsberg (1961). The composition and the payoffs of the ambiguous urn are identical in all 11 situations. In contrast, the expected payoff of the risky urn increases from one situation to the next. This change is induced by increasing the probability of winning some prize, while leaving the potential prize constant (see Appendix 1). The point at which subjects switch from preferring the ambiguous urn over the risky urn indicates their ambiguity preference. As Dimmock et al. (2015) show, this design allows measuring ambiguity preferences independent of the subject's utility function, and thus risk preferences.[1] In this task, participants were asked to select the colour of the winning ball. This ensures that subjects had no reason to believe that the experimenter had any strategic incentive to manipulate the colour of the balls in the ambiguous urn (Chow and Sarin 2002; Charness et al. 2013).

In addition, we measure risk and ambiguity preferences using self-assessment questionnaires. Such self-report measures have recently seen increasing popularity among researchers (Dohmen et al. 2011; Falk et al. 2016), most of all because of their cost-effectiveness and simplicity. Furthermore, Lönnqvist et al. (2015) show

[1] While Dimmock et al. (2015) are the first to show this in the context of ambiguity preferences, the idea goes back to Smith (1961). It has subsequently been used by Roth and Malouf (1979) and generalized in Berg et al. (1986).

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

that risk preferences obtained from self-assessment questionnaires have a higher test–retest stability, and are better in predicating actual behaviour relative to risk preferences measured using incentivized choice tasks. Risk preferences are measured using the standard risk question proposed by Dohmen et al. (2011). Different from risk preferences, the literature has not yet agreed upon a standard self-assessment question to measure ambiguity preferences. A potential explanation for this lack of question is that the connotation of the word "ambiguity" in everyday language is different from the notion of ambiguity in economics. Against this backdrop, this study resorts to two ambiguity questions, as first proposed by McLain (2009). While the first question explicitly employs the term "ambiguity", the second question uses the broader term "uncertainty" to measure ambiguity preferences. The exact wording is presented in Appendix 1.

3.2 Psychological personality traits and cognitive skills

This study resorts to the Intolerance of Ambiguity Scale by Kirton (1981), one of the most widely used and renowned scale on ambiguity intolerance in psychology. The scale combines items of the earlier work on Intolerance of Ambiguity scale by Budner (1962), the Ambiguity Tolerance scale by Mac Donald Jr (1970) and the Tolerance of Ambiguity Scale by Rydell and Rosen (1966). Kirton's selection of items exhibits better psychometric characteristics, more consistent relation to other tests and a better internal reliability.[2] We implement the entire 18-item scale using an online questionnaire. In this scale, subjects are asked to indicate the extent to which they agree or disagree with a list of 18 statements on a scale from 1 to 7.

Since it has been argued that attitudes towards uncertainty are related to optimism and pessimism (Chateauneuf et al. 2007; Pulford 2009) and self-esteem (Heath and Tversky 1991), the questionnaire includes some attitudinal questions that aim to capture these personality traits as well. Optimism is measured using a single-item question on optimism/pessimism. To measure self-esteem, we include the self-esteem measure by Robins et al. (2001).

A recent stream of literature investigates the relationship between attitudes towards uncertainty, especially in the sense of economic preferences, and cognitive skills (Burks et al. 2009; Prokosheva 2016). In light of these findings, this study also includes a measure of cognitive ability, resorting to Raven's Standard Progressive Matrix test as used by Bilker et al. (2012). As alternative measure of cognitive skills, we measure the time it takes subjects to correctly answer the control questions of the risk preference task. The conjecture is that subjects with better cognitive skills are faster in finding the correct solutions.[3] Finally, given recent evidence that attitudes towards uncertainty might be related to intuition and reasoning (Butler et al. 2014), we measure the time spent on answering Raven's Standard Progressive Matrix test. Following Rubinstein (2007), the conjecture is

2FL01 [2] Kirton (1981) is widely used in empirical work in social psychology. For a review, see Furnham and
2FL02 Ribchester (1995). Another important Ambiguity Tolerance scale is by Norton (1975).

3FL01 [3] Before proceeding to the actual choice lists to measure risk and ambiguity preferences, subjects were
3FL02 asked to find the right answers to some control questions. They are presented in Appendix 1.

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

that the more time spent on answering the cognitive skills test, the less intuitive a decision maker is. The entire survey questionnaire is presented in Appendix 2.

3.3 Participants and experimental procedure

The experiment was conducted in March 2016 at the Express Lab at Royal Holloway, University of London. The laboratory sessions were implemented in z-tree (Fischbacher 2007). 99 subjects participated in the study, most of them students of Royal Holloway, University of London. The subjects were recruited via electronic mail. The sample contains 25 (25%) male and 74 (75%) female subjects, with an average age of about 21 years.

The experimental sessions started with the cognitive skills test, followed by the self-assessment questions. Then subjects had to fill out a demographic questionnaire. The incentivized choice tasks were placed at the end of the sessions. This particular sequence was chosen to ensure that participants were motivated until the end of the sessions.

The payment modality of the incentivized tasks to measure risk and ambiguity preferences was common knowledge. Subjects were told that one situation of both tasks would be randomly selected by the computer at the end of the session. Then the computer would randomly draw one ball from the urn chosen. This procedure ensures that subjects state their true preferences. Earnings from the tasks were calculated in terms of points, and then converted at a rate of 2:1 into GBP. On average, subjects earned GBP 13, which includes a fixed show-up fee of GBP 4.[4] Earnings were paid in private at the end of the sessions.

4 Experimental data

4.1 Economic preferences

Table 1 presents the descriptive statistics of the economic preference parameters. In the *risk task*, subjects preferred in around 59% of all situations drawing a ball from the relatively safe urn over drawing a ball from the relatively risky urn (see panel A). A common choice pattern in such a binary choice list is a threshold strategy. Since the relative attractiveness of the lotteries changes monotonically from situation to situation, many subjects prefer one urn over the other up to a switching point, from which they prefer the other urn. In this specific case, the natural choice is to first select the relatively safe urn A, and then switch to urn B at some point. Yet, some subjects switch from one urn to the other more than once. Such behaviour is difficult to reconcile with expected utility theory. However, only 15% exhibit such a pattern in the risk task, in line with similar studies (Holt and Laury 2002). In case a subject exhibits multiple switching points, this study follows Falk et al. (2016) and calculates the subject's average switching point. In the risk task, the average switching point (defined as the last situation before a subject switches from

[4] Since the sessions lasted for about 60 min, the payoffs are substantial. The lowest payment was GBP 4, the highest payment GBP 21.

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

Table 1 Descriptive statistics of economic preferences

Panel A: summary statistics: risk task

	Observations	Mean	SD	Lowest	Highest
Safe choices	99	59.4%	0.15%	30.0%	100.0%
Switching point	99	5.93	1.56	3	10
Risk aversion parameter	99	0.544***	0.156	0.25	0.95

Panel B: summary statistics: ambiguity task

	Observations	Mean	SD	Lowest	Highest
Risky choices	99	56.1%	0.09%	36.4%	90.9%
Switching point	99	4.85	0.96	1	7
Ambiguity aversion parameter	99	0.565***	0.096	0.35	0.95

Panel C: summary statistics: self-assessment questions

	Observations	Mean	SD	Lowest	Highest
Risk question	99	0.444**	0.229	0	1
Ambiguity question 1	99	0.507	0.210	0	1
Ambiguity question 2	99	0.614***	0.268	0	1

Panel D: correlation statistics

	Risk (task)	Risk (question)	Ambiguity (task)	Ambiguity (question 1)	Ambiguity (question 2)
Risk (task)		0.159	−0.049	0.104	0.030
Risk (question)	0.134		−0.076	0.150	0.187*
Ambiguity (task)	0.040	−0.063		0.031	−0.023
Ambiguity (question 1)	0.095	0.139	0.012		0.199**
Ambiguity (question 2)	0.025	0.155	−0.028	0.243**	

The table summarizes the economic preferences. Panel A reports the preference parameter for risk obtained from the incentivized task; panel B reports the preference parameter for ambiguity obtained from the incentivized task. Panel C reports the preference measures obtained from the self-assessment questions. Panel D presents the correlation statistics between risk and ambiguity preferences. The lower part of the panel presents the Pearson correlation, the upper part the Spearman correlation

*, **, and *** denote statistical significance at the 10%, 5% and 1% level, respectively. For a detailed description of the preference measures, see Sect. 3.1

282 the relatively safe urn to the risky urn) is 5.9. Using this switching point, we derive a
283 non-parametric measure of risk aversion. A value of 1 indicates extreme risk
284 aversion, while a number of 0 indicates extremely risk-seeking preferences. Risk-
285 neutral subjects have a risk aversion parameter of 0.5. The average parameter value
286 of the sample is at 0.54, which is statistically different from 0.5 (t-test, p value
287 <0.01). Hence, it can be concluded that the sample of subjects exhibits a mild
288 degree of risk aversion, on average.

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

In the *ambiguity task*, subjects prefer in around 56% of all situations the risky over the ambiguous urn. A large majority of subjects (93%) exhibits a threshold strategy with a single switching point from urn 2 to urn 1. For the remaining subjects with multiple switching points, we again define a subject's switching point as their average switching point. Using this switching point, we construct a non-parametric measure of ambiguity aversion, similar to the risk task. A value of 1 indicates extreme ambiguity aversion, a number of 0 indicates extremely ambiguity seeking preferences, and ambiguity-neutrality corresponds to a parameter value of 0.5. The sample of subjects has an average ambiguity aversion parameter of 0.57, which is again statistically different from 0.5 (t-test, p value <0.01). Hence, the sample of subjects exhibits a mild degree of ambiguity aversion, on average.

Panel C reports the summary statistics of the answers to the self-assessment questionnaire to measure risk and ambiguity preferences. Similar to the incentivised choice tasks, the answers are linearly transformed into preference parameters. A value of 0 indicates extreme risk or ambiguity seeking preferences, while a number 1 corresponds to extreme risk or ambiguity aversion. Risk and ambiguity neutrality is captured by a parameter value of 0.5.

The average parameter value of the *risk question* is with 0.44 below the level of 0.5 which indicates risk neutrality. Different from the incentivized risk task, this implies some risk-seeking preferences, on average (t-test, p value <0.05). The average preference parameters of the ambiguity questions are with 0.51 and 0.61 both larger than 0.5, the value that corresponds to ambiguity neutrality. Yet, only the answers to *ambiguity question 2* are statistically different from 0.5 (t test, p value <0.01).[5]

Panel D presents the correlation statistics of the various measures of risk and ambiguity preferences, using both the linear Pearson and the Spearman rank correlation metrics. Most pairwise correlations are very small in size, and not statistically significant. The only notable (and expected) exception is the correlation of around 0.2 between the two self-assessment questions to measure ambiguity preferences.

These results show that risk and ambiguity preferences are distinct from each other, at least in this sample. While most of the experimental literature suggest a positive relation between risk and ambiguity preferences (Trautmann and van de Kuilen 2016), this evidence is not clear-cut as there are quite a few studies documenting no or a negative correlation between both preferences.

Second, preference measures obtained from incentivized tasks are different from measures based on self-assessment questions. Although both elicitation methods are supposed to measure the same concept, they come to different results. While this finding might appear surprising, it is in line with Lönnqvist et al. (2015) who similarly show that risk measures obtained from lottery tasks are different from measures based on self-assessment questionnaires.

Since the sample of participants is not evenly distributed across gender (75% of participants are female), it is important to check for gender differences in risk and

[5] The average scores of the two ambiguity questions are also significantly different from each other (t test, p value <0.01).

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

ambiguity preferences. Yet, a mean comparison test (*t*-test) cannot reject the hypothesis of equal average risk and ambiguity preferences for male and female participants.

4.2 Personality traits and cognitive skills

Similar to the economic preference measures, the responses to the psychological questionnaire have first to be transformed into some personality parameters. From the responses to the 18-item Intolerance of Ambiguity scale by Kirton (1981), we create the personality measure *ambiguity intolerance* by performing a principal component analysis on the responses. Then we estimate the first component score for each subject. This first component score is then normalized to lie in the interval between 0 and 1, where 1 corresponds to the highest level of ambiguity intolerance observed in the sample, while 0 corresponds to the lowest level of ambiguity intolerance. Similarly, the single-item questions on self-reported *optimism* and *self-esteem* are also normalized to a range from 0 to 1, with high values corresponding to high optimism and high self-esteem.

The *cognitive ability* of the subjects is measured as the fraction of correct responses to Raven's Standard Progressive Matrix test. The alternative measure of cognitive skills, the time spent on correctly answering the control question of the risk task (*test time*), is also normalized to lie in an interval between 0 and 1. The fastest subject is assigned a test time value of 0, and the slowest subject a test time value of 1. Finally, the indicator of *reasoning* (the time spent on Raven's Standard Progressive Matrix test) is similarly normalized to lie in the range between 0 and 1.

Panel A of Table 2 presents the summary statistics of the psychological personality traits. The average ambiguity intolerance parameter obtained from the principal component analysis is very close to 0.5, indicating a rather symmetric distribution of ambiguity intolerance in the sample. Similarly, the average reasoning parameter is also very close to 0.5. Subjects consider themselves on average rather optimistic (0.62) and slightly more-than-average self-confident (0.52). With more than 75% of right answers in the cognitive skill test, average cognitive ability is rather high—presumably reflecting the sample of university students. Yet, the rather low average normalized test time (0.15) indicates that there are a few subjects that had serious difficulties in finding the right answer to the control questions in the incentivized risk task.

Panel B presents the pairwise correlation statistics of the psychological personality measures. The lower triangle of the panel presents the linear Pearson correlation, and the upper triangle the Spearman rank correlation. The table allows for some important conclusions. First, subjects that consider themselves more self-confident tend to be more optimistic in life. These findings are in line with the literature in psychology that similarly documents a positive association between optimism and self-confidence (Chemers et al. 2000; Bagana et al. 2011). Next, there is a significant association between cognitive ability and test time. Since low cognitive skills imply a long test time, a negative correlation is expected. Finally, there is a positive association between test time and reasoning, which shows that subjects that tend to think more in the cognitive skills test take also more time in

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

Table 2 Descriptive statistics of personality traits

Panel A: Summary statistics

	Observations	Mean	SD
Ambiguity intolerance	99	0.516	0.214
Optimism	99	0.620	0.247
Reasoning	99	0.472	0.281
Self-esteem	99	0.523	0.284
Cognitive ability	99	0.752	0.215
Test time	99	0.145	0.147

Panel B: Correlation statistics

	Ambiguity intolerance	Optimism	Reasoning	Self-esteem	Cognitive ability	Test time
Ambiguity intolerance		−0.037	−0.123	−0.018	−0.148	0.023
Optimism	−0.024		−0.095	0.516***	−0.084	0.075
Reasoning	−0.134	−0.086		−0.039	0.078	0.125
Self-esteem	−0.054	0.518***	0.002		−0.085	−0.013
Cognitive ability	−0.151	−0.084	0.004	−0.079		−0.073
Test time	−0.019	0.050	0.224**	−0.030	−0.166*	

The table summarizes the psychological personality traits. Panel A presents the summary statistics, and panel B presents the correlation statistics. The lower part of panel B presents the Pearson correlation, and the upper part the Spearman correlation

*, **, and *** denote statistical significance at the 10%, 5% and 1% level, respectively. For a detailed description of the personality traits, see Sect. 3.2

answering the control questions. While this relation is intuitive, it suggests that test time is not a perfect measure of cognitive ability as it includes some aspects of reasoning as well.

Again, a mean comparison test (*t*-test) cannot reject the hypothesis of equal average levels of the various personality traits for male and female participants.

5 Results

This section examines the association between economic preferences and personality traits. Panel A of Table 3 presents the pairwise correlation statistics, using both the Pearson linear correlation and the Spearman (1904) rank correlation metrics. The two columns on the left show the correlation between personality traits and economic preferences inferred from incentivized tasks, while the three columns on the right show the correlations between personality traits and economic preferences obtained from self-assessment questions.

The table reveals a stark contrast in correlation patterns between economic preferences obtained from choice tasks relative to self-assessment questions. When

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

Table 3 Relation between economic preferences and psychological personality traits

Economic preferences	Choice tasks		Self-assessment questions		
	Risk aversion	Ambiguity aversion	Risk aversion	Ambiguity aversion (1)	Ambiguity aversion (2)
Panel A: correlation statistics					
Personality traits					
Ambiguity intolerance	0.138	−0.006	0.210**	0.352***	0.309***
	0.136	−0.069	0.213**	0.322***	0.318***
Optimism	−0.078	0.187*	−0.302***	−0.108	−0.176*
	−0.093	0.159	−0.290***	−0.122	−0.146
Reasoning	−0.135	0.032	−0.072	−0.187*	−0.065
	−0.188*	−0.003	−0.082	−0.184*	−0.055
Self-esteem	−0.060	0.212**	−0.326**	−0.060	−0.202**
	−0.069	0.225**	−0.299 ***	−0.052	−0.216**
Cognitive ability	−0.140	−0.036	−0.011	−0.025	−0.080
	−0.107	0.036	−0.046	−0.025	−0.125
Test time	−0.036	−0.161	0.111	0.036	−0.098
	−0.050	−0.048	0.092	0.031	0.011
Panel B: ordered logit regressions of economic preferences					
Personality traits					
Ambiguity intolerance	1.003	−0.457	2.056**	3.003***	2.730***
Optimism	−0.877	0.805	−1.713*	−1.220	−0.454
Reasoning	−0.899	0.073	−0.574	−1.146*	−0.013
Self-esteem	−0.068	1.288	−1.462*	0.348	−1.253
Cognitive ability	−1.196	0.220	−0.002	0.362	−0.455
Test time	−0.386	−2.857*	1.801	1.299	−1.529
Pseudo R^2	1.96%	3.68%	5.21%	5.31%	4.76%
Observations	99	99	99	99	99

Panel A of the table presents the correlation statistics between economic preference measures and psychological personality traits. The upper number of each pair is the Pearson linear correlation; the lower number the Spearman (1904) rank correlation. Panel B presents the estimated coefficients of ordered logit regressions of the economic preference measures on the various psychological personality traits

*, **, and *** denote statistical significance at the 10%, 5% and 1% level, respectively

examining economic preferences obtained from choice tasks, the table shows that only 4 out of 24 pairwise correlations are statistically significant from zero at a significance level of 10%, or less. This result suggests that economic preferences obtained from choice tasks are little related to personality traits. In addition to looking at levels of statistical significance, it is important to examine the actual size of the correlations. A common convention in social sciences is to consider any

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

correlation below 0.3 in absolute value as small, as medium if the correlation is between 0.3 and 0.5 and as large if the correlation is larger than 0.5 (Cohen 1988). Against this backdrop, it can be concluded that all pairwise correlations obtained from choice tasks are small.

The only consistently significant relation is the association between self-esteem and ambiguity aversion, with a sizable correlation of more than 20%. However, this association is counterintuitive, as it means that more confident subjects are more ambiguity averse. This result also contrast Heath and Tversky (1991) who show that more confident subjects tend to be more willing to engage in gambles with ambiguous payoffs.[6]

At first sight, the weak association between choice-based measures of risk and ambiguity aversion and personality traits, especially ambiguity intolerance, appears surprising. Yet, this result might be explained by the notional differences between these concepts. Ambiguity intolerance captures a much broader notion of uncertainty compared to the narrow definition of uncertainty in economics—situations with uncertain outcomes, where probabilities for each of the outcomes are known (risk) or unknown (ambiguity). In fact, previous literature examining the relation between risk preferences based on choice lists and personality traits, such as the Big Five, comes to similar conclusions. Borghans et al. (2009), Becker et al. (2012) and Lönnqvist et al. (2015) only find some weak association between risk preferences and extraversion, neuroticism or agreeableness. As far as ambiguity preferences are concerned, Borghans et al. (2009) find no relation to any personality trait.

The picture is different when looking at the correlation statistics between personality traits and economic preferences obtained from self-assessment questions. Many correlations are substantial in size and different from zero at high levels of statistical significance. Likewise, the associations have always the expected sign. Most of all, ambiguity and risk preferences are positively related to ambiguity intolerance. Next, the table shows a negative association between economic preferences and optimism, i.e. optimistic subjects are less risk and ambiguity averse. Finally, reasoning and self-esteem are negatively related to both less risk and ambiguity aversion. This means that high levels of self-esteem and a good capacity of reflection corresponds to low levels of risk and ambiguity aversion—opposed to the results of choice-based ambiguity preferences. Only the two measures of cognitive skills (Raven's matrix and test time) are not significantly related to both risk and ambiguity aversion.

The strong association between personality traits and question-based economic preference measures is likely to be explained by two reasons. First, the notion of risk and ambiguity in self-assessment questions is much broader (relative to lottery-based choice tasks), and therefore, by construction, closer to personality traits. Second, both personality traits and question-based economic preference measures share the same elicitation method, i.e. attitudinal questions using Likert scales. It

[6] It should be noted, however, that Heath and Tversky (1991) measure perceived competence and ambiguity premia for the very same specific question, whereas our measure of self-esteem is not related to the task measuring ambiguity preferences.

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

should be noted, however, that the results also imply that ambiguity intolerance might comprise some aspects of both risk and ambiguity aversion, at least when using self-assessment questions to measure these economic preferences.[7]

Panel B of Table 3 presents the estimated coefficients of ordered logit regressions of economic preferences on the various psychological personality traits. The results are similar to those of the Pearson linear correlation statistics. Economic preferences obtained from choice tasks cannot be explained by personality traits. With the exception of test time, none of the estimated coefficients is statistically significant. In contrast, economic preferences obtained from self-assessment questions are significantly related to some personality traits, especially to ambiguity intolerance.[8]

6 Discussion and concluding remarks

This study analyses and compares economic preferences and psychological personality traits that are designed to measure human attitudes towards uncertainty. In particular, this paper expands on existing research by examining the concepts of ambiguity aversion (as used in economics) and ambiguity intolerance (as used in psychology).

The results show a complex picture of the relation between economic and psychological measures that aim to assess attitudes towards uncertainty. On the one hand, standard economic preference measures based on incentivized choice tasks—the elicitation method advocated in the experimental economics literature—seem to capture rather different characteristics than psychological personality traits. Especially ambiguity aversion and ambiguity intolerance seem distinct concepts. On the other hand, economic preference measures obtained from self-assessment questions appear more related to the personality trait of ambiguity intolerance.

These findings might not be too surprising given the different nature of economic preferences and personality traits, as well as their elicitation methods. Economic preference parameters are designed to capture human decision making in narrowly defined economic models, and are measured using incentivized choice tasks. Personality traits, in contrast, more generally aim to measure characteristic patterns of feelings, thoughts and behaviours (Roberts 2009), and are inferred from self-assessment questionnaires.

The difference seems particularly pronounced for the concepts of ambiguity intolerance and ambiguity aversion. The weak association between the two concepts strengthens the view that the notion of ambiguity in economics is indeed very different from the notion of ambiguity in psychology. While ambiguity aversion in economics only refers to aversion to vague outcome probabilities, ambiguity intolerance comprises many other aspects, including aversion to complexity,

7FL01 [7] In addition to the correlation analysis, we also use kernel-weighted linear polynomial regressions to
7FL02 explore any non-linear relation between economic preferences and personality traits. A few outliers aside,
7FL03 the results suggest a monotonic relation between economic preferences and personality traits. In most
7FL04 cases the relation is even linear.

8FL01 [8] Regression tests of the psychological personality traits on the various risk and ambiguity preference
8FL02 measures give similar results as the pairwise Pearson linear correlation statistics of Table 3, panel A.

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

novelty and insolubility. Indeed, the significant correlation of ambiguity intolerance with the risk aversion parameter obtained from the self-assessment question suggests that ambiguity intolerance reflects a rather broad attitude towards uncertainty.

In fact, when looking at the historical evidence, it seems that ambiguity intolerance and ambiguity aversion have developed independently. The concept of ambiguity intolerance was first introduced by the psychologist Frenkel-Brunswik (1949). She describes ambiguity intolerance as

> one of the basic variables in both the emotional and the cognitive orientation of a person toward life (p. 113).

In particular, she viewed ambiguity intolerance, among others, as a reason for subjects to favour authoritarian structures. In contrast, Ellsberg (1961) introduced the term 'ambiguity' without any reference to the psychology literature:[9]

> What is at issue might be called the *ambiguity* of this information, a quality depending on the amount, type, reliability and 'unanimity' of information, and giving rise to one's degree of 'confidence' in an estimate of relative likelihoods (p. 657).

Actually, the title of his seminal work ("Risk, ambiguity and the Savage axioms") directly refers to the subjective expected utility (Savage 1954), which is one of the benchmark models for choice under uncertainty in economics.[10]

We would like to stress that this paper only examines a selected set of economic preferences and personality traits that measure attitudes towards uncertainty. While most economists are likely to agree that risk and ambiguity preferences are by far the most important preference parameters in decision theory, there is less of a consensus in psychology. For example, the literature has presented evidence that some of the personality traits included in the Big Five, such as extraversion, neuroticism or agreeableness, also capture individual attitudes towards uncertainty, at least to some extent (Becker et al. 2012; Lönnqvist et al. 2015).

It is important to keep in mind that the results of this study are obtained from a sample of university students, which might not be representative for the entire population. This observation is important since economic preferences and personality traits can change over the life cycle. For example, Dohmen et al. (2011) show that risk aversion increases with age. On the other hand, the work by Becker et al. (2012) suggests that pairwise associations between economic preferences and personality traits are similar across different age groups of the population.

9FL01 [9] The economic concept of ambiguity was first introduced by Knight (1921). Ambiguity is therefore
9FL02 sometimes known as 'Knightian uncertainty'. Knight, however, did not use the term 'ambiguity' to
9FL03 describe this type of uncertainty.

10FL01 [10] An alterative view is that both concepts are based on the same fundamental roots, but have been
10FL02 increasingly overstretched across the two disciplines, leading to the empirical differences documented in
10FL03 this study. The debate whether some concepts become too overstretched across subfields is well known in
10FL04 other disciplines of social sciences; see Sartori (1970).

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

Finally, the findings do not allow for a clear-cut conclusion about which measures are a priori better in measuring attitudes towards uncertainty. Only, for example, if ambiguity intolerance is assumed to be a good measure of human attitudes towards uncertainty, one can conclude that economic preferences are best measured using self-assessment questions. Only a test of predictive validity, i.e. a comparison of the various measures with real-life behaviour would be able to answer this question.[11] This question is left for future research.

Acknowledgements We are grateful to Elisa Cavatorta, Luc Meunier, Daniel Navarro, participants at the FUR 2018 conference in York (UK), the IMEBESS 2019 conference in Utrecht (Netherlands), the research seminar at Birkbeck College (UK) and two anonymous referees for helpful comments and discussions. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Any remaining errors are ours.

Appendix 1: Economic preferences

This appendix presents the economic preference measures, the two incentivized decision tasks and the three self-assessment questions.

Before each choice task, subjects were presented examples of the choice tasks to familiarize themselves with the design. In addition, subjects were asked several control questions before the risk task to ensure that they understood the tasks. Only after correctly answering these questions, the actual tasks started. The control questions are presented below the risk task.

Risk task: This task is taken from decision sheet B of Chakravarty and Roy (2009).

In this task you need to fill in the decision table shown below. The decision table consists of 10 different situations, listed 1 to 10. Each situation offers you a choice between drawing a ball from two different urns, urn A or urn B. Both urns contain 10 balls, either white or black.

- *The composition of urn A is identical in all 10 situations. There are 5 white balls and 5 black balls.*
- *The composition of urn B changes from one situation to the next. The number of white balls increases incrementally from 0 white balls in situation 1 to 9 white balls in situation 10, while the number of black balls decreases accordingly.*

At the end of the session, the computer will randomly select one out of the 10 situations. Then, depending on whether you have chosen urn A or urn B in that situation, the computer will randomly draw one ball from that urn. Depending on the color of the ball, you earn the points indicated in the table. Notice that even though you will make 10 decisions, only one of these will determine the points you

[11] This is especially important as previous studies are inconclusive on the relationship between ambiguity aversion, ambiguity intolerance and real-life behaviour. The recent survey by Trautmann and van de Kuilen (2016), e.g. finds little evidence for external validity of economic ambiguity preferences (i.e. their predictive power for real-life behaviour.)

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

earn, but you will not know in advance which situation will be selected (they are equally likely to be selected).

In each situation, from which urn do you prefer to draw a ball, urn A or urn B?

Situation	URN A: If a white ball is drawn you earn 6 points If a black ball is drawn you earn 4 points	URN B: If a white ball is drawn you earn 10 points If a black ball is drawn you earn 0 points	Your choices
1	5 white balls, 5 black balls	0 white balls, 10 black balls	Urn A ◯ ◯ Urn B
2	5 white balls, 5 black balls	1 white ball, 9 black balls	Urn A ◯ ◯ Urn B
3	5 white balls, 5 black balls	2 white balls, 8 black balls	Urn A ◯ ◯ Urn B
4	5 white balls, 5 black balls	3 white balls, 7 black balls	Urn A ◯ ◯ Urn B
5	5 white balls, 5 black balls	4 white balls, 6 black balls	Urn A ◯ ◯ Urn B
6	5 white balls, 5 black balls	5 white balls, 5 black balls	Urn A ◯ ◯ Urn B
7	5 white balls, 5 black balls	6 white balls, 4 black balls	Urn A ◯ ◯ Urn B
8	5 white balls, 5 black balls	7 white balls, 3 black balls	Urn A ◯ ◯ Urn B
9	5 white balls, 5 black balls	8 white balls, 2 black balls	Urn A ◯ ◯ Urn B
10	5 white balls, 5 black balls	9 white balls, 1 black ball	Urn A ◯ ◯ Urn B

Participants had to correctly answer three control questions before starting the risk task:

1. What is the probability of winning six points when drawing a ball from urn A, in each situation (in %)? [Correct answer: 50%]
2. In situation 4, what is the probability of winning ten points when drawing a ball from urn B (in %)? [Correct answer: 30%]
3. In situation 5, which urn should you choose if you prefer a 50% chance to win six points and a 50% chance to win four points over a 40% chance to win ten points? [Correct answer: urn A]

Ambiguity task: The task extends the Ellsberg (1961) thought experiment to different situations, similar to Lauriola and Levin (2001) and Butler et al. (2014).

In this task, we present you a decision table with 11 situations. Each situation offers you a choice between drawing a ball from two different urns, urn 1 or urn 2. Both urns contain 10 balls, either white or black.

Journal : Small-ext 11238 Article No. : 9742 MS Code : THEO-D-19-00013R2 Dispatch : 13-1-2020 LE CP Pages : 23 TYPESET DISK

- *Urn 1: The composition of urn 1 changes from one situation to the next. While the number of balls in one color (e.g., white) increases incrementally from 0 to 10, the number of balls of the other color (e.g., black) decreases accordingly.*
- *Urn 2: The composition of urn 2 is identical in each situation. However, you don't know how many balls are white and how many balls are black. Any combination is possible. There might be from 0 to 10 white balls, with the remaining balls being black.*

One ball will be drawn from the urn you choose. The points you can earn depend on the color of the ball drawn. Only one color yields some points. You can choose whether the color that yields points is white or black. Please choose the color of the ball that provides you points:

- *white*
- *black*

Please look at the decision table below.[12] *In each of the 11 situations, we would like you to indicate from which urn (urn 1 or urn 2) you prefer drawing a ball. As explained before, both urns contain 10 balls, either white or black.*

- *Urn 1: The composition of urn 1 changes from one situation to the next. The number of white balls increases incrementally from 0 white balls in situation 0 to 10 white balls in situation 10, while the number of black balls decreases accordingly.*
- *Urn 2: The composition of urn 2 is identical in all situations. However, the exact composition of urn 2 is unknown. Any combination of white and black balls is possible: there might be 10 white balls, or 10 black balls, or any other possible combination of white and black balls.*

If a white ball is drawn, you earn 10 points. If a black ball is drawn, you earn no points.

At the end of the session, the computer will randomly select one out of the 11 situations. Then, depending on whether you have chosen urn 1 or urn 2 in that situation, the computer will randomly draw one ball from that urn. Depending on the color of the ball, you earn the points indicated in the table.[13] *Notice that even though you will make 11 decisions, only one of these will determine the points you earn, but you will not know in advance which situation will be selected (they are equally likely to be selected).*

In each situation, from which urn do you prefer to draw a ball, urn 1 or urn 2?

12FL01 [12] The actual decision table presented to the subjects depends on the color chosen. In this appendix, we
12FL02 assume that the selected color is white. If the selected color is black, the word "white" has to be replaced
12FL03 with "black", and vice versa.

13FL01 [13] In practice, the ambiguous urn was filled with 10 balls of the winning colour. Of course, this was
13FL02 unknown to participants. While this is deception, this type of deception is not harmful to subjects. Since
13FL03 the computer randomly drew a ball from the chosen urn only at the end of the session, there was no
13FL04 possibility for subjects to update their belief about the composition of the ambiguous urn for subsequent
13FL05 decisions.

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

Situation	URN 1: If a white ball is drawn you earn 10 points	URN 2: If a white ball is drawn you earn 10 points	Your choices
0	0 white balls, 10 black balls	Unknown composition	Urn 1 ◯ ◯ Urn 2
1	1 white ball, 9 black balls	Unknown composition	Urn 1 ◯ ◯ Urn 2
2	2 white balls, 8 black balls	Unknown composition	Urn 1 ◯ ◯ Urn 2
3	3 white balls, 7 black balls	Unknown composition	Urn 1 ◯ ◯ Urn 2
4	4 white balls, 6 black balls	Unknown composition	Urn 1 ◯ ◯ Urn 2
5	5 white balls, 5 black balls	Unknown composition	Urn 1 ◯ ◯ Urn 2
6	6 white balls, 4 black balls	Unknown composition	Urn 1 ◯ ◯ Urn 2
7	7 white balls, 3 black balls	Unknown composition	Urn 1 ◯ ◯ Urn 2
8	8 white balls, 2 black balls	Unknown composition	Urn 1 ◯ ◯ Urn 2
9	9 white balls, 1 black ball	Unknown composition	Urn 1 ◯ ◯ Urn 2
10	10 white balls, 0 black balls	Unknown composition	Urn 1 ◯ ◯ Urn 2

In addition to incentivized choice tasks, we also assess risk and ambiguity preferences using non-incentivized self-assessment questionnaires based on Likert scales.

Risk question: The self-assessment question to measure risk preferences is taken from Dohmen et al. (2011).

How do you see yourself? Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks? Please select your answer on the scale, where the value 0 means "not at all willing to take risks" and the value 10 means "very willing to take risks."

Ambiguity questions: The two self-assessment questions to measure ambiguity preferences are taken from McLain (2009).

Please respond to the following two statements by indicating the extent to which you agree or disagree with them on a scale from 1 (I strongly agree) to 7 (I strongly disagree).

1. *I try to avoid situations that are ambiguous.*
2. *I find it hard to make a choice when the outcome is uncertain.*

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

Appendix 2: Personality traits

This appendix presents the survey or self-assessment questions used to measure the subjects' personality traits. They are taken from self-reporting scales of the psychology literature.

> *In this part, we present you a list of statements. Please indicate the extent to which you agree or disagree with them. Please do not spend too much time on each statement. There are no right or wrong answers and therefore your first response is important. Nevertheless, try to be as honest as you can be. Answer according to your own feelings, rather than how you think most people would answer. Don't worry about being consistent in your responses. Be sure to answer every statement.*
> *Please respond to the following statements by indicating the extent to which you agree or disagree with them on a scale from 1 (I strongly agree) to 7 (I strongly disagree).*[14]

Intolerance of Ambiguity Scale by Kirton (1981). Items based on Mac Donald Jr (1970) and Rydell and Rosen (1966):

1. There is a right way and a wrong way to do almost everything.
2. Practically every problem has a solution.
3. I have always felt that there is a clear difference between right and wrong.
4. Nothing gets accomplished in this world unless you stick to some basic rules.
5. If I were a doctor, I would prefer the uncertainties of a psychiatrist to the clear and definite work of someone like a surgeon or an X-ray specialist.
6. Vague and impressionistic pictures really have little appeal for me.
7. Before an examination, I feel much less anxious if I know how many questions there will be.
8. The best part of a jigsaw puzzle is putting in that last piece.
9. I do not like to work on a problem unless there is a possibility of coming out with a clear-cut and unambiguous answer.
10. I like to fool around with new ideas, even if they turn out later to be a total waste of time.
11. Perfect balance is the essence of all good composition.

Items based on Budner (1962):

12. An expert who does not come up with a definite answer probably does not know too much.
13. There is really no such thing as a problem that cannot be solved.
14. A good job is one where what is to be done and how it is to be done are always clear.
15. In the long run it is possible to get more done by tackling small, simple problems rather than lange and complicated ones.
16. What we are used to is always preferable to what is unfamiliar.

[14] The instructions are taken from the psychology literature, see, e.g. Mac Donald Jr (1970).

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

17 A person who leads an even, regular life, in which few surprises or unexpected happenings arise, really has a lot to be grateful for.

18 I like parties where I know most of the people more than the ones where all or most of the people are complete strangers.

Optimism/pessimism (own wording)[15]:

- Do you consider yourself as a pessimist or an optimist?

Single-item measure of self-esteem by Robins et al. (2001)[16]:

- I have high self-esteem.

References

Allport, G. W., & Odbert, H. S. (1936). Trait-names: A psycho-lexical study. *Psychological Monographs*, *47*, 1–171.

Almlund, M., Duckworth, A., Heckman, J., & Kautz, T. (2011). Personality psychology and economics. IZA Discussion Paper 5500.

Bagana, E., Raciu, A., & Lupu, L. (2011). Self esteem, optimism and exams' enxiety among high school students. *Procedia—Social and Behavioural Sciences*, *30*, 1331–1338.

Becker, A., Deckers, T., Dohmen, T., Falk, A., & Kosse, F. (2012). The relationship between economic preferences and psychological preference measures. *Annual Review of Economics*, *4*, 453–478.

Berg, J. E., Daley, L. A., Dickhaut, J. W., & O'Brien, J. R. (1986). Controlling preferences for lotteries on units of experimental exchange. *Quarterly Journal of Economics*, *101*(2), 281–306.

Bilker, W. B., Hansen, J. A., Brensinger, C. M., Richard, J., Gur, R. E., & Gur, R. C. (2012). Development of abbreviated nine-item forms of the raven's standard progressive matrices test. *Assessment*, *19*(3), 354–396.

Bochner, S. (1965). Defining intolerance of ambiguity. *The Psychological Record*, *15*(3), 393–400.

Borghans, L., Duckworth, A. L., Heckman, J., & ter Weel, B. (2008). The economics and psychology of personality traits. IZA working paper 3333.

Borghans, L., Golsteyn, B. H. H., Heckman, J., & Meijers, H. (2009). Gender differences in risk aversion and ambiguity aversion. *Journal of the European Economic Association*, *7*(2–3), 649–658.

Budner, S. (1962). Intolerance for ambiguity as a personal variable. *Journal of Personality*, *30*, 29–50.

Burks, S. V., Carpenter, J. P., Götte, L., & Rustichini, A. (2009). Cognitive skills affect econoics preferences, social awareness, and job attachement. *Proceedings of the National Academy of Science (USA)*, *106*, 7745–7750.

Butler, J. V., Guiso, L., & Jappelli, T. (2014). The role of intuition and reasoning in driving aversion to risk and ambiguity. *Theory and Decision*, *77*, 455–484.

Chakravarty, S., & Roy, J. (2009). Recursive expected utility and the separation of attitudes towards risk and ambiguity: An experimental study. *Theory and Decision*, *66*(3), 199–228.

Chang, E. C., Maydeu-Olivares, A., & D'Zurilla, T. (1997). Optimism and pessimism as partially independent constructs: Relationship to positive and negative affectivity and psychological well-being. *Personality and Individual Differences*, *23*(3), 433–440.

Charness, G., Karni, E., & Levin, Dan. (2013). Ambiguity attitudes and social interactions. *Journal of Risk and Uncertainty*, *46*, 1–25.

Chateauneuf, A., Eichberger, J., & Grant, S. (2007). Choice under uncertainty with the best and worst in mind: Neo-additive capacities. *Journal of Economic Theory*, *137*, 538–567.

15FL01 [15] This single-item measure is highly correlated (0.68) with the selected items of the Extended Life
15FL02 Orientation test by Chang et al. (1997).

16FL01 [16] Similar to Robins et al. (2001), this item uses a five-point answer scale.

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

Chemers, M. M., Watson, C. B., & May, S. T. (2000). Disposal affect and leadership effectiveness: A comparison of self-esteem, optimism and efficacy. *Personality and Social Psychology Bulletin*, *26*(3), 267–277.

Chow, C. C., & Sarin, R. K. (2002). Known, unknown, and unknowable uncertainties. *Theory and Decision*, *52*, 127–138.

Cohen, J. (1988). *Statistical power analysis for the social sciences*. New York: Lawrence Erlbaum Associates.

Daly, M., Harmon, C. P., & Delaney, L. (2009). Psychological and biological foundations of time preference. *Journal of the European Economic Association*, *7*(2–3), 659–669.

Dimmock, S. G., Kouwenberg, R., Mitchell, O. S., & Peijnenburg, K. (2015). Estimating ambiguity preferences and perceptions in multiple prior models: Evidence from the field. *Journal of Risk and Uncertainty*, *51*(3), 219–244.

Dohmen, T., Falk, A., Huffman, D., & Sunde, U. (2010). Are risk aversion and impatience related to cognitive ability? *American Economic Review*, *100*(3), 1238–1260.

Dohmen, T., Falk, A., Huffman, D., Sunde, U., Schupp, J., & Wagner, G. G. (2011). Individual risk attitudes: Measurement, determinants and behavioral consequences. *Journal of the European Economic Association*, *9*(3), 522–550.

Du, N., & Budescu, D. V. (2005). The effects of imprecise probabilities and outcomes in evaluating investment options. *Management Science*, *51*(12), 1791–1803.

Ellsberg, D. (1961). Risk, ambiguity and the savage axioms. *Quarterly Journal of Economics*, *75*(4), 643–669.

Falk, A., Becker, A., Dohmen, T., Huffman, D., & Sunde, U. (2016). The preference survey module: A validated instrument for measuring risk, time and social preferences. working paper.

Fischbacher, U. (2007). z-tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics*, *10*(2), 171–178.

Frenkel-Brunswik, E. (1949). Intolerance of ambiguity as and emotional and preceptual personality variable. *Journal of Personality*, *18*(1), 108–143.

Frey, R., Pedroni, A., Mata, R., Rieskamp, J., & Hertwig, R. (2017). Risk preference shares the psychometric structure of major psychological traits. *Science Advances*, *3*, 1–13.

Furnham, A., & Ribchester, T. (1995). Tolerance of ambiguity: A review of the concept, its measurement and applications. *Current Psychology*, *14*(3), 179–199.

Gilboa, I., & Schmeidler, D. (1989). Maxmin expected utility with non-unique prior. *Journal of Mathematical Economics*, *18*, 141–153.

Heath, C., & Tversky, A. (1991). Preference and belief: Ambiguity and competence in choice under uncertainty. *Journal of Risk and Uncertainty*, *4*(1), 5–28.

Holt, C. A., & Laury, S. K. (2002). Risk aversion and incentive effects. *American Economic Review*, *92*(5), 1644–1655.

Kirton, M. J. (1981). A reanalysis of two scales of tolerance of ambiguity. *Journal of Personality Assessment*, *45*(4), 407–414.

Knight, F. H. (1921). *Risk, uncertainty, and profit*. Boston, MA: Houghton Mifflin Company.

Lauriola, M., & Levin, I. P. (2001). Relating individual differences in attitude toward ambiguity to risky choices. *Journal of Behavioral Decision Making*, *14*(2), 107–122.

Lönnqvist, J.-E., Verkasalo, M., Walkowitz, G., & Wichard, P. C. (2015). Measuring individual risk attitudes in the lab: Task or ask? An empirical investigation. *Journal of Economic Behaviour and Organization*, *119*, 254–266.

Mac Donald, A. P, Jr. (1970). Revised scale for ambiguity tolerance: Reliability and validity. *Psychological Reports*, *26*, 791–798.

Mata, R., Frey, R., Richter, D., Schupp, J., & Hertwig, R. (2018). Risk preference: A view from psychology. *Journal of Economic Perspectives*, *32*(2), 155–172.

McLain, D. L. (2009). Evidence of the propoerties of an ambiguity tolerance measure: The multiple stimulus types ambiguity tolerance scale-ii (mstat-ii). *Psychological Reports*, *105*(3), 975–988.

Norton, R. W. (1975). Measurement of ambiguity tolerance. *Journal of Personality Assessment*, *39*(6), 607–619.

Prokosheva, S. (2016). Comparing decisions under compound risk and ambiguity: The importance of cognitive skills. *Journal of Behavioural and Experimental Economics*, *64*, 94–105.

Pulford, B. D. (2009). Is luck on my side? Optimism, pessimism and ambiguity aversion. *The Quarterly Journal of Experimental Psychology*, *62*(6), 1079–1087.

Journal : Small-ext 11238 | Dispatch : 13-1-2020 | Pages : 23
Article No. : 9742 | LE | TYPESET
MS Code : THEO-D-19-00013R2 | CP | DISK

Roberts, B. W. (2009). Back to the future: Personality and assessment and personality development. *Journal of Research in Personality*, *43*(2), 137–145.

Robins, R. W., Hendin, H. M., & Trzesniewski, K. H. (2001). Measuring global self-esteem: Construct validation of a single-item measure and the rosenberg self-esteem scale. *Personality and Social Bulletin*, *27*(2), 151–161.

Roth, A. E., & Malouf, M. W. (1979). Game-theoretic models and the role of information in bargaining. *Psychological Review*, *86*(6), 574–594.

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological Monographs*, *80*(1), 1–28.

Rubinstein, A. (2007). Instinctive and cognitive reasoning: A study of response times. *Economic Journal*, *117*, 1243–1259.

Rustichini, A., DeYoung, C. G., Anderson, J. E., & Burks, S. E. (2016). Toward the integration of personality theory and decision theory in explaining economic behaviour: An experimental investigation. *Journal of Behavioural and Experimental Economics*, *64*, 122–137.

Rydell, S. T., & Rosen, E. (1966). Measurement and some correlates of need cognition. *Psychological Reports*, *19*, 139–165.

Sartori, G. (1970). Concept misformation in comparative politics. *American Political Science Review*, *64*(4), 1033–1053.

Savage, L. J. (1954). *The Foundations of Statistics*. New York: Wiley.

Smith, C. A. B. (1961). Consistency in statistical inference and decision. *Journal of the Royal Statistical Society. Series B (Methodological)*, *23*(1), 1–37.

Spearman, C. (1904). The proof and measurement of association between two things. *American Journal of Psychology*, *15*, 72–101.

Tanaka, Y., Fujino, J., Ideno, T., Okubo, S., Takemura, K., Miyata, J., et al. (2015). Are ambiguity aversion and ambiguity intolerance identical? A neuroeconomics investigation. *Frontiers in Psychology*, *5*(1550), 1–7.

Trautmann, S. T., & van de Kuilen, G. (2016). *Blackwell handbook of judgment and decision making. Chapter: Ambiguity attitudes*. Oxford: Blackwell.

Journal : **Small-ext 11238** | Dispatch : **13-1-2020** | Pages : **23**
Article No. : **9742** | □ LE | □ TYPESET
MS Code : **THEO-D-19-00013R2** | ☑ CP | ☑ DISK