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# The Impact of Cognitive Ability on Social and Strategic Ambiguity Attitudes

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## *Abstract*

The present study examines the relationship between cognitive ability and attitudes toward strategic uncertainty. I seek to answer two fundamental questions: Do differences in cognitive ability between people lead to systematic differences in attitudes toward strategic uncertainty? And do these measures of cognitive ability affect attitudes toward nature ambiguity in a similar manner? To this end, 147 participants completed a survey experiment that measured their level of cognition and decision-making under uncertainty. Experimental measures include matching probabilities within the framework of Baillon et al. (2018) for the measurement of ambiguity attitudes. Measures of cognitive ability include the Cognitive Reflection Test (CRT), Wason Selection Task and cognitive uncertainty scales. Results for ambiguity aversion indicate a positive relationship with all cognitive ability measures. The findings also underline a substantial connection between cognitive uncertainty and cognitive reflection and the cognitive component of ambiguity attitudes. Differences are also found in the influence of components such as deductive reasoning and cognitive uncertainty on ambiguity attitudes across ambiguity treatments.



## *Keywords*

Cognitive Reflection Test, Cognitive Uncertainty, Wason Selection Task, Strategic Uncertainty, Ambiguity Aversion, A(mbiguity-generated) insensitivity

# 1. Introduction

Whether in a game of chess, negotiations over a business deal, or in the process of purchasing a car, certainty about others' actions and decisions is a rarity. Uncertainty is a ubiquitous feature in people's strategic decision-making. Information about other people's decisions and their probabilities is usually not available (Trautmann & van de Kuilen, 2015). Such situations with imprecise probabilities are often referred to as *ambiguous* (Ellsberg, 1961), while situations with objectively known probabilities are referred to as *risky*.

Research on decisions under ambiguity has shown that people display ambiguity averse behaviour. That is, they consistently prefer risky lotteries over ambiguous ones and are willing to pay a premium to avoid uncertainty (Ellsberg, 1961; Trautmann & van de Kuilen, 2015). Other than the well-known ambiguity aversion, another component of ambiguity attitudes is relevant in understanding people's decisions: ambiguity-generated insensitivity (a-insensitivity; Dimmock et al., 2016). A-insensitivity captures individuals' inability to discriminate between different levels of ambiguity. This component implies that people fail to differentiate between different probabilities of events and transform subjective likelihoods toward 50-50 (Abdellaoui et al., 2011). A-insensitivity translates into ambiguity seeking for low likelihood events and ambiguity aversion for high likelihood events (Dimmock et al., 2016).

Traditionally, attitudes toward ambiguity were measured through Ellsberg-like artificial events. The reason for this was that up until recently, no tools were available for the measurement of attitudes under natural events. The introduction of Baillon et al.'s (2018) measurement method provided the ground for measuring ambiguity attitudes for any natural circumstance. Li et al. (2019) were the first to apply this method to games. Li et al. (2020) followed after and employed this method to examine differences in ambiguity attitudes across nature and strategic ambiguity sources. Their findings indicated that people deal with ambiguities created by human beings differently than they do with those resulting from acts of nature, even in the absence of interactions. This non-strategic component of strategic uncertainty was labelled as social ambiguity. Results revealed heterogeneities in ambiguity attitudes across nature, social, and strategic ambiguity.

A growing body of literature shows that cognitive abilities influence individuals' economic decision-making (Agarwal & Mazumder, 2013; Burks et al., 2009; Smith et al., 2010), particularly those made under uncertainty (Enke & Graeber, 2019; Lauharantanhirun et al., 2021; Li, 2017; Prokosheva, 2016). An individual's decisions are related to a combination of preferences and cognitive processes (Dohmen et al., 2018). Therefore, understanding the relationship between cognitive skills and preferences over uncertainty is necessary for understanding human decision-making under strategic uncertainty.

There is, however, a paucity of studies on the impact of cognitive abilities on ambiguity attitudes under strategic uncertainty. This study seeks to answer two fundamental questions. Do differences in cognitive ability between people lead to differences in attitudes toward strategic uncertainty? And do these measures of cognitive ability affect attitudes toward nature ambiguity in a similar manner? To answer these questions, the relationship between three measures of cognitive ability and ambiguity attitudes under nature and strategic uncertainty is examined.

The first measure is cognitive reflection. Frederick's Cognitive Reflection Test (CRT; 2005) has received much consideration in the literature concerning the influence of cognitive ability on economic decision-making: test scores have been shown to be apt predictors of individuals' decisions under risk, uncertainty and over time (Frederick, 2005). This test measures individuals' ability to override their initial 'intuitive' reaction and answer questions rationally (Kahneman, 2011). In other words, it measures the extent to which people reflect on their choices. The underlying theory behind this test is the dual system theory of cognitive process (Stanovich & West, 2000; Kahneman & Frederick; 2004). According to this theory, decision-making is comprised of two cognitive processes: those executed quickly, intuitively and without thought (System 1), and those performed deliberately (System 2). Individuals skilled at employing their System 2 when making decisions have been shown to display lower incidences of biased behaviour (Bergman et al., 2010; Hoppe & Kusterer, 2011; Oechssler et al., 2009).

The second aspect of cognition examined is individuals' level of cognitive uncertainty. The economic literature has mainly been concerned with *external* uncertainty, that is uncertainty originating from the environment. However, a growing branch of literature focuses on the uncertainty that arises from cognitive processes involved when making decisions. The idea is that when faced with a problem, an individual experiences cognitive noise in the process of translating inputs and providing an answer to the problem not because the environment is imperfectly observable, but because of the problem's complexity (Amelio, 2022). Building on previous noisy cognition models (Gabaix, 2019; Khaw et al., 2017), Enke and Graeber (2019) defined cognitive uncertainty as an individual's subjective uncertainty about what his optimal action is (Enke & Graeber, 2019). In other words, cognitive uncertainty implies that because individuals are aware of their cognitive noise and how prone to error their decision process is, they have doubts about whether the choices they make are the right ones (Amelio, 2022). Enke and Graeber's (2019) theoretical framework is stylized in nature and does not offer a structural model of decision-making across different decision domains. The model does not prescribe what the rational action or solution is in any given situation. Rather, it is used to highlight patterns in how individuals struggle with identifying the optimal action across different domains. According to Enke and Graeber's (2019) model, all variation in cognitive uncertainty across individuals stem from heterogeneity in cognitive noise. Differences in cognitive noise across people may be the result of differences in cognitive skills, attention, individuals' response time or complexity of the decision problem (Enke & Graeber, 2019). In this construct, because decision domains are held constant, differences found in cognitive uncertainty levels would be the result of the first three items, implying that individuals' cognitive uncertainty level can be considered an individual trait. Enke and Graeber (2019) previously examined the relationship between cognitive uncertainty and likelihood insensitivity for individual decisions. They found that individuals with higher cognitive uncertainty are less capable of discriminating between different likelihoods of events, i.e., are more insensitive. Because of the novelty of this concept, little exploration has been done on the influence of this cognitive component on different ambiguity attitudes. This study is the first to report on this relationship for social and strategic ambiguity sources.

Although individuals' subjective confidence about their predictions of opponents' actions in strategic interactions is expected to guide their decisions under strategic uncertainty, it is not the exclusive determinant of individuals' choices. The final cognitive ability examined is deductive reasoning skills. Engaging in social exchange requires individuals to perform difficult computational problems (Cosmides, 1989). An individual's ability in predicting his opponents' actions in a game influences his attitude toward ambiguous strategic interactions (Nagel et al., 2018). One of the most widely discussed tasks in the psychology literature is the Wason selection task (Wason, 1960). Psychologists commonly take people's performance on this task as indicative of their deductive reasoning ability. Evans's proposed two stages of deductive reasoning (1984; 1989) suggest that when confronted with analytical problems, individuals first use preconscious heuristics to select certain aspects of information they deem as relevant, and then perform a logical assessment of information. These two stages are presumed to be behind individuals' choices on the selection task: differences in cognitive ability create differences in analytic processes that influence responses (Evans & Over, 1996; Reber, 1993; Stanovich & West; 1998). Correct responders on the standard abstract task are shown to be largely analytic reasoners (Stanovich & West; 1998).

To examine whether people's attitudes towards strategic uncertainty are systematically related to cognitive ability, 147 participants completed a survey experiment that measured their level of cognition and decision-making under uncertainty. Experimental measures include matching probabilities within the framework of Baillon et al. (2018) to elicit ambiguity aversion and a-insensitivity indices. To measure attitudes under various ambiguous situations, subjects were placed into one of three treatment groups (nature, social or strategic ambiguity), modelled after Li et al.'s (2020) construct. In addition to this, measures of cognitive ability include the Cognitive Reflection Test, the Wason selection task and cognitive uncertainty scales.

My findings extend the literature on cognitive skills and decision-making under strategic uncertainty in a new way. I explore how ambiguity attitudes vary according to cognitive ability, and highlight associations between cognitive reflection, cognitive uncertainty, deductive reasoning, and their relation to economic behaviour. I contribute to the literature on cognitive uncertainty by being the first to investigate it in games, and to the literature on deductive reasoning in games, by examining its relation to ambiguity attitudes for the first time. Additionally, this study reveals a comparison between the effect of cognition on attitudes toward uncertainty resulting from natural events and social and strategic interactions.

Results for ambiguity aversion indicate a positive relationship with all cognitive ability measures. Differences are found in the influence of components such as deductive reasoning and cognitive uncertainty across ambiguity treatments: similar to higher deductive reasoning skills, lower cognitive uncertainty levels lead people to shy away from social ambiguity more than nature ambiguity. They also result in higher aversion under strategic ambiguity than under social ambiguity. Findings underline a substantial connection between the cognitive component of ambiguity attitudes and cognitive uncertainty, consistent with previous findings (Enke & Graeber, 2019). Robustness checks performed complement the main analysis by introducing comparability between different extents of cognitive capability and their influence on choice under uncertainty.

## 2. Literature Review

The literature shows that cognitive ability is an important influential factor in individuals' economic behaviour. Studies report positive associations between cognitive skills and household wealth (Smith et al., 2010), favourable financial decision-making (Agarwal & Mazumder, 2013) and the likelihood of investing in stocks (Christelis et al., 2010; Grinblatt et al., 2011). Research has also demonstrated a link between higher levels of cognitive ability and preferences favouring economic success, such as job attachment (Burks et al., 2009), more patience (Burks et al., 2009; Frederick, 2005) and lower degrees of risk aversion (Burks et al., 2009; Dohmen et al., 2010; Oechssler et al., 2009).

Like many of their other decisions, individuals' decisions in times of uncertainty are related to a combination of internal preferences and mental processes impacted by their cognitive ability (Dohmen et al., 2018). This relation combined with the prevalence of ambiguity in economic decision-making suggests the importance of examining the impact of cognitive skills on behaviour in ambiguous situations.

## 2.1. Choice under Uncertainty

### 2.1.1. Ambiguity Indices

Since Ellsberg's seminal 1961 work demonstrating the fundamental differences between traditional risk and ambiguity, many studies have offered models for choice under uncertainty and ambiguity attitudes (Gilboa 1987; Gilboa & Schmeidler 1989; Schmeidler 1989). These studies primarily focused on Ellsberg's most prominent finding - ambiguity aversion. Ambiguity aversion is the notion that people are willing to pay a premium to avoid ambiguity and that they consistently prefer risky prospects over ambiguous ones (Ellsberg, 1961). In other words, ambiguity aversion refers to the extent to which decision-makers prefer known probabilities over unknown probabilities.

Myriad methods have been offered for measuring ambiguity attitudes (Abdellaoui et al., 2011; Baillon et al., 2018; Dimmock et al., 2016; van de Kuilen & Wakker, 2011). However, Baillon et al.'s (2018) method is the only one that can be used for all natural events. A common assumption made when measuring ambiguity attitudes is the symmetry assumption, namely that all events considered are symmetric and equally likely - an assumption that is imposed to control for individuals' beliefs. This assumption fails to hold for many ambiguity sources, creating difficulties in controlling for decision-makers' beliefs about subjective probabilities of events. This predicament can be overcome with Baillon et al's (2018) method, implying that it can be utilized for any ambiguity source. Therefore, this is the elicitation method that will hereafter be examined; all indices discussed below concern this method.

The method of Baillon et al. (2018) makes use of matching probabilities. Decision-makers' matching probability of an event *E* is defined as the probability *m* such that

$$(E{:}x) \sim (m{:}\ x). \tag{1}$$

That is, the matching probability of an event *E* is the probability that makes a decision-maker indifferent between the ambiguous lottery (*E*:*x*) offering prize *x* if event *E* occurs and nothing otherwise, and the risky lottery (*m*: *x*) offering the same prize with probability *m* and nothing otherwise.

This method requires at least three events, constituting a partition of the state space, and their unions. Events are assumed to be mutually exclusive and exhaustive. The union of two events is denoted as $E_{ij}, i \neq j$. Events $E_i$ are referred to as *single events* and their unions $E_{ij}$ as *composite events.* To control for decision-makers' subjective probabilities, six matching probabilities need to be elicited, one for each single event ($E_1$, $E_2$, and $E_3$) and one for each composite event, and this ($E_{12}$, $E_{13}$, and $E_{23}$) for every source of uncertainty. For an ambiguity averse decision-maker, $m_1 + m_2 + m_3 = 1$ and $m_{12} + m_{23} + m_{13} = 2$. Deviations from these benchmarks provide information about the decision-makers' attitudes.

Let $\overline{m_S} = (m_A + m_B + m_C)/3$ denote the average single-event matching probability and let $\overline{m_C} = (m_{AB} + m_{BC} + m_{AC})/3$ denote the average composite-event matching probability. The ambiguity aversion index (Equation 2) is as follows:

$$b = 1 - \overline{m_C} - \overline{m_S} \quad (2)$$

Under ambiguity neutrality, $\overline{m_C} + \overline{m_S} = 1$. $b$ captures how much an individual dislikes an ambiguous source relative to risk. Under ambiguity aversion, the index is positive, implying a willingness to pay a positive premium in order to avoid ambiguity, while under ambiguity seeking, it is negative.

Figure 1 (Li et al, 2020) shows a graph of the commonly observed deviations of matching probabilities from ambiguity-neutral probabilities. The dotted line illustrates the matching probabilities of a decision-maker under ambiguity neutrality. The solid line represents the Ellsberg paradox, and the relative elevation of the matching probability function reflects decision-makers' extent of ambiguity aversion. However, ambiguity aversion fails to sufficiently explain decisions under uncertainty by itself (Abdellaoui et al., 2011). The inverse S shape of Fig. 1 shows that people are often ambiguity seeking for low likelihood events and ambiguity averse for high likelihood events (Tversky & Fox, 1995; Trautman & van de Kuilen, 2015; Dimmock et al., 2016). This likelihood-dependence cannot be explained by ambiguity aversion, and rather implies the influence of another relevant component of ambiguity attitudes (Abdellaoui et al., 2011).

Empirical findings show that people's choices under uncertainty also depend on their ability to discriminate between different levels of ambiguity. This component of ambiguity attitudes is referred to as ambiguity-generated insensitivity (a-insensitivity; Dimmock et al., 2016). A-insensitivity captures individuals' inability to differentiate between different levels of ambiguity, transforming subjective likelihoods towards 50-50 (Abdellaoui et al., 2011). This component leads to people overweighing extreme events, which eventuates in ambiguity seeking for low likelihoods and ambiguity aversion for high likelihoods, explaining the inverse S shape of the matching probability function. The level of

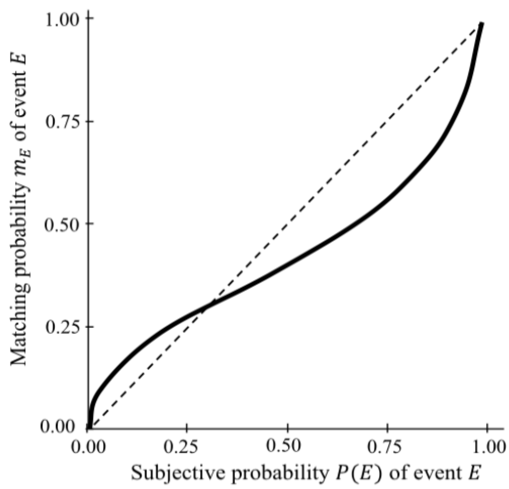



**Fig.1** Observed matching probabilities, from Li et al. (2020)

(in)sensitivity of the decision-maker is reflected in the relative flatness in the middle of his matching probability function. The a-insensitivity index (Equation 3) is as follows:

$$a = 3(\frac{1}{3} - (\overline{m_C} - \overline{m_S})) \quad (3)$$

The a-insensitivity index captures individuals' lack of discrimination between different levels of likelihood and the extent to which matching probabilities lean towards 50-50. Under perfect sensitivity, i.e., ambiguity neutrality, the difference between $\overline{3m_C}$ and $3\overline{m_S}$ is exactly 1 and *a* is 0. A maximally insensitive decision-maker would not distinguish between composite and single events, implying that $\overline{m_C} = \overline{m_S}$, and would have an insensitivity index of 1. Such an index indicates that this individual considers all uncertainties to be fifty-fifty. The index captures both individuals' perceptions of ambiguity and their cognitive discriminatory power. The more discriminatory power an individual has, the larger the gap between $\overline{m_C}$ and $\overline{m_S}$ is, and therefore, the smaller the a-insensitivity index is. By contrast, the more an individual perceives events as ambiguous, the blurrier the likelihood of events are for him, which translates to a small gap between $\overline{m_C}$ and $\overline{m_S}$ and a higher a-insensitivity index.

A-insensitivity is often considered to be a cognitive bias due to insufficient understanding of uncertainties (Li, 2017). A-insensitive people are more likely to make suboptimal decisions and are less able to incorporate new information into their decision-making. In this sense, a more a-insensitive decision-maker is less capable of dealing with uncertainty and is regarded as irrational.

The ambiguity aversion index and the a-insensitivity index each measure two psychologically independent components of ambiguity attitudes (Li, 2017). The former can be interpreted to be emotional, capturing individuals' (dis)like of ambiguity from a motivational perspective, while the latter is cognitive, reflecting their understanding of the ambiguous situation.

### 2.1.2. Distinction Between Nature and Strategic Ambiguity

Besides likelihood dependence of ambiguity attitudes, another important finding in the domain of choice under uncertainty is the concept of source dependence (Fox & Tversky, 1995). Fox and Tversky (1995) defined a *source of uncertainty* as a group of events generated by the same random mechanism. They found that individuals' aversion to ambiguity differed based on the source of ambiguity. The implication of source dependence is that individuals' ambiguity attitudes are not the same for different events. There is a plethora of ambiguity sources in human decision-making but one major source concerns social and strategic interactions.

Several studies have applied ambiguity theories to game theory. However, models concerning uncertainty in games have predominantly been theoretical (Kellner, 2015; Kelsey & le Roux, 2017; Eichberger & Kelsey, 2011), and the few and far between empirical studies have commonly taken beliefs to be Bayesian (Nagel et al., 2018; Schlag et al., 2015).

Although there have been empirical studies on the effect of non-neutral ambiguity attitudes on games (Eichberger et al., 2008; Kelsey & le Roux, 2017), rather than directly measuring individuals' ambiguity attitudes, these studies varied the level of ambiguous information, for example by changing individuals' opponents in strategic settings as in Eichberger et al. (2006). This practice limits inferences for two reasons: (1) individuals' attitudes are heterogenous, and (2) varying the level of ambiguity creates confounds due to changes in individuals' beliefs about opponents' strategies. Directly measuring ambiguity attitudes, however, requires controlling for individuals' beliefs about subjective probabilities. This requirement has been a hurdle in the application of ambiguity theories to natural events; it was not possible to do so up until recently due to the absence of necessary measurement tools. Baillon et al. (2018; Section 2.1.1) resolved this difficulty for individual choice. Their method measures ambiguity attitudes for all natural events without the need for artificial symmetries in belief, providing the ground for examining attitudes in strategic settings.

Li et al. (2019) were the first to apply Baillon et al.'s (2018) method to games, using the specific example of a trust game to illustrate the predictive power of ambiguity attitudes for individuals' choices under strategic uncertainty. Li et al. (2020) also used this method to examine the difference between strategic uncertainty and uncertainty in natural settings. They noted that even in the absence of strategic interactions, people have different attitudes towards ambiguity created by humans than by nature. They identified a non-strategic component underlying strategic ambiguity and dubbed it *social ambiguity*. They showed that people are less ambiguity averse in situations of social and strategic ambiguity than under nature ambiguity and that people are more a-insensitive under strategic ambiguity than nature and social ambiguity. Their findings supported those of Kelsey and le Roux (2017), among others

(Bolton et al., 2016; Chark & Chew, 2015). Examining attitudes in individual and group settings, Kelsey and le Roux (2017) also found context dependent ambiguity attitudes.

The cognitive nature of ambiguity attitudes and the evidential influence of cognitive skills on economic performance along with the role of ambiguous strategic interactions in individuals' decision-making beg exploration into the relationship between cognitive ability and ambiguity attitudes under social and strategic uncertainty.

## 2.2. Influence Of Cognitive Ability on Ambiguity Attitudes

Despite its potential relevance to economic performance, research on the influence of cognitive ability on ambiguity attitudes is scarce; studies have primarily focused on the relationship between cognitive components and risk attitudes. Nevertheless, evidence of correlations between risk and ambiguity attitudes (Blankenstein et al., 2017; Dimmock et al., 2012, 2013; Trautman & van de Kuilen, 2015) and of pronounced overlap between the neural mechanisms engaged in risky and ambiguous gambling (Blankenstein et al., 2017), imply that the cognitive components shown to impact risk attitudes may also have relationships with ambiguity attitudes.

The literature has found negative correlations between risk aversion and measures of cognitive ability related to numeracy (Benjamin et al., 2013; Rustichini et al., 2012, 2016; Millroth & Juslin, 2015; Dohmen et al., 2018), Raven's matrices (Anderson et al., 2016), the Cognitive Reflection Test (Frederick, 2005), test scores (Benjamin et al., 2013; Booth & Katic, 2013), fluid and crystallized intelligence (Dohmen et al., 2010) and literacy (Dohmen et al., 2018). A handful of studies have examined the relationship between individual characteristics and ambiguity attitudes. Among these, Baillon et al. (2014) suggested an association between affective states and individuals' level of a-insensitivity, and Li (2017) reported differences in ambiguity attitudes of rural and urban residents. Binswanger and Salm (2017) found that individuals with lower cognitive skills experience more ambiguity, while Grevenbrock et al. (2018) reported correlations between cognitive ability and likelihood insensitivity. Enke and Graeber suggested a positive association between cognitive uncertainty levels and likelihood insensitivity (further discussed in Section 2.2.2).

The common denominator of the aforementioned studies was their examination of artificial or natural sources of uncertainty. The literature does not sufficiently examine the effect of cognitive ability on attitudes toward strategic uncertainty. The limited studies done in this regard, however, suggest a positive relationship between cognitive skills and favourable strategic behaviour.

Burks et al. (2009) found that individuals with better cognitive skills were associated with smarter strategic responses to their opponents' choices, higher social awareness, and a greater likelihood of cooperation in strategic settings. Fehr and Huck (2016) reported non-linear effects of cognitive ability on social awareness in a beauty contest game (BCG). Lauharantanhirun et al. (2021) created a measure of social uncertainty sensitivity and examined its difference across uncertain environments. They did not measure ambiguity attitudes directly to examine their relationship with cognition, but rather, they used reaction time as a proxy for information processing and observed a relationship between reaction time and social uncertainty sensitivity.

Furthermore, due to the novelty of Baillon et al.'s (2018) measurement tool, research is limited on the cognitive factors affecting attitudes towards strategic uncertainty and their differences in effects on nature ambiguity. Heterogeneities in ambiguity attitudes across sources, namely that ambiguity aversion is more prevalent under nature ambiguity and that insensitivity is higher under strategic ambiguity (Li et al., 2020), could very well be explained by source dependence (Fox & Tversky, 1995). However, differences in neural functions under different sources of uncertainty (Nagel et al., 2018) suggest that it may also be the case that the predictive power of cognitive components differs among various sources of ambiguity, i.e., that different cognitive skills are associated with different ambiguity attitudes across different sources.

To address this gap, I identified three cognitive components relevant to choice under strategic ambiguity and examined their relationship with ambiguity attitudes in a survey experiment. As such, the relationship between ambiguity attitudes and degrees of cognitive reflection, cognitive noise, and deductive reasoning were studied. Relevant literature on these cognitive skills is discussed in the following sections.

### 2.2.1. Cognitive Reflection

The literature emphasizes the distinction between two types of cognitive processes: those executed spontaneously, without conscious deliberation, and those executed more slowly and with more reflection (Epstein, 1994; Kahneman & Frederick, 2002). These two systems are dubbed as System 1 and System 2, respectively (Stanovich & West, 2000). System 1 processes are executed quickly and rely on intuition while System 2 processes require careful deliberation. Individuals who make more use of their System 2 have been shown to perceive themselves as less impulsive, less preoccupied with the future, and less risk seeking (Frederick, 2005).

One of the most widely used measures of individuals' reliance on their System 1, and of cognitive ability in general, is the Cognitive Reflection Test (CRT). It consists of three questions, all of which have one false intuitive answer and one correct deliberate one; as thus, it can measure the extent to which individuals rely on their System 1 and the extent to which they are able to activate their System 2 (Kahneman, 2011). The intuitive answers of CRT dominate and are considered first even among individuals answering the questions correctly (Frederick, 2005). Scoring high on CRT, therefore, requires individuals to override their immediate and intuitive answers and to employ reflection in determining the correct one (Toplak et al., 2011).

Associations have been found between high CRT scores and various behaviour in economic decision-making. Placing respondents into high (those scoring 3) and low CRT groups (those scoring 0), Frederick (2005) found that CRT scores are predictive of choices in theories such as expected utility theory and prospect theory and that they provide better predictions of performance in various decision-making domains than comparable tests such as SAT and ACT. Similar to Frederick (2005), Oechssler et al. (2009) reported significant relationships between CRT scores and time and risk preferences.

The literature shows relationships between performance on CRT and display of behavioural biases. Oechssler et al. (2009) found correlations between higher CRT scores and lower incidences of the conjunction fallacy and conservatism in updating probabilities. Higher CRT scores are, furthermore, correlated with lower likelihood of susceptibility to anchoring (Bergman et al., 2010) and base rate fallacy, the conservatism bias, and overconfidence (Hoppe & Kusterer, 2011).

Given the intertwinement of cognitive reflection and behavioural biases, the existence of a relationship between cognitive reflection and ambiguity attitudes would not be out of the ordinary. Presuming that non-neutral ambiguity attitudes are irrational and that individuals with higher levels of cognitive reflection are more rational, it is expected that individuals with higher CRT scores display less ambiguity aversion and a-insensitivity. My first hypothesis is therefore as follows:

*H.1: Higher scores on CRT are associated with lower levels of ambiguity aversion and insensitivity.*

The first hypothesis contends that higher levels of cognitive reflection are associated with less aversion and insensitivity to ambiguity, regardless of the source. Different sources of ambiguity, however, have different cognitive loads and elicit different ambiguity attitudes. Given lack of significant difference between individuals' ambiguity aversion under social and strategic ambiguity (Li et al., 2020), I do not expect a significant difference in the predictive power of CRT scores on individuals' aversion under social and strategic ambiguity.

*H.2: There is no significant difference between associations of CRT scores and levels of ambiguity aversion under social and strategic ambiguity.*

However, considering individuals' tendency for higher aversion under nature ambiguity than under social and strategic ambiguity (Li et al., 2020), differences are expected in the effect of reflection on attitudes under various ambiguity sources. I suspect that the negative relationship between CRT scores and ambiguity aversion is stronger under social and strategic ambiguity than under nature ambiguity. In other words, scoring higher on CRT is associated with less ambiguity aversion under social and strategic ambiguity than under nature ambiguity. My third hypothesis is thus:

*H.3: Higher CRT scores are more strongly associated to lower levels of ambiguity aversion under social and strategic ambiguity than under nature ambiguity.*

Contrary to my predictions for ambiguity aversion, given individuals' display of higher a-insensitivity under strategic ambiguity than under social ambiguity, (Li et al., 2020), I expect that the negative relationship between CRT scores and a-insensitivity is stronger for social ambiguity than for strategic ambiguity. In other words, because of the additional difficulty in deciphering strategic interactions, higher scores on CRT are associated with higher levels of a-insensitivity under strategic ambiguity than under social ambiguity.

Furthermore, due to higher levels of a-insensitivity resulting under strategic ambiguity than under nature and social ambiguity (Li et al., 2020), a stronger inverse relationship between CRT scores and a-insensitivity is expected under nature and social ambiguity than under strategic ambiguity: higher scores on CRT are expected to result in lower levels of a-insensitivity under social and nature ambiguity than under strategic ambiguity. The fourth and fifth hypothesis are as below:

*H.4: Higher CRT scores are predictive of lower levels of a-insensitivity under social ambiguity than under to strategic ambiguity.*

*H.5: Higher CRT scores are predictive of lower levels of a-insensitivity under social and strategic ambiguity than under nature ambiguity.*

In summary, a negative association is expected between cognitive reflection skills and levels of ambiguity aversion and insensitivity. Ambiguity aversion under nature ambiguity is suspected to be more negatively associated to CRT scores than that under strategic uncertainty. Moreover, due to the inherent complexities of choice under uncertainty in strategic situations, higher cognitive reflection skills are expected to have a larger impact on individuals' a-insensitivity under strategic ambiguity than under social and nature ambiguity.

### 2.2.2. Cognitive Uncertainty

Decision-making under uncertainty is difficult for people in many economic contexts. These difficulties may give rise to cognitive noise, which is a term referring to the "unsystematic errors that arise from cognitive imperfections in the process of optimization" (Enke & Graeber, 2019). When making decisions in ambiguous situations, cognitive noise may stem from the difficulty of combining probabilities, rewards, and preferences into matching probabilities.

Presumably, people are aware of their own cognitive noise, which results in cognitive uncertainty. In any given situation, individuals generally aim to take actions closest to the rational decision. Awareness of their proneness to error leads them to doubt the optimality of their decisions. Suppose an individual is asked to state the monetary amount that would make him indifferent between a risky and ambiguous lottery. They announce €$x$. However, the individual may feel that this amount could be €$a$ lower or €$b$ higher, and that any amount in the interval [$x$-$a$, $x$+$b$] would be the rational amount. The individual's feeling of uncertainty about his indifference point reflects cognitive uncertainty. Enke and Graeber (E&G; 2019) defined cognitive uncertainty as individuals' "subjective uncertainty about what the optimal action or solution to a decision problem is". Many people display cognitive uncertainty in response to the difficult economic decisions they face. Their level of uncertainty has been shown to be predictive of their economic beliefs and actions (Enke & Graeber, 2019). The main underlying idea is that there is a link between noise and bias: cognitively noisy people tend to revert back to a cognitive default, which in turn leads to systematic bias. This implies that people's confidence in what they are doing is relevant for understanding the actions that they take.

E&G examined the relationship between cognitive uncertainty and economic beliefs through a series of experiments. They focused on four sets of well-established empirical regularities: the probability weighing function, the ambiguity weighting function, the relationship between posterior beliefs and the Bayesian posterior, and the probability estimates in subjective expectations for objectively correct probabilities. People generally displayed stable cognitive uncertainty types across and within choice domains (Enke & Graeber, 2019). Cognitive uncertainty was elicited as follows: By asking people to use a slider to calibrate the statement "I am certain that the lottery is worth between $x$ and $y$ to me." After elicitation of their certainty equivalents using lotteries, E&G measured individuals' certainty about whether a lottery is worth exactly the same as their revealed switching interval. This measure directly reflects subjects' assessment of uncertainty in a qualitative manner. The caveat is that it only captures internal uncertainty, and it approximates a subjective confidence interval.

E&G's (2019) analysis of cognitive uncertainty was structured through a theoretical framework following Bayesian noisy cognition models such as Gabaix (2019) and Khaw et al. (2017). E&G interpreted their model as capturing cognitive noise resulting from high-level reasoning: people exhibit cognitive noise in translating probabilistic information into an optimal response, which causes them to shrink objective probabilities towards a cognitive default that is influenced by an ignorance prior, which assigns equal probability to all states of the world. Those experiencing more noise were assumed to be associated with more shrinkage to the default. They kept their framework stylized and did not reflect domain-specific decision-making models: they did not predetermine individuals' optimal or rational actions or outcomes, and instead used individuals' response patterns when identifying rational actions to show common trends in how people process probabilities across different decision domains.

In other research, cognitive uncertainty was found to have an inverse relationship with over-placement and overconfidence (Amelio, 2022) and a positive association with decreasing impatience (Enke & Graeber, 2021). E&G (2019) found that individuals with higher levels of cognitive uncertainty exhibited more likelihood insensitivity. That is, individuals with higher value intervals had subjective probabilities more toward 50-50. They, furthermore, observed that ambiguous and compound lotteries magnified likelihood insensitivity. Here from comes my next hypothesis.

Decision-makers with higher cognitive uncertainty intervals are expected to have more difficulties in assigning probabilities to ambiguous events, resulting in them shying away from ambiguity. Their higher uncertainty also suggests that they perceive events as more ambiguous and likelihoods are blurrier for them, resulting in them displaying higher a-insensitivity.

*H.6.: Higher levels of cognitive uncertainty are associated with higher levels of ambiguity aversion and insensitivity.*

Although E&G hypothesized about the impact of cognitive uncertainty on choice under uncertainty and conducted an experiment for this purpose, they did not formally report their findings. This was due to interpretive problems arising from their use of ten colours in a traditional urn experiment. Therefore, examining *H.6* will contribute to the literature on cognitive uncertainty. A further contribution of this study is that the relationship between cognitive uncertainty and a-insensitivity is also examined in a game/social setting rather than just for artificial/natural sources of uncertainty as in Enke and Graeber (2019).

One explanation behind individuals' preference of social and strategic ambiguity over nature ambiguity (Li et al., 2020) could be that they are more confident in their subjective probability estimation of events under strategic uncertainty than in that under nature uncertainty. This reason would also support the findings of Bolton et al. (2004), i.e., that people are more risk seeking in stag hunt games where the source of uncertainty is another player than when the risk is determined by nature. Should this be the case, it is expected that smaller cognitive uncertainty intervals are associated with less aversion under social and strategic ambiguity than under nature ambiguity. My seventh hypothesis follows:

*H.7: Lower levels of cognitive uncertainty are predictive of lower levels of ambiguity aversion under social and strategic ambiguity than under nature ambiguity.*

Moreover, higher a-insensitivity levels under strategic ambiguity coupled with the relative difficulty of deciphering strategic situations compared to natural situations lead to the hypothesis that the relationship between cognitive uncertainty intervals and a-insensitivity is stronger for strategic ambiguity than for nature and social ambiguity. In other words, lower cognitive uncertainty results in lower a-insensitivity under nature and social ambiguity than under strategic ambiguity.

*H.8: Lower levels of cognitive uncertainty are predictive of lower levels of a-insensitivity under nature and social ambiguity* than under *strategic ambiguity*.

In summary, it is expected that cognitive uncertainty levels resulting from individuals' cognitive noise have a positive association with individuals' ambiguity aversion, more so under social and strategic ambiguity than under nature ambiguity. They are also hypothesized to have a positive relationship with a-insensitivity under social and nature ambiguity, more so than under strategic ambiguity.

### 2.2.3. Deductive Reasoning

One important cognitive skill in dealing with strategic interactions is logical reasoning. Computational theories of social exchange include two tight constraints on how humans must process information regarding social exchanges: (1) the human mind must contain algorithms that produce and operate on cost-benefit representations of exchange interactions, and (2) the human mind must include inferential procedures to judge social contracts (Cosmides, 1985; Cosmides & Tooby, 1989). Both features require skills in deductive reasoning. The main idea is that, to engage in social exchange, individuals must be able to perform complex computational problems (Cosmides, 1989).

Two oft used theories in explaining individuals' strategic thinking and behavior in games are level-k reasoning (Nagel, 1995; Stahl & Wilson, 1995) and the cognitive hierarchy theory (Camerer et al., 2004). The cognitive hierarchy theory attributes heterogeneities in players to their strategic sophistication, which manifests itself in their level of reasoning: level-0 players play randomly and without consideration to their opponents' game, while level-1 players anticipate opponents' random play and show their best response to it. Level-k players display best responses to level- k-1 reasoning. This type of backward induction perfectly exemplifies deductive reasoning in games (Asheim & Dufwenberg, 2003; Ashheim, 2006).

Although the literature has not explored the role of reasoning skills in ambiguity attitudes in depth, previous studies point to its prominence. Nagel et al. (2018) reported interactions between strategic thinking and uncertainty in entry games: deliberation, strategic uncertainty, and sophisticated behaviour in games were positively correlated. Additionally, examining the neural circuits mediating choice under strategic uncertainty, they found that when facing strategic uncertainty, the brain network mediating risk during lotteries is engaged as well as the neural circuits mediating higher order beliefs (i.e., beliefs about others' beliefs). Individuals' reasoning ability may thus influence their attitudes towards ambiguous exchanges.

The Wason Selection Task (WST; Wason, 1968) is one of the most widely used tests of deductive reasoning. The WST comprises a rule of the form "if P then Q". Respondents are presented with four cards corresponding to P, P', Q and Q', and informed that each card has a P or P' element on one side and a Q or Q' element on the other. Respondents are then asked to indicate the card that would need to be turned to judge the validity of the rule. Propositional logic prescribes P and Q' as the correct answers to the task. However, individuals generally fail to choose Q' and tend to select P and Q instead.

Individuals' tendency to choose Q over Q' reflects their adoption of a verification strategy rather than a falsification strategy. Johnson-Laird and Wason (1970) interpreted this reluctance to falsify the task's rule as individuals' need for verification. The idea behind this is that individuals tend to search for information that verifies their beliefs and views instead of seeking disconfirming evidence that will falsify a hypothesis. This complete oversight of falsification implies a total lack of insight on behalf of those focusing solely on verification (choice of P, Q), while those recognizing the merit of choosing only falsifying cards (choice of P and Q') have full insight. Although verification is a false strategy under WST, it nonetheless often coexists with falsification strategies, revealing some individuals' partial understanding of the problem (choice of P, Q and Q').

In its standard form, WST comprises of an abstract rule, where elements are alphanumerical characters. An example of such rule would be "If there is A on one side of a card, then there is a 7 on the other side". Few people answer this version correctly. Other variations of the task with thematic (Wason & Shapiro, 1971) or deontic (permission or obligation) rules (Griggs & Cox, 1982; Cosmides, 1989) yield considerably higher correct responses compared to the abstract problem (Johnson-Laird et al., 1972; Valentine, 1985; Wason & Shapiro, 1971). Reasons suggested for this diversity range from general processes like text processing (Almor & Sloman, 1996) and analogical reasoning (Halford, 1993) to social contract modules (Cosmides, 1989), heuristics cued by cards (Evans, 2006) and memory-cuing (Griggs & Cox, 1982).

One explanation offered for the low response rate on the abstract selection task concerns heuristics. The idea is that when solving the selection task, rather than rely on their natural inference rules and exhaust deductive reasoning, individuals depend on simple heuristic strategies. Among these is the relevance heuristic (Wason & Evans, 1975), which leads to individuals selecting cards that appear to be relevant. This process is further explained by Evan's (1984; 1989) two stages of deductive reasoning. Evans (1984) argued that the first stage of deductive reasoning comprises of preconscious heuristics deeming certain aspects of information as relevant, while in the second stage, individuals perform a logical analysis of selected information. Among the oft used heuristics is the matching strategy (Evans, 1972). This strategy leads to selection of P and Q cards and is not indicative of logical reasoning.

Performing well on the selection task requires overriding matching and relevance heuristics. Those failing to do so are failing to incorporate new information in the second stage of deductive reasoning (Evans, 1984). The matching heuristic leads to individuals using System 1 processes and failing to recognize the need for further analysis (Thompson et al., 2013). Since a-insensitivity is often considered as a cognitive bias, those falling susceptive to said heuristics on WST are also expected to be more a-insensitive.

Examining the relationship between motivated reasoning and performance on WST, Dawson et al. (2002) found that scepticism is associated with better performance on the selection task. They argued that healthy scepticism entails a tendency to carefully evaluate data and consider their implications. They contended that reasoners adopting a sceptical mindset may be more able at assessing proportions than relying on raw numbers (Dawson et al., 2002) and to resist generalization to support preferred beliefs (Doosje et al., 1995). Considering the falsification nature of the WST, this would result in better performance on the task.

Analogous to this argument, one could hypothesize that when under uncertainty, more logical reasoners (those recognizing the need to employ a falsification strategy) would more thoroughly evaluate and estimate probabilities of different events, resulting in lower levels of insensitivity, and would be less likely to shy away from ambiguous situations, translating to less ambiguity aversion. This would also imply a negative association between performance on the selection task and ambiguity attitudes.

The next hypothesis is thus:

*H.9: Deductive reasoning skills (as illustrated by better performance in the four-card problems) are negatively associated with ambiguity aversion and insensitivity.*

Individuals' ability to make and act upon accurate strategic computations has been found to vary across people and context (Bhatt & Camerer, 2010). Thus, similar to previously discussed cognitive abilities, the effect of deductive reasoning on individuals' ambiguity attitudes is expected to differ among ambiguity sources. The final two hypotheses, therefore, concern heterogeneities in the impact of deductive reasoning across nature, social and strategic ambiguity).

*H.10: Deductive reasoning skills (as illustrated by better performance in the four-card problems) have a stronger negative relationship with ambiguity aversion under strategic and social ambiguity than under nature ambiguity.*

*H.11: Deductive reasoning skills (as illustrated by better performance in the four-card problems) have a stronger negative relationship with a-insensitivity under nature and social ambiguity than under strategic ambiguity.*

To conclude, the aim of this study is to examine the impact of cognitive ability on social and strategic ambiguity attitudes. I summarize my predictions:

1. Cognitive reflection (i.e., higher scores on CRT) is negatively correlated with ambiguity aversion and a-insensitivity.
2. Cognitive uncertainty levels are positively associated with ambiguity aversion and a-insensitivity.
3. Higher deductive reasoning skills (i.e., better performance on four-card problems) is predictive of less ambiguity aversion and a-insensitivity.
4. Measures of cognitive components have differing predictive power on ambiguity attitudes across ambiguity sources.

# 3. Methodology

To examine the relationship between strategic uncertainty and the three measures of cognitive ability, an online survey was conducted using Qualtrics.com. Subjects were randomly assigned to one of three treatment groups and were consequently presented with a series of questions measuring their ambiguity attitudes and cognitive abilities. Prior to data collection, the university's ethical questionnaire was completed; the study was deemed to adhere to ethical standards.

## 3.1. Subjects

A total of 147 respondents completed the survey in full. Power calculations indicated a necessary sample size of minimum 103 subjects[1]. Participation was expected to take 12-17 minutes. In reality, the experiment lasted approximately 20 minutes, on average. Compensation was offered through the opportunity to participate in a raffle and be one of three winners to a €15 Amazon gift card. Furthermore, by participating in the study, respondents received SurveySwap and SurveyCircle completion codes,

[1] Effect size=0.15, significance level=0.05, power=0.8

which translated into survey respondents for subjects looking for survey respondents themselves- the monetary value of this code would equal €7.50 for SurveySwap users. [2]

Subjects were recruited through various social media platforms, friends, and family. Since the experiment entailed subjects making hypothetical choices and limited incentives were offered, judgmental sampling was employed in subjects' recruitment. Research shows that hypothetical choice normally leads to noisier data (Camerer & Hogarth 1999, Hertwig & Ortmann 2001) and that it does not work well for non-academic subjects (Dimmock et al., 2016). Thus, in order to minimize noise and ensure homogeneity, the study's target pool was constrained to students and individuals with higher education.

## 3.2. Treatments

The survey conducted involved three between-subject treatments and consisted of five sections, as summarized in Table 1. Subjects were randomly placed into one of three treatment groups: nature ambiguity (N=48), social ambiguity (N=50), and strategic ambiguity (N=48). While the main concern of this study is social and strategic ambiguity, a nature ambiguity treatment was also implemented to be used as a point of reference. To the best of my knowledge, relationships between two of the cognitive abilities examined in this study (Wason selection task and cognitive uncertainty) and nature ambiguity attitudes have not to date been examined in any other study. Implementing the nature ambiguity treatment group, therefore, serves as a means to examining differences in the effect of cognitive components on ambiguity attitudes across ambiguity sources (hypotheses *H.3*, *H.5*, *H.7*, *H.10*).

In each treatment, subjects faced a triple of mutually exclusive and exhaustive events *A*, *B* and *C*, only one of which was true. Elicitation of ambiguity attitudes was modelled after Li et al. (2020). In the nature ambiguity treatment, ambiguity was generated by the random drawing of a card from a deck of four cards with hidden markings. Subjects were informed that each card would be marked with the letter *A*, *B* or *C*, but they were unaware of the exact number of cards marked with each of the three letters. They were informed that any composition was possible.

Subjects assigned to the social ambiguity treatment were asked to imagine being assigned to a random partner. They were told that their partner would decide what their midday snack would be out of three options. Partners would have a choice between snack *A*, a savoury snack, snack *B*, dried apple rings,

[2] SurveySwap users can acquire survey responses by obtaining credits through the completion of other surveys or purchase of credits. Each credit costs €0.50. By completing this survey, users obtained 15 credits, which amounts to €7.50.

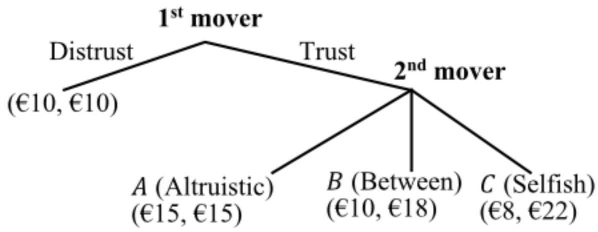



**Fig. 2** Trust game (Li et al., 2019)

and snack *C*, a chocolate bar. To avoid any speculations concerning partners' generosity, subjects were assured that all snacks had the same monetary value.

In the third treatment, strategic ambiguity was generated using the trust game of Li et al. (2019). Similar to the social ambiguity treatment, subjects were asked to envision being assigned to a random partner. They were then presented with the description of the trust game and were informed that their partner would choose between three allocations, labelled *A*, *B* and *C* (Figure 2). Partners could either chose to be altruistic and choose an equal allocation (option *A*), be selfish and take a considerably larger share (option *C*) or choose an option in between (option *B*).

## 3.3. Procedure

Table 1 presents the experimental procedure. Before participating in the survey experiment, in step 1, subjects were presented with brief information about the survey and their compensation (Experimental instructions can be found in Appendix A.1). Subjects were also informed about their rights, most notably that they could withdraw from the study at any point in time and about anonymity of responses. Before proceeding with the experiment, subjects were requested to state their explicit consent to continuation.

Section I consisted of questions eliciting subjects' ambiguity attitudes and levels of cognitive uncertainty. Treatment-specific ambiguity was presented to subjects in step 2 (Appendix A.2). In step 3, matching probabilities were elicited from each subject for each of the three single and three composite events, with the contingency events of the ambiguous lotteries varying based on subjects' treatment groups (Appendix A.3). For each event (*A*, *B*, or *C*), matching probabilities was elicited through four questions. These four questions will be hereafter referred to as a block of questions.

Although cognitive abilities were primarily measured in Section II, subjects' level of cognitive uncertainty was elicited in step 4, after each block of questions, to ensure that events and treatment-specific scenarios were fresh on the subjects' minds. Cognitive uncertainty levels were elicited for each of the six events. To measure subjects' cognitive uncertainty (Appendix A.4), subjects were presented with a binary choice between an ambiguous lottery and a risky lottery. Subjects were then asked to indicate an interval for the probability *x* of winning the prize that would make them indifferent between the ambiguous and risky lottery.

The order of each block of questions was randomly determined. In between the six blocks of questions, subjects were randomly presented with questions regarding control variables (Appendix A.5-A.10), which constitutes step 5. Controls mainly related to factors influencing subjects' decision to trust their random partner or not. Controls included subjects' alcohol consumption, number of siblings, general trust level and happiness. Subjects were also asked about their level of English fluency to correct for any misinterpretations that may arise as the result of a language barrier.

Section II concerned questions on cognitive components. This section consisted of two tests: the CRT (Frederick, 2005; Appendix A.11) and the Wason selection task (Wason, 1960; Appendix A.12). Subjects were presented with the three CRT questions in step 6 and four selection tasks in step 7.

Section III contained questions regarding subjects' demographics (Appendix A.12). Demographic questions concerned subjects' age, gender, highest education level, whether they were a student and their country of nationality (step 8).

Section IV and Section V concluded the experiment. Step 9 involved subjects being presented with the chance to enter a raffle to win an Amazon gift card, and step 10 consisted of a debriefing, in which subjects were briefly explained the purpose of the study. The full debriefing can be found in Appendix A.14.

### 3.4. Matching Probabilities and Incentives

Matching probabilities were elicited as follows. Subjects in all treatment groups faced three mutually exclusive and exhaustive ambiguous events (in the nature ambiguity treatment, only one of the three cards could be drawn out, and in the social and strategic ambiguity treatment, only one of the three options could be chosen by subjects' hypothetical random partners). Six indifferences were elicited from each subject:

$(A\text{: €x}) \sim (m_A\text{: €x})$
$(B\text{: €x}) \sim (m_B\text{: €x})$
$(C\text{: €x}) \sim (m_C\text{: €x})$
$(A \text{ or } B\text{: €x}) \sim (m_{AB}\text{: €x})$
$(A \text{ or } C\text{: €x}) \sim (m_{AC}\text{: €x})$
$(B \text{ or } C\text{: €x}) \sim (m_{BC}\text{: €x})$

**Table 1** Summary of experiment structure

| | | Ambiguity Treatment | | |
|---|---|---|---|---|
| | | Nature | Social | Strategic |
| Section I | Step 1 | Informed consent and general instructions | | |
| | Step 2.<br>Presentation of ambiguity | Subjects were informed that a card is randomly drawn from a deck of for cards, each of which are marked with *A*, *B* or *C*.<br><br>Ambiguity lay in the cards' marking. | Subjects were informed that a random partner would choose a midday snack for them out of three options: a savoury snack, snack *A*, dried apple rings, snack *B*, or a chocolate bar, snack *C*.<br><br>Ambiguity lay in the partner's choice of snack. | Subjects were informed that a random partner would choose one of three allocations: (€15, €15), (€10, €18), or (€8, €22), labelled *A*, *B* and *C*, respectively.<br><br>Ambiguity lay in the partner's choice of allocation. |
| | Step 3.<br>Measurement of ambiguity attitude | Elicitation of matching probabilities of the six events *A*, *B*, *C*, (*A* or *B*), (*A* or *C*), and (*B* or *C*). | | |
| | Step 4.<br>Measurement of cognitive uncertainty | Elicitation of cognitive uncertainty intervals for each of the six events *A*, *B*, *C*, (*A* or *B*), (*A* or *C*), and (*B* or *C*). | | |
| | Step 5.<br>Controls | Subjects are presented with questions regarding control variables such as alcohol consumption and general trust level in between elicitation of matching probabilities. | | |
| Section II | Step 6.<br>Cognitive reflection test | Subjects were presented with the three CRT questions. | | |
| | Step 7.<br>Wason selection task | Subjects were presented with four selection tasks. | | |
| Section III | Step 8.<br>Demographics | Questions regarding subjects' age, gender, highest level of education, etc. | | |
| Section IV | Step 9.<br>Raffle participation | Subjects were given the chance to participate in a raffle to be one of three winners to a €15 Amazon gift card. | | |
| Section V | Step 10.<br>Debriefing | Subjects were presented with a brief explanation of the purpose of study and were offered survey completion codes. | | |

Indifferences were elicited using four-step bisection. That is, subjects were first presented with a choice between an ambiguous lottery ($E$: $x$) and the risky lottery (0.5: $x$). The probability of winning the prize $x$ was adjusted in four steps in a manner that the matching probability $m$ was obtained such that ($m$: $x$) ~ ($E$: $x$). If a subject chose the ambiguous lottery, the risky lottery was made more attractive in the subsequent step. If a subject preferred the risky lottery over the ambiguous one, the risky lottery was made less attractive in the next step. Adjustments made to the winning chance of the risky lottery were as illustrated in Figure 3. Following the final choice between the ambiguous and risky lotteries, matching probabilities can be inferred within +/- 0.03 bounds.

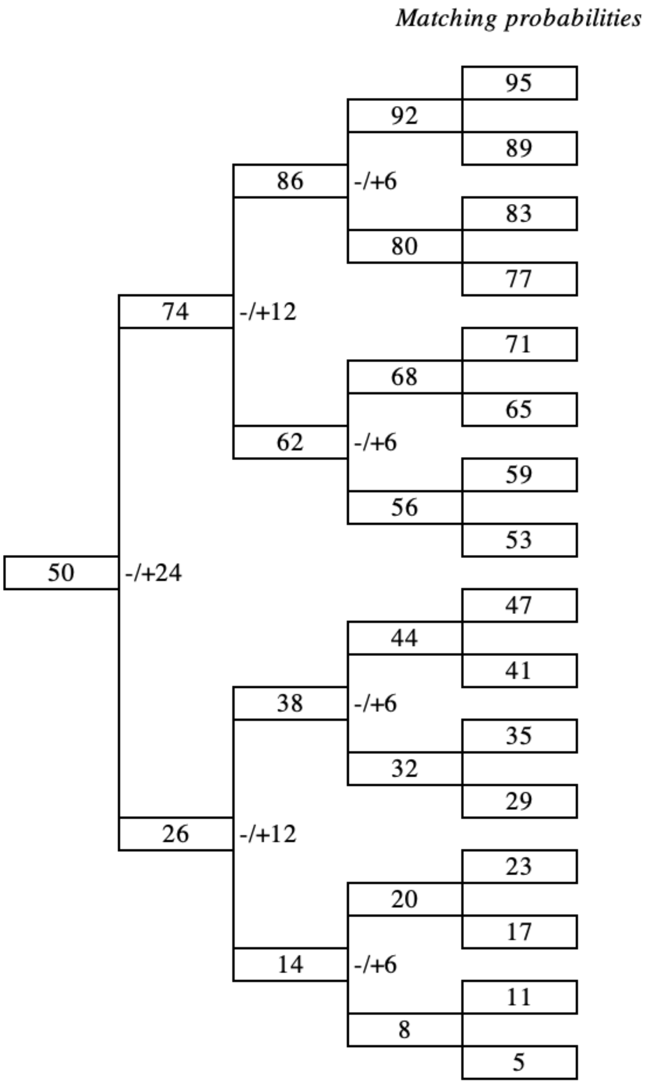



**Fig. 3** Matching probabilities in the bisection approach

The purpose of using the bisection approach is twofold: it is both easy for subjects to understand and concise and efficient, requiring only four questions. One disadvantage of this method is its potential incompatibility with real incentives. When adopting this approach, there is a chance that participants do not answer questions based on their true preferences but rather seek to gain more advantageous prospects in future choices or engage in hedging behaviour (Baillon et al., 2021). This concern rules out the implementation of a random-incentive system.

One incentive system that can be used to avoid such behaviour is the prior-incentive system. However, due to concerns over subjects' difficulty in understanding and over-complication of the experiment, this system was not adopted. Instead, compensation was offered in the form of a raffle. This lottery-incentive is not without faults: Although it alleviates concerns of reward-seeking behaviour, absence of tangible rewards may lead to subjects exhausting insufficient cognitive effort in understanding the hypothetical scenarios. The rationale behind this is that cognitive effort is a scare resource that is allocated

(1) A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? _____ cents

(2) If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? _____ minutes

(3) In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? _____ days

**Fig. 4** Cognitive Reflection Test (CRT; Frederick, 2005)

strategically. If subjects do not perceive their compensation to be contingent on their performance, they will not invest much cognitive effort (Smith 1976; 1982). Despite this flaw, aside from the general consensus that financial incentives in general have a positive effect on performance (Davis & Holt, 1993; Harrison, 1992), the advantage of employing this incentive system lies in its ease to be understood and simple implementation.

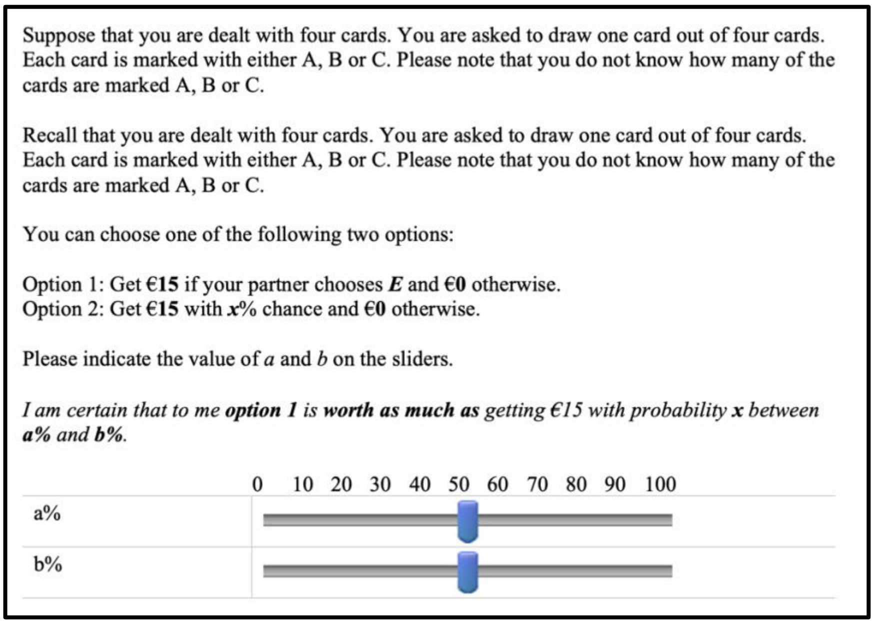
## 3.5. Measurement of Ambiguity Attitudes

All ambiguity attitudes were measured using the method of Baillon et al (2018). Indices were normalized to have a maximum value of 1. A completely ambiguity averse person would have equal average matching probabilities for single and composite events and an aversion index of 1. The ambiguity aversion index of an ambiguity seeking subject would be negative. A maximally insensitive person would have an insensitivity index of 1. Higher a-insensitivity indices imply blurrier perceptions of ambiguity, while smaller indices indicate higher levels of cognitive discriminatory power.

## 3.6. Measures of Cognitive Ability

### 3.6.1. Cognitive reflection Test (CRT)

To measure the degree to which individuals relied on their dual system of thinking, CRT (Frederick, 2005) was employed. Figure 4 displays the three questions of the test. The correct answer to questions 1,2, and 3 are 5 cents, 5 minutes, and 47 days, respectively. Subjects were given a score between 0 and 3 based on the number of questions they answered correctly. CRT scores were normalized to be in [0,1].



Suppose that you are dealt with four cards. You are asked to draw one card out of four cards. Each card is marked with either A, B or C. Please note that you do not know how many of the cards are marked A, B or C.

Recall that you are dealt with four cards. You are asked to draw one card out of four cards. Each card is marked with either A, B or C. Please note that you do not know how many of the cards are marked A, B or C.

You can choose one of the following two options:

Option 1: Get **€15** if your partner chooses ***E*** and **€0** otherwise.
Option 2: Get **€15** with ***x***% chance and **€0** otherwise.

Please indicate the value of *a* and *b* on the sliders.

*I am certain that to me **option 1** is **worth as much as** getting €15 with probability **x** between **a%** and **b%**.*



**Fig. 5** Cognitive uncertainty: example question from the nature ambiguity treatment

### 3.6.2. Cognitive Uncertainty

To measure subjects' level of cognitive uncertainty, subjects were asked to indicate the probability interval of winning a lottery ($p$:$x$) that would make them indifferent between an ambiguous treatment-specific lottery and the risky lottery (step 4). Figure 5 shows an example of the question for event $A$ in the nature ambiguity treatment. The wider subjects' stated interval is, the higher their level of cognitive uncertainty. Subjects stated their intervals six times, for each single and composite event. The average of the indicated intervals was taken as the measure of cognitive uncertainty and was normalized to be in [0,1].

### 3.6.3. Wason Selection Task (WST)

As a measure of individuals' deductive reasoning ability, four Wason selection problems were used. These card problems are illustrated in Figure 6. The selection tasks were adopted from Ball et al. (2003). Each task consisted of four cards and a rule. Subjects were informed that the rule may be true or false and were asked to choose the card(s) that would falsify or confirm the rule.

The literature on WST uses specific terminology for each of the problem's cards. Cards mentioned in the rule are referred to as *true* cards and those not mentioned as *false*. Additionally, since P and P' are

1. ***Rule: If a card has A on one side, then it has 3 on the other side.***

Please indicate the card(s) that need to be turned over to discover whether the rule is true.

- 7
- J
- A
- 3

2. ***Rule: If a card has E on one side, then it does not have 5 on the other side.***

Please indicate the card(s) that need to be turned over to discover whether the rule is true.

- 5
- L
- E
- 2

3. ***Rule: If a card doesn't have S on one side, then it has 9 on the other side.***

Please indicate the card(s) that need to be turned over to discover whether the rule is true.

- 4
- S
- 9
- D

4. ***Rule: If a card doesn't have N on one side, then it does not have 8 on the other side.***

Please indicate the card(s) that need to be turned over to discover whether the rule is true.

- N
- 8
- T
- 1

**Fig. 6** Wason selection tasks

both candidates to the first part of the rule, they are known as *antecedent* and Q and Q' as *consequent* choices. Table 2 illustrates the terminology of each card in the four selection tasks used.

The correct answers to the selection tasks are the true antecedent (TA) and false consequent (FC) cards. The first WST was the standard selection task. Correct answers of the first problem are *A* and *7*. In the remaining three tasks, negations were permuted through the conditional statements. The correct answers to the second, third and fourth questions are *E* and *5*, *D* and *4*, *T* and *8*, respectively. Subjects had WST scores between 0 and 4. As with the other cognitive measures, scores were normalized to be in [0,1].

According to Sperber et al. (1995), subjects' performance in the selection task results from them inferring directly testable consequences from the rule and inferring them in the order of accessibility and stopping when the resulting explanation of the rule meets expectation. Therefore, in order to avoid any unanticipated systematic influence on subjects' choices, the order of cards within the array was randomised. Order of accessibility and expectations thus varied with the rules and contexts of questions and subjects' performance were not affected.

**Table 2** Wason selection task: card categorization

| | Cards | | | |
|---|---|---|---|---|
| | TA | FA | TC | FC |
| If A, then 3 | **A** | J | 3 | **7** |
| If E, then not 5 | **E** | L | 2 | **5** |
| If not S, then 9 | **D** | S | 9 | **4** |
| If not N, then not 8 | **T** | N | 1 | **8** |

*Notes.* Correct card selections are boldened.

Despite prevalent utilization of thematic materials in WST for social contract modules, thematic content is invariably linked to memory-cuing strategies (Griggs & Cox, 1982). According to the memory-cuing hypothesis (Johnson-Laird et al, 1972), individuals search their memory for experiences cued by the problem content, implying that past experiences associated with cards may assist them in answering the task. Another implication is that instead of selecting cards based on their logical status, individuals choose cards based on the possibility of getting information related to past experiences. Thus, to avoid any facilitation and confounding effects on the employment of logical reasoning, thematic content was not introduced to the tasks and standard abstract WSTs were used.

# 4. Results

## 4.1. Description of Data

Out of the 147 participants, 3 were removed as they completed the survey in less than 5 minutes and displayed erratic and unthoughtful responses. Moreover, the elicited a-insensitivity index ($a$) of 17 respondents was higher than 1. These responses were removed from the analysis because the maximal value of $a$ is 1. The final sample, thus, consisted of N=129 subjects. Table 3 shows summary statistics. There is considerable heterogeneity in subjects' ambiguity attitudes. The median subject was close to ambiguity indifferent ($b \approx 0$) and a-insensitive. There were also substantial differences in subjects' cognitive ability. The median subject scored 2 on CRT, 0 out of the four WST questions and had a cognitive uncertainty level of 0.35. In addition to these variables elicited, Table 3 also displays subjects' responses to demographic and control questions regarding general happiness, general trust, number of siblings, number of weekly drinks, age, gender, and English fluency.

All subjects were either students or had higher education. 40.16% of subjects held BSc degrees, followed by 32.28% with MSc degrees (Table B.2). 64.6% of subjects were current students. The highest education level of 7 subjects was a high school diploma or secondary vocational education and training. These subjects were not excluded from the analysis, however, as they were all currently students and fit the criteria of academic subjects.

**Table 3** Summary statistics

| | Mean | Median | SD | Min | Max | Interquartile range |
|---|---|---|---|---|---|---|
| Ambiguity aversion | 0.083 | 0.02 | 0.317 | -0.900 | 0.900 | [-0.08, 0.18] |
| A-insensitivity | 0.279 | 0.22 | 0.477 | -0.98 | 1 | [0.04, 0.64] |
| Cognitive reflection test score | 1.732 | 2 | 1.237 | 0 | 3 | [0, 3] |
| Wason selection task score | 0.596 | 0 | 0.834 | 0 | 4 | [0, 1] |
| Adjusted Wason selection task score | 0.217 | 0 | 0.544 | 0 | 3 | [0, 0] |
| Cognitive uncertainty | 0.357 | 0.35 | 0.264 | 0 | 1 | [0.139, 0.514] |
| General happiness | 6.837 | 7 | 1.703 | 0 | 10 | [6, 8] |
| General trust | 0.556 | 0.666 | 0.383 | 0 | 1 | [0.33,1] |
| Siblings | 1.783 | 1 | 1.419 | 0 | 6 | [1, 3] |
| Weekly drinks | 1.82 | 0 | 3.628 | 0 | 30 | [0, 2] |
| English fluency | 8.56 | 9 | 1.248 | 5 | 10 | [8, 10] |
| Age | 31.78 | 27 | 12.01 | 19 | 75 | [23, 39] |
| Gender (female=1) | 0.434 | 0 | 0.5 | 0 | 1 | [0, 1] |
| Studentship (student=1) | 0.619 | 1 | 0.487 | 0 | 1 | [0, 1] |

The subject pool was almost equally split in gender, with 43.4% of subjects being female. Subjects predominantly originated from the Netherlands (23.33%) and Iran (30.83%) (Table B.1). Further information about subjects' nationality and highest education level can be found under Appendix B.

## 4.2. Matching Probabilities

All statistical tests are two-sided. Figures 7-9 present histograms of the six matching probabilities for the three ambiguity treatments. For nature ambiguity (Fig. 7), subjects were expected to show symmetric matching probabilities, as they had no reason to believe that the probability of one ambiguous event was higher than the rest. However, matching probabilities reject this for both single and composite events ($p$<0.001, Friedman test): the average matching probability was higher for event

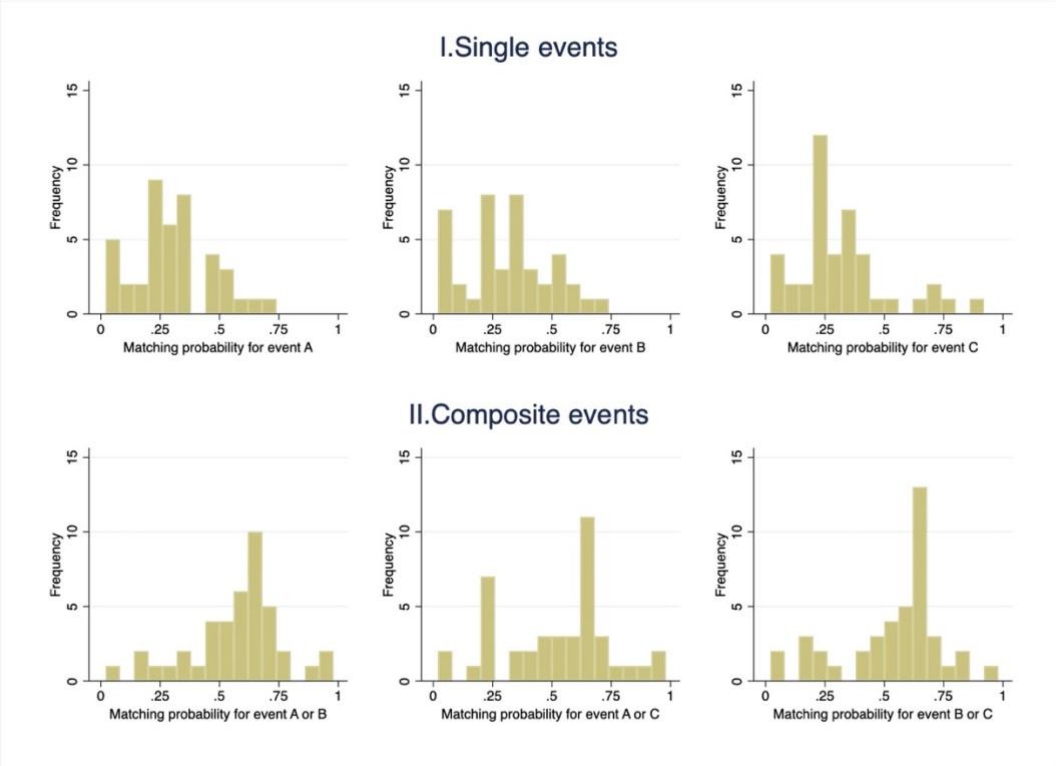



**Fig 7** Histogram of matching probabilities for the nature ambiguity treatment

*C* (0.32) compared to 0.30 for event *A* and *B*. Average matching probability was also higher for composite event *A* or *B* (0.57) compared to 0.52 and 0.54 for the other two composite events.

For social and strategic ambiguity, subjects once again did not display symmetric beliefs. For these ambiguity treatments, in contrast to nature ambiguity, symmetry was not expected; subjects had plausible reason to suspect that the likelihood of an event happening was higher than that of other events. Figures 8-9 demonstrate that for both social and strategic ambiguity, subjects perceive higher likelihood of one particular event. In the social ambiguity treatment, average matching probability was highest for single event *C* (receiving a chocolate bar; 0.34) and composite event *A* or *C* (receiving a savoury snack or a chocolate bar; 0.60), $p<0.02$ in all Friedman tests comparing single and composite matching probabilities.

In the strategic ambiguity treatment, contrary to expectations, average matching probability was only marginally significantly different for single events at 5% significance level ($p=0.0508$, Friedman test). Average matching probability was different for composite events ($p<0.02$, Friedman test). In this treatment, single event *C* (having a selfish partner; 0.43) and composite event *A* or *C* (having an altruistic or selfish partner; 0.63) had the highest average matching probabilities.

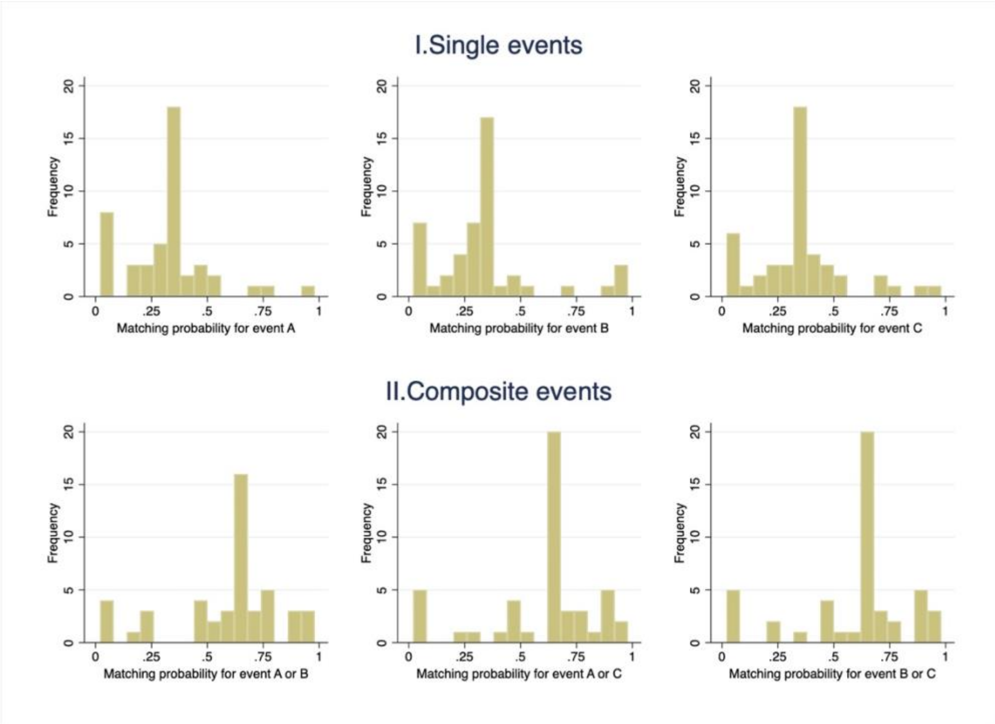



**Fig 8** Histogram of matching probabilities for the social ambiguity treatment

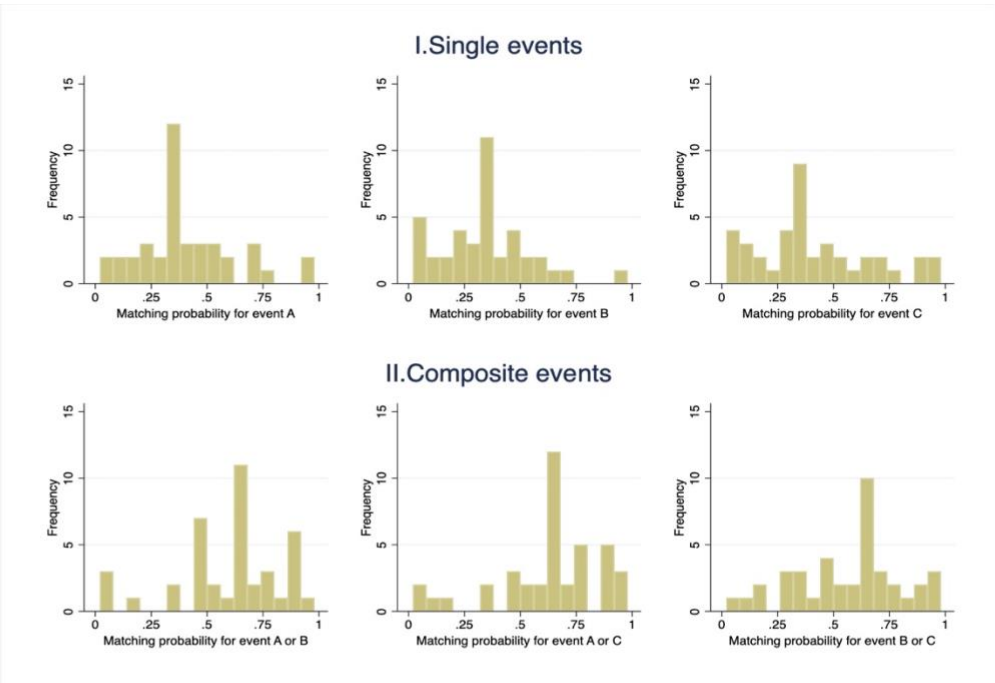



**Fig 9** Histogram of matching probabilities for the strategic ambiguity treatment

Table 4 depicts subjects' ambiguity attitudes. The top panel concerns the ambiguity aversion index. Consistent with previous findings on artificial ambiguity, subjects displayed ambiguity aversion under nature ambiguity. However, ambiguity aversion was also found for social and strategic ambiguity, contrary to the findings of Li et al. (2020). The bottom panel displays distributions of the a-insensitivity index. Similar to the findings of Li et al. (2020), a-insensitivity was significant for all treatments.

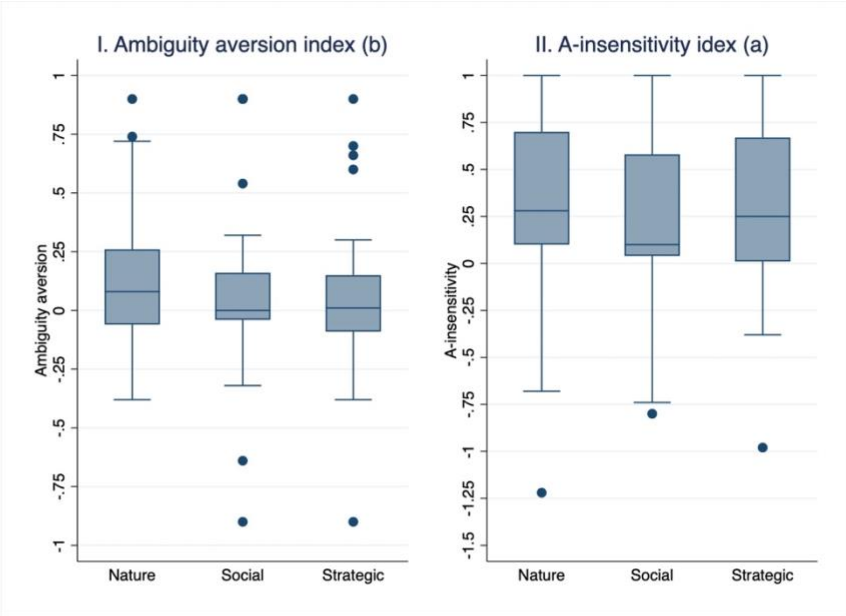



**Fig 10** Boxplot of ambiguity attitudes across treatments

Figure 10 compares ambiguity attitudes in the three ambiguity treatments. The left panel shows differences in ambiguity aversion, while the right panel shows differences in subjects' a-insensitivity. Unlike Li et al. (2020), Mann-Whitney U tests yield no differences in either ambiguity aversion or a-insensitivity across treatments.

## 4.3. Cognitive Abilities

Tables 5-7 display frequencies of subjects' answers to both tests of cognition. In total, 2% of respondents (2 respondents) had an incomplete CRT. These choices were reported as missing. The majority of subjects (38.58%) obtained full scores on CRT (Table 5), while more than half the subject pool failed to answer any of the WSTs correctly (Table 5). Similar to previous studies on the selection

**Table 4** Ambiguity attitudes by ambiguity treatment

| I. Ambiguity aversion | | | | |
|---|---|---|---|---|
| Ambiguity treatment | Mean | Median | Interquartile range | p-value Wilcoxon tests (*b*=0) |
| Nature | 0.144 | 0.08 | [-0.06, 0.26] | 0.0002 |
| Social | 0.065 | 2.98e-08 | [-0.04, 0.16] | 0.000 |
| Strategic | 0.038 | 0.01 | [-0.09, 0.15] | 0.028 |
| II. A-insensitivity | | | | |
| Ambiguity treatment | Mean | Median | Interquartile range | p-value Wilcoxon tests (*b*=0) |
| Nature | 0.31 | 0.28 | [0, 0.22] | 0.000 |
| Social | 0.233 | 0.1 | [0, 0.1] | 0.000 |
| Strategic | 0.302 | 0.25 | [0.01, 0.67] | 0.000 |

task, the standard abstract task (WST 1) had the lowest response rate, while the highest performance on the WST concerned the second task (WST 2), for which 37.98% selected the right cards (Table 6).

Subjects' high rate of correct response to WST 2, however, was not a product of their reasoning abilities. Facilitation effects found for negated abstract rules imply that the matching bias and verification bias are strategies that are used when there has been no previous experience with the problem content (Griggs & Cox, 1983). Although prepositional logic dictates E and 5 as the correct answers to this task, subjects can arrive at this answer without reasoning deductively. The matching bias (Evans, 1972) also leads to subjects selecting the correct answer, albeit without reasoning. For this reason, instead of judging subjects' reasoning ability based on the four tasks, WST 2 was excluded from the scoring and only the remaining three tasks were used in the analysis. Adjusted WST scores are reported in Table 6. Any WST scores discussed hereafter are adjusted scores.

Figure 11 compares subjects' cognitive uncertainty levels under each of the ambiguity treatment groups. Cognitive uncertainty levels were different across nature, social and strategic ambiguity treatments. Subjects experienced less uncertainty under the social ambiguity treatment than under the nature and strategic ambiguity treatments, $p<0.05$ for both Mann-Whitney tests (Table 7).

Because both ambiguity attitudes and the measures of cognitive ability discussed in this study are all to some extent related to individuals' level of susceptibility to bias, we expect to find correlation between them. The pattern of correlations among all the measures is examined in Table 8.

All correlations reported are significant at 10% significance level. The data show negative correlations between cognitive uncertainty and normalized scores on the Wason selection task and a positive relationship between a-insensitivity and ambiguity aversion.

**Table 5** Frequencies of scores on measures of cognitive ability

| I. CRT scores | Freq | Percent |
|---|---|---|
| 0 | 35 | 27.56 |
| 1 | 13 | 10.24 |
| 2 | 30 | 23.62 |
| 3 | 49 | 38.58 |
| **II. (Adjusted) WST scores (4 problems)** | **Freq** | **Percent** |
| 0 (0) | 73 (107) | 56.59 (82.95) |
| 1 (1) | 41 (18) | 31.78 (13.95) |
| 2 (2) | 11 (2) | 8.53 (1.55) |
| 3 (3) | 2 (2) | 1.55 (1.55) |
| 4 | 2 | 1.55 |

*Notes*. Numbers in parenthesis concern frequencies and precents for adjusted WST scores. Adjusted WST scores refer to subjects scores to WST 1, 3 and 4. The correct response to WST 2 could be derived without deductive reasoning and using only the matching heuristic. Thus, correct answers to WST 2 were excluded.

Understanding ambiguous scenarios and behaving rationally in the face of uncertainty requires cognitive ability. By set monotonicity, a rational decision-maker's matching probability of a composite event should exceed that of either one the two events of its composition (Baillon et al., 2018). Weak monotonicity allows for matching probabilities of composite events to also equal that of single events ($mc \gg\ ms$). Since six matching probabilities were elicited from each subject, six monotonicity checks were performed per subject. Subjects failing monotonicity checks at least twice (scoring less than 4 out of 6) are said to violate monotonicity. [3]These subjects were, nevertheless, kept in the analysis. Excluding subjects when weak monotonicity was violated did not influence findings.

The negative correlation between a-insensitivity and set (-0.714; $p < 0.1$) and weak monotonicity (-0. 271; $p < 0.1$), imply that lower cognitive skills lead to less rational choices. Nonparametric tests confirm this. Individuals scoring higher on CRT (2 or 3) are found to have different a-insensitivity levels under nature ambiguity compared to those with lower scores (Mann-Whitney U test, $p$<0.01). There were also differences in set monotonicity scores between the high and low CRT group (Mann-Whitney U test, $p$<0.01). Behaving according to monotonicity principles, itself, also depends on cognitive ability, as evident by the variables' pairwise correlation (0. 280; $p < 0.1$).

**Table 6** Insights on the Wason selection task (WST)

| | Insight | | |
|---|---|---|---|
| *Score categories* | Full insight | Lack of insight | Partial insight |
| WST 1: If A, then 3 | 5 (3.88) | 88 (68.22) | 36 (27.91) |
| WST 2: If E, then not 5 | 49 (37.98) | 40 (37.01) | 40 (31.01) |
| WST 3: If not S, then 9 | 12 (9.30) | 60 (46.51) | 57 (49.19) |
| WST 4: If not N, then not 8 | 11 (8.53) | 45 (34.88) | 73 (56.59) |

*Notes*. Subjects using a falsification strategy and selecting P and Q' are known to have full insight, while subjects using a verification strategy and indicating P and Q as correct answers have lack of insight. Subjects using a combination of falsification and verification strategies (and selection P, Q and Q') have partial insight. Numbers in parenthesis concern relative frequencies.

**Table 7** Cognitive uncertainty by ambiguity treatment

| Ambiguity treatment | Mean | Median | Interquartile range | p-value Mann-Whitney U |
|---|---|---|---|---|
| Nature | 0.410 | 0.30 | [0.19, 0.63] | *0.023 |
| Social | 0.249 | 0.20 | [0.08, 0.44] | **0.030 |
| Strategic | 0.392 | 0.39 | [0.24, 0.57] | ***0.921 |

*Notes*. *Mann-Whitney test for differences between nature and social ambiguity
** Mann-Whitney test for differences between social and strategic ambiguity
***Mann-Whitney test for differences between strategic and nature ambiguity

[3] On average, the fail rate of monotonicity checks was 27.3% for set monotonicity and 5.43% for weak monotonicity.

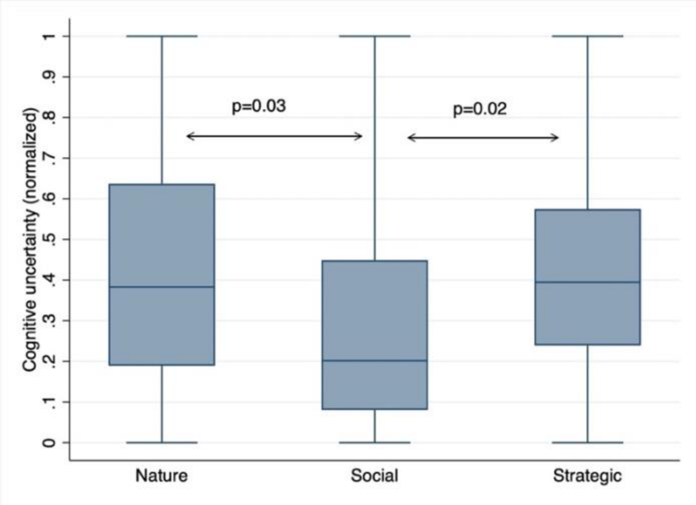



**Fig 11** Boxplot of cognitive uncertainty levels across ambiguity treatments

Nonparametric tests primarily did not yield any significant relationship between ambiguity attitudes and correct responses on each of the WSTs. Only those answering WST 3 correctly were found to have significantly different ambiguity aversion under strategic ambiguity (*p*<0.01, Mann-Whitney U test).

## 4.4. Cognitive Abilities as Determinants of Ambiguity Attitudes

Tables 9-11 present OLS regressions of subjects' cognitive ability scores and their ambiguity attitudes. The dependent variables of all models are the two indexes (ambiguity aversion and a-insensitivity) describing subjects' ambiguity attitudes. I did not find significant effects of demographics and controls and therefore do not report on them. All relationships reported in this study are significant at 5% significance level.

**Table 8** Pairwise correlations

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| (1) A-insensitivity | 1.000 | | | | | | |
| (2) Ambiguity aversion | 0.267* | 1.000 | | | | | |
| | (0.002) | | | | | | |
| (3) WST scores normalized | -0.092 | -0.059 | 1.000 | | | | |
| | (0.302) | (0.509) | | | | | |
| (4) CRT scores normalized | -0.136 | -0.052 | 0.205* | 1.000 | | | |
| | (0.128) | (0.558) | (0.021) | | | | |
| (5) Cognitive uncertainty | 0.191* | 0.138 | -0.189* | -0.051 | 1.000 | | |
| | (0.030) | (0.118) | (0.032) | (0.566) | | | |
| (6) Weak monotonicity score | -0.271* | 0.047 | 0.071 | 0.111 | -0.019 | 1.000 | |
| | (0.002) | (0.598) | (0.422) | (0.213) | (0.834) | | |
| (7) Set monotonicity score | -0.714* | -0.369* | 0.098 | 0.280* | -0.141 | 0.291* | 1.000 |
| | (0.000) | (0.000) | (0.270) | (0.001) | (0.111) | (0.001) | |

**** p<0.01, ** p<0.05, * p<0.1*

### 4.4.1. Cognitive Ability in Isolation

Table 9 shows OLS regressions of the three measures of cognitive ability and ambiguity attitudes, in isolation. Panel A concerns normalized CRT scores, whilst Panel B and C relate to normalized cognitive uncertainty levels and normalized WST scores. Each panel consists of 7 models: Model 1 looks at the effect of the measure in isolation, while Model 2 adds controls and demographics. Models 3 and 5 introduce treatment dummies and interactions, respectively, and Models 4, 6 and 7 add controls and demographics.

*Ambiguity Aversion Index (b)*

Examining normalized CRT scores in isolation, no significant impact is found on ambiguity aversion at 5% significance level, contrary to *H.1*. With the introduction of treatment dummies to the model, however, ambiguity aversion is shown to be lower under strategic ambiguity than under nature ambiguity (Models 3-6). These effects are only significant at the 10% significance level though.

Cognitive uncertainty is found to be significant when used as the sole explanatory variable and with the inclusion of demographics and controls (Panel B; Models 2 & 4). Adding treatment variables and interactions to the model shows differences between ambiguity aversion under nature and social ambiguity: ambiguity aversion is higher under nature ambiguity than under social ambiguity (Models 5-7). This is in line with the findings of Li et al. (2020). Furthermore, Models 5-7 depict that higher cognitive uncertainty is linked to higher ambiguity aversion under social ambiguity than under nature ambiguity, supporting *H.7*.

Moreover, Panel C illustrates a positive relationship between normalized WST scores and ambiguity aversion when ambiguity treatments, interactions, and controls and demographics are accounted for (Models 6-7). Better performance on the selection task is associated with a lower *b*, confirming *H.10*. Model 7 also indicates that higher deductive reasoning skills are linked to higher ambiguity aversion under social ambiguity than under nature ambiguity, disconfirming *H.11*.

*A-insensitivity Index (a)*

Panel A shows a negative relationship between CRT scores and a-insensitivity, when demographics are controlled for (Model 2) and when interactions are added to the model (Model 5). Findings show that the more reflective people are, the less they perceive probabilities as blurry and the more capable they are of discriminating between different likelihoods of events, resulting in a lower *a*. This is in line with *H.1*.

A-insensitivity is also found to have a positive relationship with cognitive uncertainty: individuals indicating larger intervals of subjective probabilities for events have larger a-insensitivity indices. This association is as predicted in *H.6*. However, this relationship is only significant in the absence of demographics, treatment groups and interactions (Models 1 & 3).

Higher deductive reasoning ability is presumed to be a predictor of lower a-insensitivity. Individuals with superior performance on WST are expected to demonstrate more skill in overriding cognitive biases and in incorporating new information in their decisions. Panel C depicts the influence of deductive reasoning skills on *a*. In contrast to expectations, no significant relationship is found between the two variables.

### 4.4.2. Cognitive Abilities Combined

Tables 10-11 show OLS regressions of the three measures of cognitive ability and ambiguity attitudes, combined. Model 1 includes subjects' cognitive abilities, namely normalized CRT and WST scores and cognitive uncertainty levels, as explanatory variables. Model 2 also includes demographics and controls. Models 3 and 4 add a treatment variable to Model 1 and Model 2, respectively. Model 5 adds interactions between measures of cognitive ability and treatment groups, and Models 6 and 7 complement Model 4 by adding demographics and controls. Table 10 presents regression results for social and strategic ambiguity treatments, while Table 11 that for all ambiguity treatments.

*Ambiguity Aversion Index (b)*

Because higher scores on CRT are indicative of individuals' lower likelihood of susceptibility to biases and non-rational behaviour and given the irrational nature of non-neutral ambiguity attitudes, individuals scoring higher on CRT are expected to display less ambiguity aversion and a-insensitivity (*H.1*). In the absence of interactions between cognitive ability and ambiguity treatments, no impact of CRT scores was found. However, Table 10 shows a negative relationship between CRT scores and ambiguity aversion under social and strategic ambiguity, when interactions were introduced to the analysis (Table 10, Models 5-7). Contrary to *H.1.*, no significant relationship was witnessed between normalized CRT scores and *b* at a 5% significance level when observations under the nature ambiguity treatment were also included in the analysis (Table 11).

**Table 9** Ambiguity attitude indices and measures of cognitive ability in isolation

| | *Ambiguity aversion* | | | | | | | *A-insensitivity* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panel A | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [1] | [2] | [3] | [4] | [5] | [6] | [7] |
| Social ambiguity | | | -0.0807 | -0.0950 | -0.0469 | 0.0426 | 0.0326 | | | -0.0754 | 0.0198 | -0.326 | -0.0685 | -0.112 |
| | | | (0.0677) | (0.0787) | (0.134) | (0.183) | (0.188) | | | (0.103) | (0.107) | (0.204) | (0.233) | (0.232) |
| Strategic ambiguity | | | -0.118* | -0.113* | -0.206* | -0.181* | -0.181 | | | 0.00998 | 0.0478 | -0.0982 | 0.0348 | 0.0247 |
| | | | (0.0664) | (0.0671) | (0.108) | (0.107) | (0.115) | | | (0.105) | (0.108) | (0.195) | (0.212) | (0.207) |
| CRT scores | -0.0403 | 0.0179 | -0.0324 | -0.0156 | -0.0567 | 0.0148 | 0.0165 | -0.158 | 0.234** | -0.161 | -0.22* | -0.371** | -0.280 | -0.278 |
| | (0.0689) | (0.0750) | (0.0678) | (0.0708) | (0.109) | (0.0952) | (0.103) | (0.105) | (0.110) | (0.105) | (0.113) | (0.155) | (0.179) | (0.182) |
| Social X CRT | | | | | -0.0590 | -0.204 | -0.224 | | | | | 0.449* | 0.133 | 0.148 |
| | | | | | (0.179) | (0.228) | (0.231) | | | | | (0.254) | (0.301) | (0.305) |
| Strategic X CRT | | | | | 0.144 | 0.0852 | 0.103 | | | | | 0.199 | 0.0201 | 0.0479 |
| | | | | | (0.144) | (0.138) | (0.146) | | | | | (0.240) | (0.261) | (0.261) |
| Constant | 0.101* | 0.0477 | 0.162** | 0.101 | 0.175** | 0.0920 | 0.0690 | 0.372*** | 0.0999 | 0.398*** | 0.131 | 0.513*** | 0.109 | -0.026 |
| | (0.0528) | (0.182) | (0.0623) | (0.176) | (0.0832) | (0.200) | (0.229) | (0.0845) | (0.254) | (0.102) | (0.263) | (0.131) | (0.305) | (0.351) |
| Observations | 127 | 106 | 127 | 106 | 127 | 106 | 106 | 127 | 106 | 127 | 106 | 127 | 106 | 106 |
| R-squared | 0.003 | 0.114 | 0.026 | 0.090 | 0.038 | 0.165 | 0.201 | 0.018 | 0.119 | 0.025 | 0.070 | 0.051 | 0.123 | 0.183 |
| Demographics | NO | YES | NO | YES | NO | YES | YES | NO | YES | NO | YES | NO | YES | YES |
| Controls | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO | NO | NO | NO | YES |
| Panel B | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [1] | [2] | [3] | [4] | [5] | [6] | [7] |
| Social ambiguity | | | -0.0579 | -0.0499 | -0.255** | -0.29*** | -0.32*** | | | -0.0338 | 0.0430 | -0.125 | -0.123 | -0.153 |
| | | | (0.0712) | (0.0784) | (0.108) | (0.108) | (0.111) | | | (0.104) | (0.108) | (0.176) | (0.185) | (0.190) |
| Strategic ambiguity | | | -0.103 | -0.123* | -0.157 | -0.216 | -0.212 | | | -0.00148 | 0.0300 | 0.0750 | 0.0414 | 0.0268 |
| | | | (0.0677) | (0.0674) | (0.150) | (0.133) | (0.135) | | | (0.107) | (0.112) | (0.199) | (0.216) | (0.229) |
| Cognitive uncertainty | 0.166 | 0.307** | 0.159 | 0.330** | -0.0749 | -0.356 | -0.0359 | 0.345** | 0.227 | 0.331** | 0.257 | 0.282 | 0.0457 | -0.058 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (0.128) | (0.135) | (0.141) | (0.142) | (0.187) | (0.139) | (0.132) | (0.152) | (0.173) | (0.160) | (0.176) | (0.259) | (0.258) | (0.266) |
| Social X CU | | | | | 0.597** | 0.841*** | 0.863*** | | | | | 0.302 | 0.527 | 0.495 |
| | | | | | (0.297) | (0.252) | (0.257) | | | | | (0.348) | (0.380) | (0.399) |
| Strategic X CU | | | | | 0.127 | 0.236 | 0.230 | | | | | -0.197 | -0.0038 | 0.0604 |
| | | | | | (0.299) | (0.237) | (0.238) | | | | | (0.417) | (0.440) | (0.482) |
| Constant | 0.0234 | 0.0203 | 0.0791 | 0.0628 | 0.175** | 0.233 | 0.247 | 0.156** | -0.113 | 0.174 | -0.062 | 0.194 | -0.0432 | -0.156 |
| | (0.0514) | (0.157) | (0.0703) | (0.151) | (0.0831) | (0.177) | (0.229) | (0.0703) | (0.207) | (0.106) | (0.219) | (0.144) | (0.272) | (0.319) |
| Observations | 129 | 107 | 129 | 107 | 129 | 107 | 107 | 129 | 107 | 129 | 107 | 129 | 107 | 107 |
| R-squared | 0.019 | 0.171 | 0.036 | 0.152 | 0.082 | 0.285 | 0.306 | 0.036 | 0.094 | 0.038 | 0.052 | 0.049 | 0.114 | 0.162 |
| Demographics | NO | YES | NO | YES | NO | YES | YES | NO | YES | NO | YES | NO | YES | YES |
| Controls | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO | NO | NO | NO | YES |
| Panel C | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [1] | [2] | [3] | [4] | [5] | [6] | [7] |
| Social ambiguity | | | -0.0792 | -0.0894 | -0.0831 | -0.105 | -0.126 | | | -0.0788 | 0.0103 | -0.0998 | -0.0341 | -0.077 |
| | | | (0.0670) | (0.0766) | (0.0731) | (0.0829) | (0.0865) | | | (0.102) | (0.105) | (0.110) | (0.117) | (0.120) |
| Strategic ambiguity | | | -0.101 | -0.105 | -0.0976 | -0.149* | -0.147* | | | 0.00867 | 0.0519 | -0.0350 | 0.00306 | -0.003 |
| | | | (0.0679) | (0.0666) | (0.0749) | (0.0752) | (0.0778) | | | (0.108) | (0.114) | (0.119) | (0.129) | (0.126) |
| WST scores | -0.103 | -0.158 | -0.0803 | -0.152 | -0.0957 | -0.459** | -0.513** | -0.241 | -0.242 | -0.265 | -0.258 | -0.655 | -0.725 | -0.885 |
| | (0.0997) | (0.119) | (0.0975) | (0.106) | (0.255) | (0.197) | (0.209) | (0.191) | (0.189) | (0.196) | (0.193) | (0.559) | (0.550) | (0.536) |
| Social X WST | | | | | 0.0760 | 0.464* | 0.571** | | | | | 0.377 | 0.538 | 0.908 |
| | | | | | (0.273) | (0.239) | (0.256) | | | | | (0.593) | (0.608) | (0.641) |
| Strategic X WST | | | | | -0.0199 | 0.395 | 0.477* | | | | | 0.579 | 0.618 | 0.836 |
| | | | | | (0.302) | (0.272) | (0.268) | | | | | (0.607) | (0.599) | (0.600) |
| Constant | 0.0902*** | 0.0424 | 0.149*** | 0.0943 | 0.150*** | 0.0953 | 0.0513 | 0.297*** | -0.0850 | 0.325*** | -0.026 | 0.346*** | -0.0910 | -0.247 |
| | (0.0307) | (0.167) | (0.0458) | (0.165) | (0.0490) | (0.174) | (0.210) | (0.0457) | (0.214) | (0.0743) | (0.225) | (0.0801) | (0.242) | (0.289) |
| Observations | 129 | 107 | 129 | 107 | 129 | 107 | 107 | 129 | 107 | 129 | 107 | 129 | 107 | 107 |
| R-squared | 0.003 | 0.119 | 0.022 | 0.093 | 0.022 | 0.153 | 0.182 | 0.008 | 0.089 | 0.015 | 0.045 | 0.022 | 0.101 | 0.169 |
| Demographics | NO | YES | NO | YES | NO | YES | YES | NO | YES | NO | YES | NO | YES | YES |
| Controls | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO | NO | NO | NO | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

On one hand, the previous lack of finding of significant differences between ambiguity aversion under social and strategic ambiguity (Li et al., 2020) suggested that there would be no significant differences between the effect of higher reflection on ambiguity aversion under the two treatments (*H.2)*. The study's findings support this hypothesis (Table 10, Panel B, Models 5-7). On the other hand, heterogeneities in ambiguity aversion resulting from nature uncertainty and strategic uncertainty implied that scoring higher on CRT would be associated with lower aversion under strategic uncertainty than under nature uncertainty (*H.3*). However, Table 11 failed to show any differences between nature and social ambiguity or between strategic and nature ambiguity (contrary to *H.3*).

Considering the subjective nature of the cognitive uncertainty measure, wider cognitive uncertainty intervals imply perceptions of lower competence on subjects' behalf. Therefore, the more cognitively uncertain a decision-maker is, the more ambiguity averse he is expected to be (*H.6*). Higher cognitive uncertainty levels were indeed associated with a higher ambiguity aversion index for social and strategic ambiguity when interactions were not included in the model (Table 10, Panel A, Models 1-4).

Upon including interactions between cognitive ability and ambiguity sources to the analysis, differences were found in the effect of cognitive uncertainty on *b* under social and strategic ambiguity. Models 6-7 of Table 10 show that higher cognitive uncertainty levels are linked to a smaller *b* under strategic ambiguity than under social ambiguity. This supports *H.7*. The reverse relation was found when comparing nature and social ambiguity. Models 6-7 of Table 11 demonstrate that more cognitively uncertain individuals are linked with higher levels of *b* under social ambiguity than under nature ambiguity. This finding is opposite to predictions (*H.7*). Thus, *H.7* is only partially supported.

Better performance on WST is presumably linked to individuals' higher deductive reasoning ability (Sperber et al., 1995). Providing correct answers to the selections tasks requires individuals to push past their heuristics and to view the problem as a disconfirmation task rather than to give into their confirmation bias and employ a verification strategy. Considering logical reasoners' higher tendency to carefully evaluate probabilistic data and resist generalizations, individuals with higher scores on WST are expected to display more rational behaviour under uncertainty, demonstrating lower ambiguity aversion and a-insensitivity *(H.9).* Findings do not support this prediction. Table 10 failed to find a significant relationship between ambiguity aversion under social and strategic ambiguity and deductive reasoning (contrary to *H.9*). Naturally, no differences in the effect of deductive reasoning were found either (in contrast to *H.10*).

When examining aversion under all ambiguity treatments, in contrast to *H.9* and in the absence of interactions and with the inclusion of demographics and controls, Model 2 and 4 of Table 10 show a positive association between scores on WST and *b*: individuals with higher deductive reasoning skills tend to be more ambiguity averse. When interactions were added to the analysis, differences were found in the effect of deductive reasoning on ambiguity aversion. Models 6-7 demonstrate that superior deductive reasoning skills are associated with higher ambiguity aversion under social ambiguity than under nature ambiguity, disconfirming *H.10*.

Besides the impact of cognitive ability, the models of Table 10-11 illustrated the effect of ambiguity treatments on ambiguity aversion. While no significant differences were found in *b* under social and strategic ambiguity treatments (Table 10), differences were found between social and nature ambiguity under Model 5 of Table 11, and between strategic and nature ambiguity under Model 7. When interactions are included in the analysis, ambiguity aversion is shown to be lower under social ambiguity than under nature ambiguity, corroborating Li et al.'s findings. With the inclusion of demographics and controls, however, this difference loses significance, and a significant difference is found between ambiguity aversion under strategic and nature ambiguity: ambiguity aversion is higher under nature ambiguity than under strategic ambiguity. This too confirms Li et al. (2020).

### *A-insensitivity Index (a)*

The findings show little effect of cognitive ability on a-insensitivity. Table 10 shows a negative relationship between normalized CRT scores and a-insensitivity under all ambiguity sources when interactions between cognitive ability and ambiguity treatment are added (Model 5). Higher scores on CRT are generally associated with better discrimination between likelihoods of events (confirmation of *H.1*).

Individuals' display of higher a-insensitivity under strategic ambiguity (Li et al., 2020) implies that better performance on CRT is less predictive of lower a-insensitivity under strategic ambiguity than under social ambiguity (*H.4*). That is, because of the more complex nature of strategic ambiguity, the positive impact of higher reflection on a-insensitivity is smaller under strategic ambiguity, translating into a positive interaction coefficient for *Strategic ambiguity X CRT scores*. Results, however, show no significant differences between the impact of CRT scores on a-insensitivity under social and strategic ambiguity, disconfirming this hypothesis.

Although no differences were found in the impact of cognitive reflection on *a* between the social and strategic ambiguity treatment groups, heterogeneities were found between nature and social ambiguity sources. A stronger inverse relationship is expected between CRT scores and a-insensitivity under nature and social ambiguity than under strategic ambiguity (*H.5*) due to reports of relatively higher a-insensitivity resulting from strategic ambiguity (Li et al., 2020). Table 11 only reports significant differences between the effect of scores on *a* under nature and social ambiguity when interactions are included and in the absence of controls and demographics. According to Table 11, higher cognitive reflection is associated with higher a-insensitivity under social ambiguity than under nature ambiguity, which implies that the negative relationship between CRT scores and individuals' discriminatory power between likelihood of events is stronger for nature ambiguity than under social ambiguity. No significant differences were found between strategic and nature ambiguity. This contradicts predictions of stronger effect under strategic ambiguity than under nature and social ambiguity (*H.5*).

Unlike ambiguity aversion, cognitive uncertainty only has a significant relationship with *a* under social and strategic ambiguity (Table 10) once interactions and demographics are added to the analysis. According to Enke and Graeber (2019), the more uncertain a decision-maker is, the more incapable he is of correctly translating probabilistic information into an appropriate response. Therefore, it is predicted that decision-makers displaying higher cognitive uncertainty also display higher a-insensitivity (*H.6*). However, contrary to *H.6* and *H.8*, higher levels of cognitive uncertainty led to larger *a* under social and strategic ambiguity (Models 5-6).

Despite predictions of negative associations between WST scores and *a (H.9)*, similar to ambiguity aversion, no significant relationships were found for any of the ambiguity sources. Deductive reasoning skills (as measured by performance in the selection tasks) were only significant in the absence of treatment dummies, interactions and demographics and controls (Model 1). Heterogeneities in the relationship across sources were also not witnessed (contrary to *H.11*).

Li et al. (2020) reported higher levels of a-insensitivity for strategic ambiguity than under nature and social ambiguity. However, my data did not depict any differences in a-insensitivity across treatment groups. None of the treatment dummies of Tables 10-11 were significant at the 5% significance level.

### 4.5. Robustness

To account for the robustness of my results, alternative models were estimated using various other scoring systems of CRT and WST. These measures were as follows:

In place of normalized CRT scores, robustness checks utilized either (i) actual (non-normalized) CRT scores, or they (ii) placed subjects into CRT high and low groups:

i. Actual CRT scores ranged from 0 to 3. Subjects were placed into one of four categories based on their scores. Any inferences made about the relationship between CRT scores and ambiguity attitudes were relative to the reference category (scoring 0 on the test).

**Table 10** Ambiguity attitude indices and cognitive abilities for strategic uncertainty

| | *Ambiguity aversion* | | | | | | | *A-insensitivity* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [1] | [2] | [3] | [4] | [5] | [6] | [7] |
| Strategic ambiguity | | | -0.0899 | -0.0813 | -0.0390 | -0.0227 | -0.00468 | | | 0.0388 | -0.018 | 0.467 | 0.313 | 0.317 |
| | | | (0.0795) | (0.0933) | (0.191) | (0.216) | (0.209) | | | (0.109) | (0.117) | (0.296) | (0.313) | (0.328) |
| CRT scores (normalized) | -0.00433 | 0.0623 | 0.0419 | 0.108 | 0.548** | 0.888*** | 0.890*** | 0.0121 | -0.218 | 0.00867 | -0.219 | 0.193 | -0.0403 | -0.073 |
| | (0.120) | (0.146) | (0.121) | (0.163) | (0.232) | (0.218) | (0.208) | (0.140) | (0.155) | (0.140) | (0.157) | (0.198) | (0.207) | (0.230) |
| WST scores (normalized) | 0.0147 | -0.0404 | 0.0227 | -0.0428 | -0.0575 | -0.120 | -0.178 | -0.0558 | 0.182 | -0.0758 | 0.192 | -0.226 | -0.0479 | 0.0560 |
| | (0.0827) | (0.111) | (0.0802) | (0.110) | (0.124) | (0.163) | (0.163) | (0.180) | (0.178) | (0.185) | (0.189) | (0.244) | (0.257) | (0.439) |
| Cognitive uncertainty | 0.348** | 0.531*** | 0.400** | 0.583*** | 0.160 | 0.198 | 0.369* | 0.380* | 0.321 | 0.358 | 0.333 | 0.646** | 0.716** | 0.622 |
| | (0.169) | (0.173) | (0.182) | (0.182) | (0.150) | (0.151) | (0.192) | (0.224) | (0.289) | (0.234) | (0.290) | (0.266) | (0.335) | (0.381) |
| Strategic X CU | | | | | -0.371 | -0.641** | -0.655** | | | | | -0.647 | -0.566 | -0.521 |
| | | | | | (0.344) | (0.308) | (0.298) | | | | | (0.450) | (0.508) | (0.534) |
| Strategic X CRT scores | | | | | 0.170 | 0.231 | 0.289 | | | | | -0.363 | -0.253 | -0.188 |
| | | | | | (0.159) | (0.185) | (0.181) | | | | | (0.282) | (0.301) | (0.322) |
| Strategic X WST scores | | | | | -0.238 | -0.253 | -0.465* | | | | | 0.204 | 0.158 | 0.0484 |
| | | | | | (0.241) | (0.228) | (0.248) | | | | | (0.367) | (0.377) | (0.538) |
| Constant | -0.0812 | -0.0604 | -0.0660 | -0.0512 | -0.0692 | 0.123 | 3.20e-05 | 0.135 | 0.0627 | 0.129 | 0.0647 | -0.0503 | 0.0259 | -0.084 |
| | (0.0807) | (0.254) | (0.0774) | (0.252) | (0.0942) | (0.230) | (0.302) | (0.147) | (0.361) | (0.149) | (0.361) | (0.187) | (0.331) | (0.476) |
| Observations | 85 | 70 | 85 | 70 | 85 | 70 | 70 | 85 | 70 | 85 | 70 | 85 | 70 | 70 |
| R-squared | 0.069 | 0.278 | 0.086 | 0.291 | 0.118 | 0.342 | 0.415 | 0.040 | 0.145 | 0.041 | 0.145 | 0.082 | 0.233 | 0.268 |
| Demographics | NO | YES | NO | YES | NO | YES | YES | NO | YES | NO | YES | NO | YES | YES |
| Controls | NO | YES | NO | YES | NO | NO | YES | NO | YES | NO | YES | NO | NO | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

**Table 11** Ambiguity attitude indices and cognitive abilities for all ambiguity treatments

| | *Ambiguity aversion* | | | | | | | *A-insensitivity* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [1] | [2] | [3] | [4] | [5] | [6] | [7] |
| Social ambiguity | | | -0.0564 | -0.0781 | -0.28** | -0.312* | -0.334* | | | -0.0386 | 0.00955 | -0.461* | -0.305 | -0.358 |
| | | | (0.0719) | (0.0806) | (0.133) | (0.163) | (0.168) | | | (0.104) | (0.107) | (0.258) | (0.296) | (0.313) |
| Strategic ambiguity | | | -0.117* | -0.112 | -0.317* | -0.353* | -0.358** | | | 0.0179 | 0.0418 | 0.00587 | 0.00743 | -0.0416 |
| | | | (0.0685) | (0.0733) | (0.190) | (0.178) | (0.174) | | | (0.108) | (0.111) | (0.290) | (0.308) | (0.310) |
| Cognitive uncertainty | -0.0221 | -0.0733 | 0.0125 | -0.0399 | -0.0822 | -0.0827 | -0.100 | -0.0865 | -0.0532 | -0.110 | -0.0723 | 0.326 | 0.0707 | -0.0839 |
| | (0.115) | (0.126) | (0.117) | (0.135) | (0.223) | (0.157) | (0.157) | (0.188) | (0.217) | (0.195) | (0.230) | (0.278) | (0.275) | (0.270) |
| CRT scores (normalized) | -0.0320 | -0.0258 | -0.0266 | -0.0270 | -0.0436 | -0.00147 | -0.00619 | -0.140 | -0.211* | -0.141 | -0.210* | -0.39** | -0.301 | -0.264 |
| | (0.0689) | (0.0767) | (0.0679) | (0.0766) | (0.132) | (0.110) | (0.114) | (0.104) | (0.112) | (0.104) | (0.114) | (0.160) | (0.195) | (0.193) |
| WST scores (normalized) | 0.191 | 0.336** | 0.194 | 0.341** | -0.127 | -0.472* | -0.466* | 0.324** | 0.190 | 0.302* | 0.179 | -0.353 | -0.590 | -0.784 |
| | (0.133) | (0.136) | (0.146) | (0.149) | (0.320) | (0.271) | (0.272) | (0.159) | (0.196) | (0.166) | (0.193) | (0.496) | (0.583) | (0.568) |
| Strategic X CU | | | | | 0.260 | 0.320 | 0.324 | | | | | -0.327 | -0.0643 | 0.0580 |
| | | | | | (0.338) | (0.271) | (0.266) | | | | | (0.458) | (0.462) | (0.498) |
| Social X CU | | | | | 0.631* | 0.933*** | 0.955*** | | | | | 0.320 | 0.546 | 0.581 |
| | | | | | (0.322) | (0.257) | (0.250) | | | | | (0.384) | (0.414) | (0.436) |
| Social X CRT scores | | | | | -0.0139 | -0.118 | -0.149 | | | | | 0.585** | 0.235 | 0.174 |
| | | | | | (0.181) | (0.189) | (0.193) | | | | | (0.254) | (0.298) | (0.311) |
| Strategic X CRT scores | | | | | 0.156 | 0.109 | 0.129 | | | | | 0.223 | 0.0295 | 0.0181 |
| | | | | | (0.165) | (0.155) | (0.158) | | | | | (0.256) | (0.280) | (0.277) |
| Social X WST scores | | | | | 0.287 | 0.724** | 0.797** | | | | | 0.126 | 0.561 | 0.977 |
| | | | | | (0.354) | (0.317) | (0.324) | | | | | (0.553) | (0.642) | (0.686) |
| Strategic X WST scores | | | | | 0.0493 | 0.450 | 0.407 | | | | | 0.330 | 0.617 | 0.815 |
| | | | | | (0.372) | (0.344) | (0.328) | | | | | (0.566) | (0.638) | (0.625) |
| Constant | 0.0287 | 0.110 | 0.0784 | 0.124 | 0.209** | 0.278 | 0.284 | 0.250** | 0.00587 | 0.269** | 0.00574 | 0.411** | 0.215 | 0.0734 |
| | (0.0622) | (0.207) | (0.0772) | (0.204) | (0.0940) | (0.193) | (0.241) | (0.109) | (0.303) | (0.132) | (0.315) | (0.177) | (0.329) | (0.389) |
| Observations | 127 | 106 | 127 | 106 | 127 | 106 | 106 | 127 | 106 | 127 | 106 | 127 | 106 | 106 |
| R-squared | 0.029 | 0.177 | 0.050 | 0.198 | 0.109 | 0.340 | 0.374 | 0.053 | 0.134 | 0.055 | 0.136 | 0.113 | 0.173 | 0.226 |
| Demographics | NO | YES | NO | YES | NO | YES | YES | NO | YES | NO | YES | NO | YES | YES |
| Controls | NO | YES | NO | YES | NO | NO | YES | NO | YES | NO | YES | NO | NO | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

ii. Individuals with CRT scores of 2 and over were placed into the high CRT group and those with scores lower than 2 in the low CRT group. To measure for cognitive reflection, a dummy variable was added to the model, taking value 1 when individuals were in the high CRT group and 0 when they were in the low group. Inferences made using this variable were relative to the low CRT group.

As an alternative to normalized scores on WST, either (i) subjects' answers to each of the WSTs were used or (ii) their insights on each task:

i. Dummy variables were generated for each of the selection tasks that took value 1 when the subject correctly answered the task and 0 otherwise. Inferences made using these dummies were relative to reference categories (not answering the task correctly). Each subject had three dummies for WST.

ii. Subjects were assigned to insight groups based on their responses to the selection tasks, following Table 6. Three categorical variables were generated for WST. Each variable had three categories: full insight, partial insight, and lack of any insight. Inferences made about the relationship between subjects' performance on WST and their ambiguity attitudes were relative to the reference category, namely having full insight.

For each of the ambiguity attitude components, four robustness models were estimated (Appendix C & D). The findings of one particular robustness check (Appendix E) will be discussed in depth. The estimation results for other robustness models were mainly similar to the regression results in Tables 9-13. Coefficients differ slightly, but most of the main patterns remain:

All models except one (Tables C.1.3 & C.2.3) showed that higher cognitive uncertainty led to higher ambiguity aversion for all ambiguity sources, under social ambiguity more so than under nature ambiguity and under strategic ambiguity more so than under social ambiguity; performance on WST 1 and 4 led to lower and higher ambiguity aversion, respectively; better performance on WSTs was correlated with higher ambiguity aversion under social ambiguity than under nature ambiguity and under strategic ambiguity than under nature ambiguity. As for a-insensitivity: performance on CRT was negatively related to a-insensitivity, with its effect being weaker under social ambiguity than under nature ambiguity; cognitive uncertainty was positively associated with $a$; and performance on WST failed to significantly relate to individuals' a-insensitivity under all ambiguity treatments.

Appendix E examines the relationship between individuals' normalized cognitive uncertainty levels, CRT scores and WST insight categories and their ambiguity attitudes. Model 1 includes subjects' measures of cognitive ability and a treatment variable as explanatory variables. Model 2 also includes demographics and controls. Models 3 adds interactions between measures of cognitive ability and treatment groups, and Model 4 completes Model 3 by adding demographics and controls.

### *Ambiguity Aversion Index (b)*

Main findings indicated small influence of cognitive reflection on ambiguity aversion under social and strategic ambiguity, only with the inclusion of interaction terms. Table E.1.1 also indicates little impact of CRT scores on *b* under social and strategic ambiguity (Model 4). Only when interactions and demographics and controls are accounted for (Model 4) does scoring 1 compared to null on CRT lead to lower ambiguity aversion (support of *H.1*).

Further supporting the main results, a consistently significant positive relationship was found between cognitive uncertainty and *b*. Although main results only indicated the effect of cognitive uncertainty in the absence of interactions and demographics and controls, Models 1-4 of Table E.1.1 show that higher cognitive uncertainty is consistently linked to individuals shying away from both social and strategic ambiguity (confirming *H.6*). Differences were also found when interactions and demographics and controls were included in the model (Model 4): higher cognitive uncertainty resulted in less ambiguity aversion under strategic ambiguity than under social ambiguity.

Main regression results also indicated little relationship between WST scores and ambiguity attitudes under any of the ambiguity sources. In the absence of interactions and demographics and controls (Model 1), relationships were found between deductive reasoning and ambiguity aversion under social and strategic ambiguity. Having partial or lack of insight compared to full insight on WST 1 was shown to result in higher *b* under social and strategic ambiguity (supporting *H.9*) while having partial or lack of insight on WST 4 in lower *b* (contrary to *H.9*). The relationship between lack of insight on WST 1 persisted with the introduction of interactions (Model 3) but lost significance when demographics and controls were added (Model 2 & 4), while the effect of having partial insight was only significant in the absence of interactions and demographics and controls. The association between having partial or lack of insight on WST 4 remained when demographics and controls were added (Model 2) but only differences between having partial and full insight remained significant under Model 3. This relation also faded when demographics and controls were added to the model (Model 4).

When interactions between cognitive ability and ambiguity treatments were added to the analysis (Model 3), differences were found between performance on the selection task under strategic ambiguity: those with partial or lack of insight were shown to have higher ambiguity aversion compared to those with full insight under strategic ambiguity.

Similar patterns were found when all ambiguity sources were accounted for, with the exception of cognitive reflection. Table E.1.2 depicts no significant relationships between *b* under nature, social and strategic ambiguity, and performance in CRT (contrary to *H.1* & *H.3*). Cognitive uncertainty is also related to *b* under all ambiguity sources only when demographics are included in the analysis and interactions excluded (Model 2). Despite prevalent insignificance of the impact of cognitive uncertainty on ambiguity aversion (disconfirming *H.4*), heterogeneities are found in its effect across ambiguity sources: higher cognitive uncertainty is associated with higher ambiguity aversion under social ambiguity than under nature ambiguity. This is opposite to predictions in *H.3*.

Relationships found in Table E.1.1 were also partly present when all ambiguity treatments were examined. No significant relationships were found between *b*_under nature, social and strategic ambiguity and having lack of insight on WSTs compared to full insight. However, having partial as opposed to full insight on WST 3 was found to significantly increase *b* when interactions were not included in the analysis (Model 2). With adding interactions, having partial insight compared to full insight on WST 1 led to higher level of *b* in the absence of controls and demographics (Model 3); having partial insight compared to full insight on WST 4 led to higher level of *b* when controls and demographics are also included (Model 4). In both cases, having partial or lack of insight compared to full insight on WST 4 led to lower ambiguity aversion under strategic ambiguity (Models 3-4). That is, those with lower deductive reasoning skills (as measured by the selection tasks) were more ambiguity averse under strategic ambiguity than under those with better performance on the tasks.

Similar to prior results, Table E.1.2 fail to show significant differences in ambiguity aversion across different ambiguity treatments at 5% significance level.

### *A-insensitivity Index (a)*

Similar to previous findings, Table E.2.1 shows the negative impact of cognitive reflection on *a* (support of *H.1*). When interactions are included in the analysis and in the absence of demographics and controls (Model 3), scoring 1 on CRT is linked to a smaller *a* under social and strategic ambiguity compared to scoring 0. With the inclusion of demographics and controls, this relation loses significance. No relationships were found between *a* and other CRT scores (i.e., CRT=2-3). Furthermore, no differences were found in the effect of cognitive reflection on a-insensitivity across social and strategic ambiguity, disconfirming *H.4*.

Table E.2.1 depicts no significant relationships of cognitive uncertainty and deductive reasoning on *a*. Cognitive uncertainty is only found to have a significant effect on a-insensitivity under social and strategic ambiguity when interactions are included in the model and demographics and controls are excluded (Model 3). In this case, higher cognitive uncertainty is linked to higher a-insensitivity, which supports *H.4*. No differences are found in this effect across ambiguity treatments.

Table E.2.2 illustrates similar relationships when all ambiguity sources are considered (nature, social and strategic ambiguity). In the absence of demographics and controls (Table E.2.2, Models 1 & 3), having a score of 1 or 3 on CRT leads to lower a-insensitivity compared to scoring 0 (support of *H.1*). This relationship also holds for a score of 2 when interactions are included in the analysis (Models 3-4). With the inclusion of demographics and controls, the relationship between *a* and CRT=3 remains significant but that with CRT=1 loses significance.

Differences in the effect of cognitive reflection are witnessed in the absence of demographics and controls (Model 3). Scoring 2 or 3 on CRT is shown to result in higher levels of a-insensitivity under social ambiguity than under nature ambiguity. This relation partially confirms *H.5*.

No significant relationships were found for cognitive uncertainty (in contrast to *H.6* & *H.8*) and deductive reasoning (contrary to *H.9* & *H.11*) and cognitive uncertainty. Cognitive uncertainty only showed a positive association with a-insensitivity under all ambiguity sources in the absence of interactions and demographics and controls (Model 1). Similar to main results, no significant differences were found in *a* across ambiguity treatments.

# 5. Discussion and Conclusion

Cognitive ability has been shown to be a determinant of individuals' decision-making under uncertainty. Many studies on the effect of cognitive ability on decision-making under uncertainty have so far focused on artificial and natural sources of ambiguity. While relevant, uncertainty in the real world is not limited to these sources of ambiguity. Rather, big sources of ambiguity in the real world include social and strategic interactions.

This study investigated the relationship between people's cognitive ability and ambiguity attitudes. The current study is the first to measure this relationship for strategic uncertainty and compare it with nature uncertainty. Using the measurement method of Baillon et al. (2018), I measured individuals' ambiguity attitudes under three sources of ambiguity and examined the effects of three cognitive measures on them.

Findings on ambiguity attitudes were comparable to those of Li et al. (2020). Although non-parametric tests found no differences between ambiguity attitudes across ambiguity sources, regression results did indicate differences in the motivational component of ambiguity attitudes caused by the ambiguity source: ambiguity aversion was found to be lower under social and strategic ambiguity than under nature ambiguity. Results failed to show differences in cognitive a-insensitivity across ambiguity treatments.

This study found effects of two out of three measures of cognitive ability on each component of ambiguity attitudes. Individuals' reliance on their System 2 process was found to be negatively related to their ambiguity aversion and a-insensitivity. However, relationships between cognitive reflection and both components of ambiguity attitudes were limited to particular scores on CRT, implying the non-linear effect of this cognitive ability on ambiguity attitudes. Moreover, the impact of performance on CRT on ambiguity aversion was only significant under social and strategic ambiguity, and not under nature ambiguity. Nonlinear effects of cognitive ability on ambiguity attitudes under social and strategic ambiguity suggest evidence against a dual system theory view for social and strategic interactions. This conclusion is supported by Nagel et al. (2018).

Although no differences were found in the impact of cognitive reflection on a-insensitivity under social and strategic ambiguity, higher CRT scores were found to lead to higher a-insensitivity under social ambiguity than under nature ambiguity: scoring of 2 or 3 points on CRT led to higher a-insensitivity under social ambiguity compared to null points. One explanation for this may be that difficulty in understanding resulting from the social ambiguity treatment hinders the positive influences of cognitive reflection. Another hypothesis could be that people with higher cognitive ability tend to overestimate their abilities in social interactions and fail to sufficiently discriminate between likelihoods of events. Overconfidence has previously been linked to ambiguity seeking behaviour (Gutierrez et al., 2020; Schroder, 2011; Shyti, 2013). However, the literature on the effect of overconfidence does not discuss a-insensitivity. Future studies could examine the plausibility of this hypothesis by investigating the influence of overconfidence and cognitive ability on behaviour in ambiguous social settings.

This study is among the first to examine the relationship of cognitive uncertainty with ambiguity attitudes. Results confirm Enke and Graeber's (2019) previous findings of a positive relationship with a-insensitivity, but only under social and strategic ambiguity and not under nature ambiguity. A-insensitivity under nature ambiguity was independent of individuals' uncertainty, implying that the finding of a-insensitivity in Ellsberg-like experiments (Trautmann & van de Kuilen, 2015) did not reflect cognitive uncertainty. A-insensitivity in social and strategic situations, on the other hand, was partly driven by individuals' subjective uncertainty in their partners' actions and their optimal responses.

In addition to associations with the cognitive component of ambiguity attitudes, cognitive uncertainty was also shown to be positively associated with motivational dislike of ambiguity under strategic and social ambiguity. One interesting finding was that cognitive uncertainty had a stronger inhibitory impact on ambiguity aversion under social ambiguity than under nature ambiguity. A potential explanation could be the competence hypothesis (Heath & Tversky, 1991): people prefer sources of uncertainty over which they feel more competent over the ones which they feel less competent over. In this case, people may have felt more confident about their understanding of nature ambiguity than their understanding of the midday-snack scenario. What seems paradoxical, though, is that individuals reported higher cognitive uncertainty under nature uncertainty than under social uncertainty (Fig. 11). Cognitive uncertainty is a direct measure of individuals' subjective confidence about their probability estimation of a particular event (Enke & Graeber, 2019). The higher the confidence interval, the less confident individuals are about their estimation. Thus, for the competence hypothesis to explain this finding, either average cognitive uncertainty levels would need to be higher under social ambiguity, or there would exist a gap between individuals perceived competence and subjective confidence in decisions. Future studies are needed to investigate the reasons behind this difference in impact between sources of uncertainty.

Taking performance on WST as a measure of deductive reasoning, individual's reasoning ability was inversely associated with their level of ambiguity aversion. However, a closer look at differences in performance on individual questions and ambiguity aversion paints different pictures for different questions. Demonstrating higher deductive reasoning skills on the first selection task was related to displaying lower levels of ambiguity aversion, while it was linked to higher aversion for the fourth task. The underlying cognitive processes underlying choices in WST may help justify this finding. Choices in the selection task can be produced by different cognitive processes. They may reflect respondents' reasoning or simply their matching of a card to an element of the rule. For example, choosing card P may either be due to correct reasoning or it may reflect a matching strategy; choosing card Q may reflect an incorrect matching strategy or a reasonable biconditional interpretation of the rule; not selecting of card P' may be because of failure of matching to the elements of the rule or valid reasoning; non-selection of card Q' may indicate failure to matching to the rule element, which implies successful deduction, or it may reflect failure to carry out the required reasoning (Cutmore et al., 2015). Negations were permuted in the fourth selection task, and a common strategy in dealing with negative components in the selection task is the matching bias (Evans, 1998). Following a matching strategy to answer the fourth task would lead to subjects with lower reasoning skills answering the task correctly. Scores on the first and fourth question, therefore, are not comparable in terms of cognitive load, and findings indicate that those with superior deductive reasoning skills (reasoners correctly answering the first task) do display more rational behaviour under uncertainty, in the form of lower ambiguity aversion.

### *Limitations*

Although the findings of this study are informative, it is important to note that the sample pool of this research does not guarantee external validity. This research was conducted using a diverse set of subjects with a nationally disperse population, a wide age range and different levels of education. These findings are likely to differ in meaningful ways from the findings of university student populations or representative household samples.

My findings concerning strategic uncertainty are limited to the source of uncertainty, being the trust game. The ambiguity attitudes found in this study and their relations with cognitive ability are source dependent and only reflect the trust game. Future studies could investigate the impact of cognitive ability on other sources of strategic ambiguity such as coordination or cooperation games.

What is worth mentioning is that subjects may interpret ambiguity treatments in different ways than expected. One may contend that the ambiguity generated in the nature ambiguity treatment of the study was, in reality, partly social ambiguity (Li et al., 2020). This is because of the experiment being designed by human beings. However, in the nature ambiguity treatment, the experimenters (designers) did not have any incentives to mark cards in any certain way or to act with respect to their own interests, while partners in the social ambiguity treatment act according to their own interests.

Moreover, the hypothetical nature of the experiment may have implications on the study's findings. Uncertainty in the real world is often associated with the strategic decision-making of others; any hypothetical strategic ambiguity treatment may be seen as analogous to artificial and nature ambiguity, since the role of a human being in generating uncertainty is not fully experienced. The social and strategic ambiguity generated using the snack-choosing partner scenario and the trust game are of little consequence and may fail to elicit strong and realistic reactions when implemented hypothetically. The hypothetical bias resulting from lack of salience (Hensher, 2010) would explain subjects' lack of discrimination in matching probabilities between the nature, social and strategic ambiguity treatments (Fig. 10). Future replication of this study in a laboratory setting could verify the results. Further, neuroeconomic studies on the differences in neural circuits and brain networks between ambiguous social and strategic interactions would also be helpful in corroborating experimental findings about the impact of various cognitive components on behaviour under uncertainty.

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# Appendices

## Appendix A. Design of Survey Experiment

### A.1. Welcome Message and Informed Consent

Welcome!

This survey is part of my final MSc thesis in Behavioural Economics at Erasmus School of Economics. The survey concerns the impact of cognitive components on individuals' choice under uncertainty. Participation in this study is voluntary and completing it will take approximately 12 to 17 minutes. I kindly ask you to answer as truthfully as possible. Please keep in mind that you may withdraw from the survey at any moment you wish to.

At the end of the survey, you will have the opportunity to participate in a lottery to **win one of three €15 Amazon gift cards** by entering your contact details. You need not provide identifying information unless you wish to and responses may be fully anonymous. Any identifying information provided, such as name and email address, and responses will be treated confidentially and will not be traced back to responses.

P.S.: This survey contains a completion code for SurveySwap.io & SurveyCircle users.

*By participating in the survey, you are indicating that you are older than 18 years old, you consent to the consent to survey conditions, and that you understand you can withdraw from the survey at any given point.*

If you have any questions, do not hesitate to contact me at 576857sk@eur.nl.

Thank you in advance for your time and patience.

Sara Kazemi

If you have read the information above and you agree to voluntarily participate in this study, *please indicate your consent below.*

- o Yes, I consent to participation in the study.
- o No, I do not consent, and I will not participate in the study.

### A.2. Explanation of Ambiguity Scenarios

The following sections illustrate the explanation subjects received about the ambiguity treatment-specific scenarios before their ambiguity attitudes were elicited.

#### *A.2.1. Nature Ambiguity*

In the first section of the survey, please consider the following scenario:

Suppose that you are dealt with four cards. You are asked to draw one card out of four cards. Each card is marked with either A, B or C. Please note that you do not know how many of the cards are marked A, B or C.

In the following questions, you will be given a choice between two options. Please indicate the option that you prefer. Please answer with careful consideration.

### *A.2.2. Social Ambiguity*

In the first section of the survey, please consider the following scenario:

Suppose you are paired with a random partner, and he/she chooses your midday snack. He/she can choose one of three following snacks labelled A (savoury party mixture), B (dried apple rings) and C (chocolate bar). Note that all snacks have the same cost and monetary value.

In the following questions, you will be given a choice between two options. Please indicate the option that you prefer. Please answer with careful consideration.

### *A.2.3. Strategic Ambiguity*

In the first section of the survey, please consider the following scenario:

Suppose you are paired with a random partner and your partner can determine how payment is allocated between the two of you. He/she has the following three options:

Option A: That the two of you get **€15 each.**
Option B: That **you** get €**10**, and **he/she** gets €**18**.
Option C: That **you** get **€8**, and **he/she** gets €**22**.

So, if your partner chooses option A, you both get €15. If your partner chooses option B, you get €10, and your partner gets €18. If your partner chooses option C, you get €8, and your partner gets €22.

In the following questions, you will be given a choice between two options. Please indicate the option that you prefer. Please answer with careful consideration.

## A.3. Elicitation of Ambiguity Attitudes

In the following questions, *E* refers to one of the six events, *A*, *B*, *C*, *A* or *B*, *A* or *C*, and *B* or *C*. Matching probabilities were elicited six times. For each of the six events, *x* refers to the probability of receiving €15. Subjects were first given a dichotomous choice between the ambiguous lottery (Option 1) and the risky lottery (Option 2) with $x$=0.5. Four-step bisection was used to elicited matching probabilities. Thus, *x* was adjusted in each subsequent question, with the size of the adjustment shrinking from +/-0.24 to +/-0.12 and +/-0.06.

### *A.3.1. Nature Ambiguity*

**Question 1-4:** Suppose that you are dealt with four cards. You are asked to draw one card out of four cards. Each card is marked with either A, B or C. Please note that you do not know how many of the cards are marked A, B or C.

You can choose one of the following two options:

Option 1: Get €**15** if your partner chooses ***E*** and €**0** otherwise.
Option 2: Get €**15** with ***x***% chance and €**0** otherwise.

Which option would you choose?

- Option 1
- Option 2

### *A.3.2. Social Ambiguity*

**Question 1-4:** Suppose you are paired with a random partner, and he/she chooses your midday snack. He/she can choose one of three following snacks labelled A (savoury party mixture), B (dried apple rings) and C (chocolate bar). Note that all snacks have the same cost and monetary value.

You can choose one of the following two options:

Option 1: Get €**15** if your partner chooses ***E*** and €**0** otherwise.
Option 2: Get €**15** with ***x***% chance and €**0** otherwise.

Which option would you choose?

- Option 1
- Option 2

### *A.3.3. Strategic Ambiguity*

**Question 1-4:** Suppose you are paired with a random partner and your partner can determine how payment is allocated between the two of you. He/she has the following three options:

Option A: That the two of you get **€15 each.**
Option B: That **you** get €**10**, and **he/she** gets €**18**.
Option C: That **you** get €**8**, and **he/she** gets €**22**.

So, if your partner chooses option A, you both get €15. If your partner chooses option B, you get €10, and your partner gets €18. If your partner chooses option C, you get €8, and your partner gets €22.

You can choose one of the following two options:

Option 1: Get €**15** if your partner chooses ***E*** and €**0** otherwise.
Option 2: Get €**15** with ***x***% chance and €**0** otherwise.

Which option would you choose?

- Option 1
- Option 2

## A.4. Cognitive Uncertainty

After being presented with Questions 1-4, subjects are asked the following question. This question is asked for each of the six events.

**Question 5:** Recall that you are paired with a random partner that chooses payment allocation between the two of you. He/she has the following three options:

Option A: That the two of you get **€15 each.**
Option B: That **you** get €**10**, and **he/she** gets €**18**.
Option C: That **you** get €**8**, and **he/she** gets €**22**.

You can choose one of the following two options:

Option 1: Get €**15** if your partner chooses ***E*** and €**0** otherwise.
Option 2: Get €**15** with ***x***% chance and €**0** otherwise.

Please indicate the value of *a* and *b* on the sliders.

*I am certain that to me* ***option 1*** *is* ***worth as much as*** *getting €15 with probability* ***x*** *between* ***a%*** *and* ***b%****.*

| | 0 10 20 30 40 50 60 70 80 90 100 |
|---|---|
| a% | |
| b% | |

This is an example from the strategic ambiguity treatment. The brief explanation at the beginning of the question differs among treatments.

## A.5. English Fluency

**Question 6:** How fluent is your English? Please rate your level of fluency on a scale of 0 to 10, 0 being not at all fluent and 10 being perfectly fluent.

| | 0 1 2 3 4 5 6 7 8 9 10 |
|---|---|
| English Proficiency | |

## A.6. General Happiness

**Question 7:** Please rate how happy you feel in general on a scale of 0 to 10, 0 being not at all happy and 10 being perfectly happy.

| | 0 1 2 3 4 5 6 7 8 9 10 |
|---|---|
| Level of happiness | |

## A.7. General Trust Level

**Question 8-10:**

1. Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people
   - Most people can be trusted.
   - You can't be too careful.
2. Would you say that most of the time, people try to be helpful, or that they are mostly just looking out for themselves?
   - Try to be helpful.
   - Just looking out for themselves.
3. Do you think that most people would try to take advantage of you if they got the chance or would they try to be fair?
   - Take advantage.
   - Try to be fair.

## A.8. Siblings

**Question 11:** How many siblings do you have? Please answer 0 if you do not have any.

## A.9. Alcohol

**Question 12:** On average, how many glasses of alcohol do you consume per week?

## A.10. Cognitive Reflection Test

### *A.10.1. Explanation of task*

This section of the survey entails you responding to three problems. Please answer these questions in number (e.g., 10, 20, etc) and refrain from entering text in the box (e.g., ten, twenty, etc).

### *A.10.2. Test*

**Question 13-16:**

1. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? _____ cents
2. If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets? _____ minutes
3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? _____ days

**Question 17:** Did you have previous experience with these questions?

- Yes
- No

## A.11. Wason Selection Task

### *A.11.1. Explanation of task*

This section of the survey entails you having to tackle four problems. Each problem consists of four cards and a rule that applies to those cards. This rule may be true or false. The cards have been constructed so that **each one always has a letter on one side and a single figure on the other side.**

Only one side of each card will be visible to you. For each problem, you will need to decide **which card or cards need to be turned over to discover whether the rule is true.**

### *A.11.2. Problems*

**Question 18-22:**

1. Consider the following rule and four cards (7, J, A and 3):

***Rule: If a card has A on one side, then it has 3 on the other side.***

Recall that each card always has a letter on one side and a single figure on the other side. **Please indicate the card(s) that need to be turned over to discover whether the rule is true.**

- 7
- J
- A
- 3

2. Consider the following rule and four cards (5, L, E, and 2):

***Rule: If a card has E on one side, then it does not have 5 on the other side.***

Please indicate the card(s) that need to be turned over to discover whether the rule is true.

- 5
- L
- E
- 2

3. Consider the following rule and four cards (4, S, 9, and D)

***Rule: If a card doesn't have S on one side, then it has 9 on the other side.***

Please indicate the card(s) that need to be turned over to discover whether the rule is true.

- 4
- S
- 9
- D

4. Consider the following rule and four cards (N, 8, T, and 1):

***Rule: If a card doesn't have N on one side, then it does not have 8 on the other side.***

Please indicate the card(s) that need to be turned over to discover whether the rule is true.

- N
- 8
- T
- 1

**Question 23:** Did you have previous experience with this task?

- Yes
- No

## A.12. Demographics

### *A.12.1. Age*

**Question 24:** Please indicate your age in the text box.

### *A.12.2. Highest Education Level*

**Question 25:** What is your highest achieved level of education?

- High School
- Secondary Vocational Education and Training (MBO)
- Higher Professional Education (HBO)
- Bachelor's Degree (WO)
- Master's Degree (WO+)
- PhD

### *A.12.3. Gender*

**Question 26:** Please indicate your gender.

- Female
- Male
- Other
- Prefer not to say

### *A.12.4. Studentship*

**Question 27:** Are you currently a university student?

- Yes
- No

### *A.12.5. Nationality*

**Question 28:** Please indicate your country of nationality (with drop-down menu).

## A.13. Participation in the Raffle

You have the chance to enter the lottery to be one of three winners to a **€15 Amazon gift card.** Please enter your name and e-mail address below if you wish to enter.

*Note that your identifying information will be deleted as soon as winners are chosen and your responses to survey questions will not be traced to your identifying information.*

## A.14. Debriefing

Thank you for your participation.

The purpose of this study is to examine the relationship between individuals' cognitive abilities and ambiguity attitudes. You were asked a number of questions that measured the level of cognitive noise, deductive reasoning, and cognitive reflection. You were also randomly placed into one of three treatment groups: nature ambiguity, social ambiguity, and strategic ambiguity. Subjects in the nature ambiguity group were asked to consider four cards, each of which was marked with either A, B or C; subjects in the social ambiguity group were asked to imagine that a random partner selected their midday snack; subjects in the strategic ambiguity group were asked to imagine that a random partner allocated money between the two of them. Consequently, you were asked to choose between ambiguous and risky lotteries. These responses are used to measure ambiguity attitudes.

Your answer has been recorded. For further questions or comments, please contact me at 576857sk@eur.nl.

I would greatly appreciate it if you shared the survey.

## Appendix B. Summary Statistics

**Table B.1.** Summary statistics on nationality

| *Nationality* | Freq. | Percent |
|---|---|---|
| Australia | 2 | 1.67 |
| Austria | 2 | 1.67 |
| Belgium | 3 | 2.50 |
| Canada | 1 | 0.83 |
| China | 3 | 2.50 |
| Colombia | 1 | 0.83 |
| Croatia | 2 | 1.67 |
| Finland | 1 | 0.83 |
| France | 2 | 1.67 |
| Germany | 4 | 3.33 |
| Greece | 3 | 2.50 |
| Iceland | 1 | 0.83 |
| India | 1 | 0.83 |
| Iran | 37 | 30.83 |
| Ireland | 2 | 1.67 |
| Italy | 4 | 3.33 |
| Japan | 1 | 0.83 |
| Luxembourg | 1 | 0.83 |
| Netherlands | 28 | 23.33 |
| Norway | 3 | 2.50 |
| Peru | 1 | 0.83 |
| Romania | 1 | 0.83 |
| Russian Federation | 3 | 2.50 |
| Switzerland | 1 | 0.83 |
| Turkey | 1 | 0.83 |
| United Kingdom of Great Britain and Northern Ireland | 8 | 6.67 |
| United States of America | 3 | 2.50 |

**Table B.2.** Summary statistics on education

| *Highest education level* | Freq. | Percent |
|---|---|---|
| Bachelor's Degree (WO) | 51 | 40.16 |
| High School | 5 | 3.94 |
| Higher Professional Education (HBO) | 3 | 2.36 |
| Master's Degree (WO+) | 41 | 32.28 |
| PhD | 25 | 19.69 |
| Secondary Vocational Education and Training (MBO) | 2 | 1.57 |

## Appendix C. Robustness Checks for Ambiguity Aversion

### C.1. Strategic and Social Ambiguity

#### *C.1.1. High and Low CRT Groups*

**Table C.1.1.** Ambiguity aversion and CRT groups

| *Dependent variable= Ambiguity aversion* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Strategic ambiguity | | | -0.0889 | -0.0815 |
| | | | (0.0798) | (0.0966) |
| WST scores (normalized) | -0.00238 | 0.0428 | 0.0460 | 0.0916 |
| | (0.117) | (0.146) | (0.117) | (0.164) |
| CRT group (high= 1) | 0.0116 | -0.00358 | 0.0137 | -0.0115 |
| | (0.0723) | (0.104) | (0.0711) | (0.107) |
| Cognitive uncertainty (normalized) | 0.349** | 0.534*** | 0.399** | 0.585*** |
| | (0.171) | (0.177) | (0.184) | (0.183) |
| Constant | -0.0802 | -0.0785 | -0.0618 | -0.0683 |
| | (0.0831) | (0.258) | (0.0778) | (0.257) |
| Observations | 85 | 70 | 85 | 70 |
| R-squared | 0.069 | 0.276 | 0.086 | 0.289 |
| Demographics | NO | YES | NO | YES |
| Controls | NO | YES | NO | YES |

| | Model 5 | Model 6 | Model 7 |
|---|---|---|---|
| Strategic ambiguity | -0.0390 | -0.0227 | -0.00468 |
| | (0.191) | (0.216) | (0.209) |
| Cognitive uncertainty (normalized) | 0.548** | 0.888*** | 0.890*** |
| | (0.232) | (0.218) | (0.208) |
| CRT group (high= 1) | -0.0575 | -0.120 | -0.178 |
| | (0.124) | (0.163) | (0.163) |
| WST scores (normalized) | 0.160 | 0.198 | 0.369* |
| | (0.150) | (0.151) | (0.192) |
| Strategic ambiguity X Cognitive uncertainty | -0.371 | -0.641** | -0.655** |
| | (0.344) | (0.308) | (0.298) |
| Strategic ambiguity X CRT group (high= 1) | 0.170 | 0.231 | 0.289 |
| | (0.159) | (0.185) | (0.181) |
| Strategic ambiguity X WST scores | -0.238 | -0.253 | -0.465* |
| | (0.241) | (0.228) | (0.248) |
| Constant | -0.0692 | 0.123 | 3.20e-05 |
| | (0.0942) | (0.230) | (0.302) |
| Observations | 85 | 70 | 70 |
| R-squared | 0.118 | 0.342 | 0.415 |
| Demographics | NO | YES | YES |
| Controls | NO | NO | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

#### *C.1.2. Correct Responses to WST and CRT Scores*

**Table C.1.2.** Ambiguity aversion and CRT and WST scores

| *Dependent variable: ambiguity aversion* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Strategic ambiguity | | | -0.122 | -0.134 |
| | | | (0.0772) | (0.0950) |
| Correct answer to WST.1 (=1) | -0.254** | -0.139 | -0.238** | -0.0585 |
| | (0.108) | (0.108) | (0.108) | (0.103) |
| Correct answer to WST.3 (=1) | -0.119 | -0.150 | -0.127 | -0.161 |
| | (0.102) | (0.104) | (0.0933) | (0.105) |
| Correct answer to WST.4 (=1) | 0.292** | 0.293** | 0.341*** | 0.340** |
| | (0.118) | (0.118) | (0.127) | (0.133) |
| CRT score=1 | -0.111 | -0.235* | -0.104 | -0.237* |
| | (0.116) | (0.123) | (0.105) | (0.129) |
| CRT score=2 | -0.0465 | -0.0450 | -0.0497 | -0.0238 |
| | (0.103) | (0.145) | (0.104) | (0.162) |
| CRT score=3 | 0.0340 | -0.0338 | 0.0494 | -0.0231 |
| | (0.0864) | (0.117) | (0.0817) | (0.124) |
| Cognitive uncertainty (normalized) | 0.329* | 0.516*** | 0.393** | 0.593*** |
| | (0.173) | (0.182) | (0.177) | (0.180) |
| Constant | -0.0515 | 0.0237 | -0.0274 | 0.0106 |
| | (0.0766) | (0.237) | (0.0776) | (0.261) |
| Observations | 85 | 70 | 85 | 70 |
| R-squared | 0.142 | 0.365 | 0.172 | 0.415 |
| Demographics | NO | YES | NO | YES |
| Controls | NO | YES | NO | YES |

| *Dependent variable: Ambiguity aversion* | Model 5 | Model 6 |
|---|---|---|
| Strategic ambiguity | -0.0986 | -0.109 |
| | (0.152) | (0.225) |
| Correct answer to WST.1 (=1) | -0.422** | 0.00971 |
| | (0.174) | (0.279) |
| Correct answer to WST.3 (=1) | 0.118 | 0.0472 |
| | (0.142) | (0.188) |
| Correct answer to WST.4 (=1) | 0.333*** | 0.238** |
| | (0.105) | (0.114) |
| Strategic ambiguity X WST.1 (=1) | 0.179 | -0.102 |
| | (0.188) | (0.327) |
| Strategic ambiguity X WST.3 (=1) | -0.441** | -0.347* |
| | (0.173) | (0.189) |
| CRT scores=1 | -0.103 | -0.539*** |
| | (0.132) | (0.177) |
| CRT scores=2 | -0.198 | -0.195 |
| | (0.144) | (0.237) |
| CRT scores=3 | -0.0449 | -0.228 |
| | (0.134) | (0.186) |
| Strategic ambiguity X CRT=1 | -0.0197 | 0.459 |
| | (0.217) | (0.285) |
| Strategic ambiguity X CRT=2 | 0.335 | 0.387 |
| | (0.203) | (0.248) |
| Strategic ambiguity X CRT=3 | 0.176 | 0.349* |
| | (0.160) | (0.204) |
| Cognitive uncertainty (CU; normalized) | 0.512** | 0.975*** |
| | (0.236) | (0.214) |
| Strategic ambiguity X CU | -0.343 | -0.718** |

| | | |
|---|---|---|
| | (0.305) | (0.282) |
| Constant | -0.00778 | 0.235 |
| | (0.110) | (0.302) |
| | | |
| Observations | 85 | 70 |
| R-squared | 0.259 | 0.559 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### *C.1.3. Normalized CRT Scores and Insight Groups on WST*

**Table C.1.3.** Ambiguity aversion and normalized CRT scores and insights on WST

| *Dependent variable= Ambiguity aversion* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Strategic ambiguity | -0.120 | -0.135 | -0.445* | -0.697* |
| | (0.0864) | (0.110) | (0.232) | (0.412) |
| Cognitive uncertainty (normalized) | 0.391** | 0.588*** | 0.567** | 0.957*** |
| | (0.190) | (0.205) | (0.251) | (0.242) |
| CRT scores (normalized) | 0.0688 | 0.00627 | -0.0547 | -0.312* |
| | (0.0858) | (0.117) | (0.134) | (0.172) |
| *Insight in WST.1* | | | | |
| Lack of insight | 0.200** | 0.0394 | 0.333* | 0.0943 |
| | (0.0967) | (0.109) | (0.178) | (0.298) |
| Partial insight | 0.240** | 0.0461 | 0.386* | 0.0531 |
| | (0.110) | (0.167) | (0.219) | (0.386) |
| *Insight in WST.3* | | | | |
| Lack of insight | 0.0961 | 0.113 | -0.134 | -0.302 |
| | (0.105) | (0.109) | (0.137) | (0.243) |
| Partial insight | 0.160 | 0.177 | -0.0578 | -0.0688 |
| | (0.0981) | (0.118) | (0.132) | (0.263) |
| *Insight in WST.4* | | | | |
| Lack of insight | -0.302** | -0.301** | -0.311* | -0.412** |
| | (0.119) | (0.119) | (0.180) | (0.198) |
| Partial insight | -0.377*** | -0.343*** | -0.386*** | -0.283** |
| | (0.122) | (0.123) | (0.142) | (0.119) |
| Strategic ambiguity X Lack of insight (WST1) | | | -0.0903 | 0.0120 |
| | | | (0.185) | (0.342) |
| Strategic ambiguity X Partial insight (WST1) | | | -0.0497 | 0.0836 |
| | | | (0.219) | (0.469) |
| Strategic ambiguity X Lack of insight (WST3) | | | 0.434** | 0.567* |
| | | | (0.186) | (0.285) |
| Strategic ambiguity X Partial insight (WST3) | | | 0.467** | 0.428 |
| | | | (0.190) | (0.260) |
| Strategic ambiguity X Lack of insight (WST4) | | | 0.00138 | 0.249 |
| | | | (0.151) | (0.191) |
| Strategic ambiguity X CRT scores (normalized) | | | 0.277 | 0.464** |
| | | | (0.182) | (0.227) |
| Strategic ambiguity X Cognitive uncertainty (normalized) | | | -0.453 | -0.732** |
| | | | (0.320) | (0.318) |
| Constant | -0.0665 | 0.0738 | 0.0261 | 0.597* |
| | (0.126) | (0.252) | (0.135) | (0.298) |
| | | | | |
| Observations | 85 | 70 | 85 | 70 |
| R-squared | 0.169 | 0.382 | 0.248 | 0.542 |
| Demographics | NO | YES | NO | NO |

| Controls | NO | YES | NO | NO |
|---|---|---|---|---|

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

## C.2. Nature, Social and Strategic Ambiguity

### *C.2.1. High and Low CRT Groups*

**Table C.2.1.** Ambiguity aversion and CRT groups

| *Dependent variable= Ambiguity aversion* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Social ambiguity | | -0.0784 | -0.0558 | -0.0784 |
| | | (0.0808) | (0.0717) | (0.0808) |
| Strategic ambiguity | | -0.113 | -0.118* | -0.113 |
| | | (0.0740) | (0.0689) | (0.0740) |
| WST scores (normalized) | -0.0223 | -0.0480 | 0.0147 | -0.0480 |
| | (0.112) | (0.134) | (0.113) | (0.134) |
| CRT group (high=1) | -0.0336 | -0.0107 | -0.0322 | -0.0107 |
| | (0.0597) | (0.0717) | (0.0591) | (0.0717) |
| Cognitive uncertainty (normalized) | 0.190 | 0.337** | 0.194 | 0.337** |
| | (0.132) | (0.148) | (0.146) | (0.148) |
| Constant | 0.0315 | 0.112 | 0.0831 | 0.112 |
| | (0.0632) | (0.203) | (0.0785) | (0.203) |
| Observations | 127 | 106 | 127 | 106 |
| R-squared | 0.030 | 0.197 | 0.052 | 0.197 |
| Demographics | NO | YES | NO | YES |
| Controls | NO | YES | NO | YES |

| | Model 5 | Model 6 | Model 7 |
|---|---|---|---|
| Social ambiguity | -0.256* | -0.358** | -0.371** |
| | (0.133) | (0.168) | (0.178) |
| Strategic ambiguity | -0.338* | -0.375** | -0.381** |
| | (0.191) | (0.172) | (0.176) |
| WST scores (normalized) | -0.119 | -0.461* | -0.484* |
| | (0.318) | (0.267) | (0.262) |
| CRT group (high=1) | -0.0524 | -0.00307 | -0.0119 |
| | (0.118) | (0.103) | (0.103) |
| Cognitive uncertainty (normalized) | -0.0741 | -0.0918 | -0.107 |
| | (0.227) | (0.156) | (0.148) |
| Strategic ambiguity X Cognitive uncertainty | 0.254 | 0.325 | 0.333 |
| | (0.334) | (0.264) | (0.268) |
| Social ambiguity X Cognitive uncertainty | 0.601* | 0.947*** | 0.949*** |
| | (0.326) | (0.257) | (0.258) |
| Social ambiguity X CRT group (high=1) | -0.0310 | -0.0387 | -0.0191 |
| | (0.154) | (0.174) | (0.187) |
| Strategic ambiguity X CRT group (high=1) | 0.187 | 0.145 | 0.167 |
| | (0.156) | (0.147) | (0.148) |
| Strategic ambiguity X WST scores (normalized) | 0.0396 | 0.428 | 0.434 |
| | (0.367) | (0.337) | (0.334) |
| Social ambiguity X WST scores (normalized) | 0.294 | 0.669** | 0.693** |
| | (0.351) | (0.310) | (0.325) |
| Constant | 0.213** | 0.268 | 0.305 |
| | (0.0953) | (0.193) | (0.247) |

| | | | |
|---|---|---|---|
| Observations | 127 | 106 | 106 |
| R-squared | 0.120 | 0.343 | 0.348 |
| Demographics | NO | YES | YES |
| Controls | NO | NO | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### *C.2.2. Correct Responses to WST and CRT Scores*

**Table C.2.2.** Ambiguity aversion and CRT and WST scores

| *Dependent variable=Ambiguity aversion* | Model 1 | Model 2 | Model 3z | Model 4 |
|---|---|---|---|---|
| Social ambiguity | | | -0.0285 | -0.0453 |
| | | | (0.0772) | (0.0870) |
| Strategic ambiguity | | | -0.108 | -0.128 |
| | | | (0.0698) | (0.0771) |
| Correct answer to WST.1 | -0.196** | -0.0645 | -0.150 | 0.107 |
| | (0.0888) | (0.0856) | (0.0952) | (0.0905) |
| Correct answer to WST.3 | -0.0855 | -0.151* | -0.0862 | -0.174** |
| | (0.0989) | (0.0894) | (0.0937) | (0.0810) |
| Correct answer to WST.4 | 0.159** | 0.101 | 0.167* | 0.0753 |
| | (0.0768) | (0.0852) | (0.0897) | (0.100) |
| CRT score= 1 | -0.0842 | -0.160 | -0.0694 | -0.171 |
| | (0.104) | (0.122) | (0.0996) | (0.128) |
| CRT score= 2 | -0.0923 | -0.0695 | -0.0911 | -0.0592 |
| | (0.0835) | (0.105) | (0.0854) | (0.109) |
| CRT score= 3 | -0.0284 | -0.0483 | -0.0228 | -0.0612 |
| | (0.0710) | (0.0789) | (0.0696) | (0.0808) |
| Cognitive uncertainty (normalized) | 0.184 | 0.331** | 0.196 | 0.341** |
| | (0.130) | (0.137) | (0.142) | (0.146) |
| Constant | 0.0548 | 0.155 | 0.0873 | 0.149 |
| | (0.0608) | (0.218) | (0.0762) | (0.232) |
| Observations | 127 | 106 | 127 | 106 |
| R-squared | 0.064 | 0.214 | 0.083 | 0.282 |

| | Model 5 | Model 6 |
|---|---|---|
| Social ambiguity | -0.203 | -0.211 |
| | (0.148) | (0.190) |
| Strategic ambiguity | -0.301** | -0.351** |
| | (0.143) | (0.147) |
| Correct answer to WST.1 | -0.243* | -0.0537 |
| | (0.126) | (0.104) |
| Correct answer to WST.3 | 0.0382 | -0.0552 |
| | (0.253) | (0.254) |
| Correct answer to WST.4 | -0.108 | -0.252** |
| | (0.142) | (0.115) |
| Social ambiguity X Correct answer to WST.1 | 0.262 | 0.655** |
| | (0.235) | (0.272) |
| Social ambiguity X Correct answer to WST.3 | 0.0796 | 0.0309 |
| | (0.290) | (0.305) |
| Strategic ambiguity X Correct answer to WST.3 | -0.362 | -0.238 |
| | (0.272) | (0.263) |

| | | |
|---|---|---|
| Strategic ambiguity X Correct answer to WST.4 | 0.441** | 0.486*** |
| | (0.176) | (0.144) |
| CRT score= 1 | 0.0609 | 0.0415 |
| | (0.218) | (0.271) |
| CRT score= 2 | -0.0402 | -0.0125 |
| | (0.156) | (0.119) |
| CRT score= 3 | -0.0148 | 0.0134 |
| | (0.141) | (0.113) |
| Social ambiguity X CRT score= 1 | -0.164 | -0.618** |
| | (0.255) | (0.288) |
| Strategic ambiguity X CRT score= 1 | -0.183 | -0.124 |
| | (0.277) | (0.329) |
| Social ambiguity X CRT score= 2 | -0.158 | -0.198 |
| | (0.212) | (0.246) |
| Strategic ambiguity X CRT score= 2 | 0.177 | 0.217 |
| | (0.212) | (0.189) |
| Social ambiguity X CRT score= 3 | -0.0301 | -0.222 |
| | (0.194) | (0.200) |
| Strategic ambiguity X CRT score= 3 | 0.146 | 0.103 |
| | (0.166) | (0.153) |
| Cognitive uncertainty (normalized) | -0.0808 | -0.0791 |
| | (0.242) | (0.161) |
| Social ambiguity X Cognitive uncertainty (normalized) | 0.593* | 1.015*** |
| | (0.337) | (0.238) |
| Strategic ambiguity X Cognitive uncertainty (normalized) | 0.249 | 0.331 |
| | (0.309) | (0.233) |
| Constant | 0.195* | 0.363 |
| | (0.0991) | (0.232) |
| Observations | 127 | 106 |
| R-squared | 0.211 | 0.501 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### *D.2.3. Normalized CRT Scores and Insight Groups on WST*

**Table C.2.3.** Ambiguity aversion and CRT scores and insights on WST

| *Dependent variable= Ambiguity aversion* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Social ambiguity | -0.0395 | -0.0503 | 0.199 | 0.567 |
| | (0.0773) | (0.0846) | (0.306) | (0.348) |
| Strategic ambiguity | -0.111 | -0.122 | -0.246 | -0.0816 |
| | (0.0729) | (0.0779) | (0.293) | (0.271) |
| Cognitive uncertainty (normalized) | 0.194 | 0.334** | -0.106 | -0.0700 |
| | (0.151) | (0.152) | (0.228) | (0.180) |
| CRT scores (normalized) | -0.0240 | -0.0499 | -0.00616 | 0.0106 |
| | (0.0700) | (0.0757) | (0.134) | (0.112) |
| *Insight in WST.1* | | | | |
| Lack of insight | 0.118 | -0.0974 | 0.295 | 0.205 |
| | (0.0922) | (0.0998) | (0.194) | (0.207) |
| Partial insight | 0.137 | -0.153 | 0.336** | 0.125 |
| | (0.0998) | (0.114) | (0.147) | (0.171) |

| | | | | |
|---|---|---|---|---|
| *Insight in WST.3* | | | | |
| Lack of insight | 0.0673 | 0.124 | -0.0665 | -0.0766 |
| | (0.102) | (0.0920) | (0.268) | (0.297) |
| Partial insight | 0.0976 | 0.173** | -0.0594 | 0.00683 |
| | (0.0946) | (0.0829) | (0.262) | (0.284) |
| *Insight in WST.4* | | | | |
| Lack of insight | -0.149 | -0.0812 | 0.0969 | 0.256* |
| | (0.0907) | (0.105) | (0.148) | (0.146) |
| Partial insight | -0.176* | -0.0662 | 0.162 | 0.286** |
| | (0.0919) | (0.0999) | (0.136) | (0.121) |
| Social ambiguity X Lack of insight WST.1 | | | -0.510* | -0.780** |
| | | | (0.268) | (0.361) |
| Social ambiguity X Partial insight WST.3 | | | -0.498* | -0.713* |
| | | | (0.260) | (0.374) |
| Strategic ambiguity X Lack of insight WST.1 | | | -0.0518 | -0.106 |
| | | | (0.183) | (0.191) |
| Social ambiguity X Lack of insight WST.3 | | | -0.0673 | -0.0921 |
| | | | (0.301) | (0.359) |
| Social ambiguity X Partial insight WST.3 | | | 0.00156 | -0.0129 |
| | | | (0.293) | (0.378) |
| Strategic ambiguity X Lack of insight WST.3 | | | 0.367 | 0.347 |
| | | | (0.296) | (0.333) |
| Strategic ambiguity X Partial insight WST.3 | | | 0.469 | 0.342 |
| | | | (0.295) | (0.302) |
| Social ambiguity X Lack of insight WST.4 | | | 0.140 | -0.0795 |
| | | | (0.151) | (0.175) |
| Strategic ambiguity X Lack of insight WST.4 | | | -0.406** | -0.443** |
| | | | (0.190) | (0.167) |
| Strategic ambiguity X Partial insight WST.4 | | | -0.548*** | -0.585*** |
| | | | (0.196) | (0.162) |
| Social ambiguity X CRT score | | | -0.0485 | -0.248 |
| | | | (0.189) | (0.187) |
| Strategic ambiguity X CRT score | | | 0.229 | 0.148 |
| | | | (0.182) | (0.176) |
| Social ambiguity X CU | | | 0.673** | 0.995*** |
| | | | (0.339) | (0.291) |
| Strategic ambiguity X CU | | | 0.221 | 0.293 |
| | | | (0.302) | (0.266) |
| Constant | 0.0286 | 0.103 | -0.173 | -0.0561 |
| | (0.123) | (0.228) | (0.275) | (0.321) |
| Observations | 127 | 106 | 127 | 106 |
| R-squared | 0.075 | 0.272 | 0.205 | 0.469 |
| Demographics | NO | YES | NO | NO |
| Controls | NO | YES | NO | NO |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

## Appendix D. Robustness Checks for A-insensitivity

### D.1. Social and Strategic Ambiguity

### *D.1.1. High and Low CRT Groups*

**Table D.1.1.** A-insensitivity and CRT groups

| *Dependent variable= A-insensitivity* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Strategic ambiguity | | | 0.0379 | -0.0282 |
| | | | (0.110) | (0.119) |
| WST scores (normalized) | -0.0747 | 0.154 | -0.0954 | 0.171 |
| | (0.176) | (0.188) | (0.183) | (0.198) |
| CRT group (high= 1) | 0.0609 | -0.166 | 0.0600 | -0.169 |
| | (0.120) | (0.139) | (0.120) | (0.142) |
| Cognitive uncertainty (normalized) | 0.397* | 0.305 | 0.376 | 0.323 |
| | (0.232) | (0.297) | (0.241) | (0.297) |
| Constant | 0.0993 | 0.00298 | 0.0914 | 0.00650 |
| | (0.146) | (0.356) | (0.149) | (0.356) |
| Observations | 85 | 70 | 85 | 70 |
| R-squared | 0.043 | 0.137 | 0.044 | 0.138 |
| Demographics | NO | YES | NO | YES |
| Controls | NO | YES | NO | YES |

| | Model 5 | Model 6 | Model 7 |
|---|---|---|---|
| Strategic ambiguity | 0.525* | 0.363 | 0.363 |
| | (0.281) | (0.293) | (0.308) |
| Cognitive uncertainty (normalized) | -0.266 | -0.0842 | -0.00888 |
| | (0.241) | (0.258) | (0.456) |
| CRT group (high= 1) | 0.265* | 0.0536 | 0.0773 |
| | (0.159) | (0.177) | (0.196) |
| WST scores (normalized) | **0.711*** ** | **0.747** ** | 0.631 |
| | (0.264) | (0.340) | (0.380) |
| Strategic ambiguity X Cognitive uncertainty | -0.705 | -0.593 | -0.520 |
| | (0.451) | (0.508) | (0.536) |
| Strategic ambiguity X CRT group (high= 0) | -0.406* | -0.304 | -0.312 |
| | (0.233) | (0.243) | (0.254) |
| Strategic ambiguity X WST scores | 0.229 | 0.168 | 0.132 |
| | (0.364) | (0.374) | (0.558) |
| Constant | -0.125 | -0.0315 | -0.186 |
| | (0.178) | (0.315) | (0.473) |
| Observations | 85 | 70 | 70 |
| R-squared | 0.104 | 0.234 | 0.254 |
| Demographics | NO | YES | YES |
| Controls | NO | NO | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### *D.1.2. Correct Responses to WST and CRT Scores*

**Table D.1.2.** A-insensitivity and CRT and WST scores

| *Dependent variable=A-insensitivity* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Strategic ambiguity | | | 0.0409 | 0.0153 |
| | | | (0.116) | (0.133) |
| Correct answer to WST.1 | -0.135 | -0.111 | -0.140 | -0.236 |
| | (0.234) | (0.237) | (0.235) | (0.234) |
| Correct answer to WST.3 (=1) | -0.0620 | 0.0522 | -0.0593 | 0.0384 |
| | (0.136) | (0.126) | (0.134) | (0.164) |
| Correct answer to WST.4 (=1) | 0.135 | 0.206 | 0.118 | 0.278 |
| | (0.234) | (0.209) | (0.238) | (0.222) |
| CRT score= 1 | -0.153 | -0.145 | -0.155 | -0.154 |
| | (0.199) | (0.205) | (0.196) | (0.204) |
| CRT score= 2 | 0.0701 | -0.147 | 0.0712 | -0.130 |
| | (0.172) | (0.220) | (0.174) | (0.229) |
| CRT score= 3 | -0.00880 | -0.206 | -0.0139 | -0.168 |
| | (0.150) | (0.171) | (0.151) | (0.172) |
| Cognitive uncertainty (normalized) | 0.400* | 0.321 | 0.378 | 0.374 |
| | (0.228) | (0.304) | (0.237) | (0.308) |
| Constant | 0.138 | 0.0780 | 0.130 | 0.0167 |
| | (0.162) | (0.377) | (0.166) | (0.433) |
| Observations | 85 | 70 | 85 | 70 |
| R-squared | 0.062 | 0.154 | 0.064 | 0.269 |
| Demographics | NO | YES | NO | YES |
| Controls | NO | YES | NO | YES |

| *Dependent variable=A-insensitivity* | Model 5 | Model 6 |
|---|---|---|
| Strategic ambiguity | 0.356 | 0.235 |
| | (0.326) | (0.410) |
| Correct answer to WST.1 (=1) | -0.00785 | 0.132 |
| | (0.356) | (0.561) |
| Correct answer to WST.3 (=1) | -0.175 | -0.0790 |
| | (0.242) | (0.375) |
| Correct answer to WST.4 (=1) | 0.0507 | 0.176 |
| | (0.282) | (0.287) |
| Strategic ambiguity X WST.1 (=1) | -0.0772 | -0.324 |
| | (0.316) | (0.564) |
| Strategic ambiguity X WST.3 (=1) | 0.205 | 0.154 |
| | (0.279) | (0.393) |
| CRT score=1 | -0.422* | -0.471* |
| | (0.219) | (0.259) |
| CRT score=2 | 0.187 | 0.0192 |
| | (0.212) | (0.313) |
| CRT score=3 | 0.116 | -0.141 |
| | (0.211) | (0.259) |
| Strategic ambiguity X CRT=1 | 0.515 | 0.492 |
| | (0.334) | (0.425) |
| Strategic ambiguity X CRT=2 | -0.211 | -0.265 |
| | (0.382) | (0.437) |
| Strategic ambiguity X CRT=3 | -0.243 | -0.0320 |
| | (0.308) | (0.369) |
| Cognitive uncertainty (CU; normalized) | **0.725*** ** | 0.719* |
| | (0.246) | (0.410) |
| Strategic ambiguity X CU | -0.707 | -0.579 |

| | | |
|---|---|---|
| | (0.439) | (0.570) |
| Constant | -0.00612 | 0.00365 |
| | (0.210) | (0.501) |
| | | |
| Observations | 85 | 70 |
| R-squared | 0.146 | 0.318 |
| Demographics | NO | YES |
| Controls | NO | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### *D.1.3. Normalized CRT Scores and Insight Groups on WST*

**Table D.1.3.** A-insensitivity and CRT scores and insight on WST

| *Dependent variable= A-insensitivity* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Strategic ambiguity | 0.0490 | 0.0470 | 0.657 | -0.138 |
| | (0.116) | (0.149) | (0.442) | (0.775) |
| Cognitive uncertainty (normalized) | 0.398* | 0.384 | **0.629**** | 0.537 |
| | (0.212) | (0.296) | (0.267) | (0.413) |
| CRT scores (normalized) | -0.00703 | -0.230 | 0.179 | -0.226 |
| | (0.150) | (0.198) | (0.204) | (0.229) |
| Insight in WST.1 | | | | |
| Lack of insight | 0.164 | 0.197 | 0.0514 | 0.0204 |
| | (0.204) | (0.210) | (0.370) | (0.529) |
| Partial insight | 0.0556 | 0.0112 | -0.0111 | -0.321 |
| | (0.230) | (0.312) | (0.381) | (0.643) |
| Insight in WST.3 | | | | |
| Lack of insight | 0.0569 | -0.122 | 0.136 | -0.132 |
| | (0.167) | (0.158) | (0.295) | (0.368) |
| Partial insight | -0.0303 | -0.125 | 0.0766 | -0.0333 |
| | (0.171) | (0.178) | (0.302) | (0.437) |
| Insight in WST.4 | | | | |
| Lack of insight | -0.182 | -0.297 | -0.0697 | -0.256 |
| | (0.244) | (0.228) | (0.321) | (0.376) |
| Partial insight | 0.00400 | -0.106 | 0.0603 | -0.0671 |
| | (0.244) | (0.234) | (0.240) | (0.278) |
| Strategic ambiguity X Lack of insight (WST1) | | | 0.0809 | 0.204 |
| | | | (0.346) | (0.557) |
| Strategic ambiguity X Partial insight (WST1) | | | -0.108 | 0.483 |
| | | | (0.425) | (0.791) |
| Strategic ambiguity X Lack of insight (WST3) | | | -0.171 | 0.0830 |
| | | | (0.344) | (0.429) |
| Strategic ambiguity X Partial insight (WST3) | | | -0.205 | -0.0447 |
| | | | (0.346) | (0.441) |
| Strategic ambiguity X Lack of insight (WST4) | | | -0.0486 | 0.00635 |
| | | | (0.270) | (0.323) |
| Strategic ambiguity X CRT scores (normalized) | | | -0.440 | 0.0221 |
| | | | (0.348) | (0.431) |
| Strategic ambiguity X Cognitive uncertainty (normalized) | | | -0.501 | -0.363 |
| | | | (0.435) | (0.592) |
| Constant | 0.0380 | 0.0703 | -0.193 | 0.155 |
| | (0.226) | (0.351) | (0.210) | (0.426) |

| | | | | |
|---|---|---|---|---|
| Observations | 85 | 70 | 85 | 70 |
| R-squared | 0.085 | 0.299 | 0.126 | 0.320 |
| Demographics | NO | YES | YES | YES |
| Controls | NO | YES | YES | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

## D.2. Nature, Social and Strategic Ambiguity

### *D.2.1. High and Low CRT Groups*

**Table D.2.1.** A-insensitivity and CRT groups

| *Dependent variable= A-insensitivity* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Social ambiguity | | 0.00818 | -0.0390 | 0.00818 |
| | | (0.109) | (0.104) | (0.109) |
| Strategic ambiguity | | 0.0352 | 0.0122 | 0.0352 |
| | | (0.112) | (0.109) | (0.112) |
| WST scores (normalized) | -0.124 | -0.101 | -0.146 | -0.101 |
| | (0.190) | (0.235) | (0.198) | (0.235) |
| CRT group (high=1) | -0.0613 | -0.155 | -0.0604 | -0.155 |
| | (0.0941) | (0.103) | (0.0942) | (0.103) |
| Cognitive uncertainty (normalized) | 0.324** | 0.157 | 0.303* | 0.157 |
| | (0.163) | (0.196) | (0.171) | (0.196) |
| Constant | 0.211* | -0.0465 | 0.230* | -0.0465 |
| | (0.112) | (0.319) | (0.138) | (0.319) |
| Observations | 127 | 106 | 127 | 106 |
| R-squared | 0.043 | 0.127 | 0.045 | 0.127 |
| Demographics | NO | YES | NO | YES |
| Controls | NO | YES | NO | YES |

| | Model 5 | Model 6 | Model 7 |
|---|---|---|---|
| Social ambiguity | -0.493* | -0.325 | -0.400 |
| | (0.267) | (0.307) | (0.311) |
| Strategic ambiguity | 0.0319 | 0.0382 | -0.0247 |
| | (0.295) | (0.309) | (0.308) |
| WST scores (normalized) | -0.390 | -0.653 | -0.892 |
| | (0.530) | (0.596) | (0.582) |
| CRT group (high=1) | -0.283* | -0.186 | -0.179 |
| | (0.161) | (0.186) | (0.183) |
| Cognitive uncertainty (normalized) | 0.321 | 0.0328 | -0.131 |
| | (0.277) | (0.262) | (0.258) |
| Strategic ambiguity X Cognitive uncertainty | -0.316 | -0.0341 | 0.103 |
| | (0.459) | (0.457) | (0.496) |
| Social ambiguity X Cognitive uncertainty | 0.390 | 0.594 | 0.615 |
| | (0.383) | (0.417) | (0.439) |
| Social ambiguity X CRT group (high=1) | 0.548** | 0.216 | 0.245 |
| | (0.226) | (0.273) | (0.284) |
| Strategic ambiguity X CRT group (high=1) | 0.142 | -0.0501 | -0.0554 |
| | (0.234) | (0.260) | (0.264) |
| Strategic ambiguity X WST scores (normalized) | 0.352 | 0.655 | 0.938 |
| | (0.596) | (0.651) | (0.649) |
| Social ambiguity X WST scores (normalized) | 0.123 | 0.585 | 0.997 |
| | (0.582) | (0.654) | (0.712) |

| | | | |
|---|---|---|---|
| Constant | 0.368* | 0.144 | 0.0173 |
| | (0.200) | (0.352) | (0.421) |
| | | | |
| Observations | 127 | 106 | 106 |
| R-squared | 0.115 | 0.163 | 0.210 |
| Demographics | NO | YES | YES |
| Controls | NO | NO | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### *D.2.2. Correct Responses to WST and CRT Scores*

**Table D.2.2.** A-insensitivity and CRT and WST scores

| *Dependent variable=A-insensitivity* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Social ambiguity | | | -0.0337 | -0.00648 |
| | | | (0.106) | (0.113) |
| Strategic ambiguity | | | 0.0370 | 0.0640 |
| | | | (0.114) | (0.120) |
| Correct answer to WST.1 | -0.00404 | 0.0776 | -0.0205 | -0.0135 |
| | (0.189) | (0.205) | (0.197) | (0.210) |
| Correct answer to WST.3 | -0.0408 | -0.0415 | -0.0373 | -0.0155 |
| | (0.122) | (0.121) | (0.122) | (0.132) |
| Correct answer to WST.4 | -0.0470 | -0.0719 | -0.0654 | -0.0663 |
| | (0.158) | (0.172) | (0.160) | (0.183) |
| CRT score= 1 | -0.321* | -0.202 | -0.323* | -0.218 |
| | (0.184) | (0.190) | (0.186) | (0.196) |
| CRT score= 2 | -0.101 | -0.188 | -0.0960 | -0.191 |
| | (0.129) | (0.156) | (0.133) | (0.159) |
| CRT score= 3 | -0.181* | -0.236* | -0.183* | -0.244* |
| | (0.107) | (0.120) | (0.108) | (0.123) |
| Cognitive uncertainty (normalized) | 0.319** | 0.201 | 0.295* | 0.168 |
| | (0.158) | (0.212) | (0.163) | (0.209) |
| Constant | 0.300** | 0.0801 | 0.311** | 0.0496 |
| | (0.115) | (0.301) | (0.128) | (0.320) |
| | | | | |
| Observations | 127 | 106 | 127 | 106 |
| R-squared | 0.080 | 0.142 | 0.084 | 0.196 |

| | Model 5 | Model 6 |
|---|---|---|
| Social ambiguity | -0.521** | -0.415 |
| | (0.256) | (0.354) |
| Strategic ambiguity | -0.165 | -0.137 |
| | (0.289) | (0.348) |
| Correct answer to WST.1 | -0.0850 | -0.150 |
| | (0.250) | (0.239) |
| Correct answer to WST.3 | -0.103 | -0.189 |
| | (0.247) | (0.380) |
| Correct answer to WST.4 | -0.230 | -0.414 |
| | (0.201) | (0.280) |
| Social ambiguity X Correct answer to WST.1 | 0.357 | 0.962* |
| | (0.387) | (0.575) |
| Social ambiguity X Correct answer to WST.3 | -0.0719 | 0.120 |
| | (0.345) | (0.488) |

| | | |
|---|---|---|
| Strategic ambiguity X Correct answer to WST.3 | 0.133 | 0.223 |
| | (0.283) | (0.401) |
| Strategic ambiguity X Correct answer to WST.4 | 0.280 | 0.519 |
| | (0.346) | (0.395) |
| CRT score= 1 | -0.703 | -0.478 |
| | (0.494) | (0.542) |
| CRT score= 2 | -0.353 | -0.275 |
| | (0.224) | (0.311) |
| CRT score= 3 | -0.397** | -0.270 |
| | (0.180) | (0.228) |
| Social ambiguity X CRT score= 1 | 0.282 | 0.0330 |
| | (0.540) | (0.586) |
| Strategic ambiguity X CRT score= 1 | 0.797 | 0.491 |
| | (0.554) | (0.635) |
| Social ambiguity X CRT score= 2 | 0.540* | 0.311 |
| | (0.308) | (0.442) |
| Strategic ambiguity X CRT score= 2 | 0.329 | -0.0377 |
| | (0.389) | (0.479) |
| Social ambiguity X CRT score= 3 | 0.513* | 0.109 |
| | (0.277) | (0.344) |
| Strategic ambiguity X CRT score= 3 | 0.270 | 0.0808 |
| | (0.287) | (0.310) |
| Cognitive uncertainty (normalized) | 0.248 | -0.0625 |
| | (0.247) | (0.302) |
| Social ambiguity X Cognitive uncertainty (normalized) | 0.477 | 0.741 |
| | (0.349) | (0.445) |
| Strategic ambiguity X Cognitive uncertainty (normalized) | -0.230 | 0.107 |
| | (0.439) | (0.517) |
| Constant | 0.514*** | 0.322 |
| | (0.147) | (0.402) |
| Observations | 127 | 106 |
| R-squared | 0.186 | 0.276 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### *D.2.3. Normalized CRT Scores and Insight Groups on WST*

**Table D.2.3.** A-insensitivity and CRT scores and insights on WST

| *Dependent variable= A-insensitivity* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Social ambiguity | -0.0366 | 0.0151 | -0.339 | 0.871 |
| | (0.110) | (0.106) | (0.453) | (0.579) |
| Strategic ambiguity | 0.0573 | 0.135 | 0.318 | 0.695* |
| | (0.115) | (0.124) | (0.351) | (0.354) |
| Cognitive uncertainty (normalized) | 0.342** | 0.201 | 0.409 | -0.0291 |
| | (0.160) | (0.181) | (0.276) | (0.265) |
| CRT scores (normalized) | -0.188* | -0.309*** | -0.499*** | -0.315* |
| | (0.104) | (0.111) | (0.136) | (0.169) |
| *Insight in WST.1* | | | | |
| Lack of insight | 0.0615 | 0.106 | 0.183 | 0.590 |
| | (0.190) | (0.203) | (0.386) | (0.464) |

| | | | | |
|---|---|---|---|---|
| Partial insight | -0.131 | -0.266 | -0.119 | 0.0779 |
| | (0.209) | (0.219) | (0.326) | (0.400) |
| *Insight in WST.3* | | | | |
| Lack of insight | -0.0562 | -0.148 | -0.123 | -0.156 |
| | (0.136) | (0.116) | (0.192) | (0.268) |
| Partial insight | -0.0106 | -0.00868 | 0.153 | 0.172 |
| | (0.137) | (0.122) | (0.181) | (0.255) |
| *Insight in WST.4* | | | | |
| Lack of insight | 0.0148 | -0.0213 | 0.153 | 0.287 |
| | (0.163) | (0.175) | (0.141) | (0.203) |
| Partial insight | 0.124 | 0.132 | 0.141 | 0.306 |
| | (0.162) | (0.165) | (0.170) | (0.211) |
| Social ambiguity X Lack of insight WST.1 | | | -0.212 | -0.856 |
| | | | (0.516) | (0.633) |
| Social ambiguity X Partial insight WST.3 | | | 0.0265 | -0.759 |
| | | | (0.472) | (0.635) |
| Strategic ambiguity X Lack of insight WST.1 | | | -0.0504 | -0.371 |
| | | | (0.349) | (0.399) |
| Social ambiguity X Lack of insight WST.3 | | | 0.259 | -0.0587 |
| | | | (0.351) | (0.400) |
| Social ambiguity X Partial insight WST.3 | | | -0.0762 | -0.282 |
| | | | (0.352) | (0.447) |
| Strategic ambiguity X Lack of insight WST.3 | | | 0.0879 | 0.117 |
| | | | (0.261) | (0.352) |
| Strategic ambiguity X Partial insight WST.3 | | | -0.281 | -0.244 |
| | | | (0.246) | (0.314) |
| Social ambiguity X Lack of insight WST.4 | | | -0.142 | -0.218 |
| | | | (0.268) | (0.294) |
| Strategic ambiguity X Lack of insight WST.4 | | | -0.271 | -0.495 |
| | | | (0.292) | (0.339) |
| Strategic ambiguity X Partial insight WST.4 | | | -0.0811 | -0.283 |
| | | | (0.293) | (0.319) |
| Social ambiguity X CRT score | | | 0.677*** | 0.0517 |
| | | | (0.245) | (0.267) |
| Strategic ambiguity X CRT score | | | 0.237 | 0.0749 |
| | | | (0.313) | (0.358) |
| Social ambiguity X CU | | | 0.220 | 0.557 |
| | | | (0.383) | (0.417) |
| Strategic ambiguity X CU | | | -0.281 | 0.141 |
| | | | (0.440) | (0.494) |
| Constant | 0.212 | -0.0843 | 0.147 | -0.680 |
| | (0.203) | (0.344) | (0.402) | (0.570) |
| Observations | 127 | 106 | 127 | 106 |
| R-squared | 0.092 | 0.291 | 0.181 | 0.354 |
| Demographics | NO | YES | YES | YES |
| Controls | NO | YES | YES | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

## Appendix E. Robustness Checks Using CRT Scores and Insight Groups on WST

### E.1. Ambiguity Aversion

#### *E.1.1, Social and Strategic Ambiguity*

**Table E.1.1.** Ambiguity aversion and CRT scores and insight on WST

| *Dependent variable= Ambiguity aversion* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Strategic ambiguity | -0.132 | -0.140 | -0.391* | -0.479 |
| | (0.0854) | (0.113) | (0.224) | (0.394) |
| Cognitive uncertainty (normalized) | 0.373** | 0.568*** | 0.526** | 1.023*** |
| | (0.180) | (0.194) | (0.251) | (0.248) |
| CRT score=1 | -0.115 | -0.264* | -0.113 | -0.526** |
| | (0.115) | (0.147) | (0.152) | (0.227) |
| CRT score=2 | -0.0507 | -0.0328 | -0.184 | -0.211 |
| | (0.107) | (0.162) | (0.150) | (0.234) |
| CRT score=3 | 0.0613 | -0.0230 | -0.0365 | -0.294* |
| | (0.0886) | (0.115) | (0.140) | (0.170) |
| *Insight in WST.1* | | | | |
| Lack of insight | 0.239** | 0.0798 | 0.417** | 0.0823 |
| | (0.0986) | (0.101) | (0.203) | (0.295) |
| Partial insight | 0.284** | 0.0903 | 0.477* | 0.0537 |
| | (0.118) | (0.173) | (0.280) | (0.380) |
| *Insight in WST.3* | | | | |
| Lack of insight | 0.124 | 0.168 | -0.125 | -0.148 |
| | (0.115) | (0.115) | (0.168) | (0.232) |
| Partial insight | 0.166 | 0.199* | -0.0810 | 0.0398 |
| | (0.106) | (0.118) | (0.172) | (0.271) |
| *Insight in WST.4* | | | | |
| Lack of insight | -0.301** | -0.313** | -0.308* | -0.252 |
| | (0.130) | (0.140) | (0.175) | (0.256) |
| Partial insight | -0.399*** | -0.401** | -0.387*** | -0.286* |
| | (0.134) | (0.150) | (0.130) | (0.153) |
| Strategic ambiguity X Lack of insight (WST1) | | | -0.173 | -0.00151 |
| | | | (0.213) | (0.333) |
| Strategic ambiguity X Partial insight (WST1) | | | -0.149 | 0.0270 |
| | | | (0.283) | (0.462) |
| Strategic ambiguity X Lack of insight (WST3) | | | 0.438** | 0.407 |
| | | | (0.201) | (0.290) |
| Strategic ambiguity X Partial insight (WST3) | | | 0.490** | 0.304 |
| | | | (0.217) | (0.259) |
| Strategic ambiguity X Lack of insight (WST4) | | | -0.0127 | 0.0820 |
| | | | (0.158) | (0.219) |
| Strategic ambiguity X CRT=1 | | | 0.0276 | 0.464 |
| | | | (0.233) | (0.361) |
| Strategic ambiguity X CRT=2 | | | 0.345 | 0.372 |
| | | | (0.207) | (0.239) |
| Strategic ambiguity X CRT=3 | | | 0.219 | 0.410* |
| | | | (0.176) | (0.205) |
| Strategic ambiguity X CU | | | -0.417 | -0.823** |
| | | | (0.307) | (0.304) |
| Constant | -0.0530 | 0.130 | 0.0114 | 0.558* |
| | (0.133) | (0.251) | (0.140) | (0.289) |

| | | | | |
|---|---|---|---|---|
| Observations | 85 | 70 | 85 | 70 |
| R-squared | 0.192 | 0.424 | 0.284 | 0.583 |
| Demographics | NO | YES | NO | YES |
| Controls | NO | YES | NO | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### *E.1.2. Nature, Social and Strategic Ambiguity*

**Table E.1.2.** Ambiguity aversion and CRT scores and insight on WST

| *Dependent variable= Ambiguity aversion* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Social ambiguity | -0.0285 | -0.0377 | 0.181 | 0.455 |
| | (0.0801) | (0.0872) | (0.315) | (0.347) |
| Strategic ambiguity | -0.108 | -0.111 | -0.210 | -0.0230 |
| | (0.0735) | (0.0793) | (0.291) | (0.273) |
| Cognitive uncertainty (normalized) | 0.189 | 0.347** | -0.0947 | -0.0407 |
| | (0.146) | (0.147) | (0.239) | (0.185) |
| CRT score=1 | -0.0651 | -0.172 | 0.0466 | -0.0235 |
| | (0.105) | (0.135) | (0.243) | (0.308) |
| CRT score=2 | -0.0891 | -0.0647 | -0.0318 | -0.0548 |
| | (0.0876) | (0.112) | (0.173) | (0.155) |
| CRT score=3 | -0.0209 | -0.0763 | -0.00351 | 0.00332 |
| | (0.0727) | (0.0775) | (0.140) | (0.118) |
| Insight in WST.1 | | | | |
| Lack of insight | 0.144 | -0.0878 | 0.292 | 0.134 |
| | (0.0938) | (0.0951) | (0.203) | (0.212) |
| Partial insight | 0.160 | -0.148 | 0.328** | 0.0477 |
| | (0.103) | (0.112) | (0.148) | (0.174) |
| Insight in WST.3 | | | | |
| Lack of insight | 0.0819 | 0.146 | -0.0663 | -0.0490 |
| | (0.105) | (0.0936) | (0.274) | (0.306) |
| Partial insight | 0.106 | 0.182** | -0.0521 | 0.0493 |
| | (0.0987) | (0.0856) | (0.272) | (0.292) |
| Insight in WST.4 | | | | |
| Lack of insight | -0.151 | -0.0814 | 0.0936 | 0.250 |
| | (0.0957) | (0.110) | (0.154) | (0.151) |
| Partial insight | -0.182* | -0.0737 | 0.153 | 0.283** |
| | (0.0985) | (0.107) | (0.149) | (0.131) |
| Social ambiguity X Lack of insight WST.1 | | | -0.414 | -0.746** |
| | | | (0.301) | (0.338) |
| Social ambiguity X Partial insight WST.3 | | | -0.391 | -0.662* |
| | | | (0.324) | (0.357) |
| Strategic ambiguity X Lack of insight WST.1 | | | -0.0471 | -0.0650 |
| | | | (0.190) | (0.195) |
| Social ambiguity X Lack of insight WST.3 | | | -0.0587 | 0.0318 |
| | | | (0.322) | (0.365) |
| Social ambiguity X Partial insight WST.3 | | | -0.0288 | 0.0374 |
| | | | (0.322) | (0.374) |
| Strategic ambiguity X Lack of insight WST.3 | | | 0.379 | 0.300 |
| | | | (0.296) | (0.333) |
| Strategic ambiguity X Partial insight WST.3 | | | 0.461 | 0.278 |
| | | | (0.303) | (0.307) |
| Social ambiguity X Lack of insight WST.4 | | | 0.138 | 0.0882 |
| | | | (0.161) | (0.190) |
| Strategic ambiguity X Lack of insight WST.4 | | | -0.414** | -0.447** |
| | | | (0.190) | (0.177) |
| Strategic ambiguity X Partial insight WST.4 | | | -0.539*** | -0.576*** |

| | | | | |
|---|---|---|---|---|
| | | | (0.198) | (0.173) |
| Social ambiguity X CRT score=1 | | | -0.160 | -0.559* |
| | | | (0.287) | (0.330) |
| Social ambiguity X CRT score=2 | | | -0.152 | -0.152 |
| | | | (0.228) | (0.261) |
| Social ambiguity X CRT score=3 | | | -0.0329 | -0.235 |
| | | | (0.198) | (0.192) |
| Strategic ambiguity X CRT score=1 | | | -0.132 | -0.0550 |
| | | | (0.300) | (0.384) |
| Strategic ambiguity X CRT score=2 | | | 0.193 | 0.244 |
| | | | (0.224) | (0.219) |
| Strategic ambiguity X CRT score=3 | | | 0.186 | 0.1000 |
| | | | (0.176) | (0.167) |
| Social ambiguity X CU | | | 0.621* | 1.024*** |
| | | | (0.346) | (0.273) |
| Strategic ambiguity X CU | | | 0.203 | 0.253 |
| | | | (0.297) | (0.256) |
| Constant | 0.0160 | 0.161 | -0.170 | 0.0379 |
| | (0.125) | (0.234) | (0.282) | (0.337) |
| Observations | 127 | 106 | 127 | 106 |
| R-squared | 0.086 | 0.288 | 0.232 | 0.519 |
| Demographics | NO | YES | NO | YES |
| Controls | NO | YES | NO | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

## E.2. A-insensitivity

### *E.2.1. Social and Strategic Ambiguity*

**Table E.2.1.** A-insensitivity and CRT scores and insight on WST

| *Dependent variable= A-insensitivity* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Strategic ambiguity | 0.0648 | 0.0503 | 0.618 | 0.00452 |
| | (0.121) | (0.154) | (0.458) | (0.886) |
| Cognitive uncertainty (normalized) | 0.415* | 0.387 | **0.732*** ** | 0.668 |
| | (0.216) | (0.308) | (0.225) | (0.416) |
| CRT score=1 | -0.151 | -0.125 | **-0.512** ** | -0.533 |
| | (0.185) | (0.213) | (0.242) | (0.368) |
| CRT score=2 | 0.0661 | -0.131 | 0.182 | -0.0229 |
| | (0.169) | (0.247) | (0.215) | (0.337) |
| CRT score=3 | -0.0540 | -0.237 | 0.102 | -0.231 |
| | (0.153) | (0.201) | (0.206) | (0.241) |
| *Insight in WST.1* | | | | |
| Lack of insight | 0.151 | 0.198 | -0.126 | -0.108 |
| | (0.208) | (0.221) | (0.332) | (0.536) |
| Partial insight | 0.0125 | 0.00607 | -0.290 | -0.431 |
| | (0.235) | (0.314) | (0.359) | (0.626) |
| *Insight in WST.3* | | | | |
| Lack of insight | 0.0528 | -0.114 | 0.206 | 0.00224 |
| | (0.177) | (0.166) | (0.276) | (0.372) |
| Partial insight | -0.0161 | -0.121 | 0.198 | 0.0938 |
| | (0.172) | (0.183) | (0.261) | (0.450) |
| *Insight in WST.4* | | | | |
| Lack of insight | -0.183 | -0.296 | 0.137 | -0.0750 |

| | | | | |
|---|---|---|---|---|
| | (0.230) | (0.232) | (0.317) | (0.461) |
| Partial insight | -0.0113 | -0.112 | 0.0998 | -0.0662 |
| | (0.238) | (0.244) | (0.234) | (0.303) |
| Strategic ambiguity X Lack of insight (WST1) | | | 0.212 | 0.298 |
| | | | (0.311) | (0.571) |
| Strategic ambiguity X Partial insight (WST1) | | | 0.0808 | 0.528 |
| | | | (0.415) | (0.834) |
| Strategic ambiguity X Lack of insight (WST3) | | | -0.321 | -0.0671 |
| | | | (0.332) | (0.458) |
| Strategic ambiguity X Partial insight (WST3) | | | -0.358 | -0.186 |
| | | | (0.319) | (0.466) |
| Strategic ambiguity X Lack of insight (WST4) | | | -0.260 | -0.142 |
| | | | (0.267) | (0.372) |
| Strategic ambiguity X CRT=1 | | | 0.583* | 0.523 |
| | | | (0.330) | (0.518) |
| Strategic ambiguity X CRT=2 | | | -0.165 | -0.164 |
| | | | (0.369) | (0.446) |
| Strategic ambiguity X CRT=3 | | | -0.361 | 0.0296 |
| | | | (0.363) | (0.479) |
| Strategic ambiguity X CU | | | -0.577 | -0.526 |
| | | | (0.431) | (0.633) |
| Constant | 0.0701 | 0.0919 | -0.125 | 0.174 |
| | (0.229) | (0.380) | (0.213) | (0.437) |
| Observations | 85 | 70 | 85 | 70 |
| R-squared | 0.102 | 0.300 | 0.197 | 0.349 |
| Demographics | NO | YES | NO | YES |
| Controls | NO | YES | NO | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

### *E.2.2. Nature, Social and Strategic Ambiguity*

**Table E.2.2.** A-insensitivity and CRT scores and insight on WST

| *Dependent variable= A-insensitivity* | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| Social ambiguity | -0.0198 | 0.0249 | -0.319 | 0.820 |
| | (0.109) | (0.110) | (0.449) | (0.604) |
| Strategic ambiguity | 0.0840 | 0.144 | 0.299 | 0.715* |
| | (0.119) | (0.130) | (0.347) | (0.382) |
| Cognitive uncertainty (normalized) | 0.339** | 0.213 | 0.405 | 0.0501 |
| | (0.154) | (0.186) | (0.244) | (0.290) |
| CRT score=1 | -0.371** | -0.231 | -0.888** | -0.640 |
| | (0.183) | (0.185) | (0.445) | (0.502) |
| CRT score=2 | -0.130 | -0.221 | -0.637*** | -0.549** |
| | (0.130) | (0.158) | (0.199) | (0.241) |
| CRT score=3 | -0.241** | -0.331*** | -0.547*** | -0.372** |
| | (0.103) | (0.116) | (0.135) | (0.174) |
| *Insight in WST.1* | | | | |
| Lack of insight | 0.0819 | 0.111 | 0.235 | 0.624 |
| | (0.191) | (0.212) | (0.400) | (0.497) |
| Partial insight | -0.138 | -0.265 | -0.210 | 0.00954 |
| | (0.207) | (0.224) | (0.334) | (0.433) |
| *Insight in WST.3* | | | | |
| Lack of insight | -0.0263 | -0.131 | -0.0696 | -0.133 |
| | (0.135) | (0.117) | (0.168) | (0.289) |
| Partial insight | 0.0102 | -0.00300 | 0.224 | 0.222 |

| | | | | |
|---|---|---|---|---|
| | (0.137) | (0.126) | (0.167) | (0.267) |
| *Insight in WST.4* | | | | |
| Lack of insight | 0.00721 | -0.0207 | 0.100 | 0.271 |
| | (0.156) | (0.176) | (0.148) | (0.208) |
| Partial insight | 0.105 | 0.127 | 0.197 | 0.383* |
| | (0.156) | (0.166) | (0.160) | (0.207) |
| Social ambiguity X Lack of insight WST.1 | | | -0.459 | -1.130* |
| | | | (0.487) | (0.659) |
| Social ambiguity X Partial insight WST.3 | | | -0.178 | -0.889 |
| | | | (0.460) | (0.661) |
| Strategic ambiguity X Lack of insight WST.1 | | | -0.150 | -0.442 |
| | | | (0.357) | (0.418) |
| Social ambiguity X Lack of insight WST.3 | | | 0.276 | 0.0220 |
| | | | (0.323) | (0.424) |
| Social ambiguity X Partial insight WST.3 | | | -0.0261 | -0.218 |
| | | | (0.309) | (0.444) |
| Strategic ambiguity X Lack of insight WST.3 | | | -0.0451 | 0.0770 |
| | | | (0.249) | (0.367) |
| Strategic ambiguity X Partial insight WST.3 | | | -0.384 | -0.308 |
| | | | (0.248) | (0.328) |
| Social ambiguity X Lack of insight WST.4 | | | 0.134 | 0.00818 |
| | | | (0.257) | (0.341) |
| Strategic ambiguity X Lack of insight WST.4 | | | -0.223 | -0.454 |
| | | | (0.291) | (0.358) |
| Strategic ambiguity X Partial insight WST.4 | | | -0.0971 | -0.362 |
| | | | (0.283) | (0.346) |
| Social ambiguity X CRT score=1 | | | 0.375 | 0.179 |
| | | | (0.507) | (0.567) |
| Social ambiguity X CRT score=2 | | | 0.820*** | 0.524 |
| | | | (0.292) | (0.396) |
| Social ambiguity X CRT score=3 | | | 0.649*** | 0.0880 |
| | | | (0.246) | (0.268) |
| Strategic ambiguity X CRT score=1 | | | 0.959* | 0.662 |
| | | | (0.499) | (0.593) |
| Strategic ambiguity X CRT score=2 | | | 0.655* | 0.351 |
| | | | (0.360) | (0.429) |
| Strategic ambiguity X CRT score=3 | | | 0.288 | 0.137 |
| | | | (0.328) | (0.377) |
| Social ambiguity X CU | | | 0.327 | 0.684 |
| | | | (0.332) | (0.414) |
| Strategic ambiguity X CU | | | -0.250 | 0.109 |
| | | | (0.441) | (0.531) |
| Constant | 0.230 | -0.0347 | 0.194 | -0.431 |
| | (0.200) | (0.340) | (0.396) | (0.626) |
| Observations | 127 | 106 | 127 | 106 |
| R-squared | 0.125 | 0.296 | 0.276 | 0.401 |
| Demographics | NO | YES | NO | YES |
| Controls | NO | YES | NO | YES |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1