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Ambiguity Attitudes and Beliefs about Others in the Public Goods Game

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Abstract. This study investigates the Public Goods Game (PGG) and the role of ambiguity attitudes and beliefs about others' tendency to contribute, in someone's own contribution decision. The PGG is framed as the environmental issue of sustaining the global climate. This research employed a recently introduced quantitative method that allows to measure ambiguity attitudes for natural events. Such a natural event includes the move of an opponent in the Public Goods Game. This method measures two components of the ambiguity attitude: *ambiguity aversion* and *a(mbiguity)-insensitivity*. In addition, the ambiguity neutral *beliefs* about others' tendency to contribute, while controlling for ambiguity attitudes, are revealed. The results show that ambiguity plays a role in the contribution decision. Specifically, ambiguity neutral *beliefs* about others' tendency to contribute are strongly related to people's own contributions: optimistic beliefs about others' are associated with higher contribution levels. This relationship is weakened by a subject's a-insensitivity. As a result, to what extent subjects are guided by beliefs depends on their ambiguity attitude. The results did not support the expectation that ambiguity aversion decreases contribution. In general, this paper extends prior research by showing how the role of ambiguity attitudes in games can be studied empirically.

Keywords: ambiguity attitudes, Public Goods Game, a-insensitivity, ambiguity aversion, cooperation, contribution, beliefs.

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1 Introduction

The last two centuries, human population has been growing exponentially and economic globalisation has become a trend (Hansen et al., 2006; Roser & Ortiz-Ospina, 2017). This sharpens the debate concerning the protection of our common resources, which was already mentioned by Hardin in 1968. With regards to our common resources, there are two main drivers of the environmental change we are witnessing. First, there is an increase in total and per capita demand for these resources. Second, the way we take care of these resources is increasingly insufficient (Dietz, Ostrom, & Stern, 2003). The challenge of managing our resources is a typical example of a tradeoff between private and collective interests. A situation in which the temptation of choosing short-term self-interest outweighs decisions in the collective interest, in which neglecting the collective benefit will harm society in the long run, is referred to as a social dilemma (Kollock, 1998).

The environmental issue of managing common resources is a social dilemma and is referred to as a common dilemma (Hardin, 1968; van Lange, Joireman, Parks, & van Dijk, 2013).

The Tragedy of the Commons depicts a common dilemma. Hardin (1968) uses a simple example of grazing land. Herd animals are grazing on common land that yields enough food to support the population. However, when natural controls break down due to, for example, medicines, the population of herd animals will increase, resulting in the scarcity of grazing land. As a result, if everyone acts in their own interest, the already scarce resources will become even more scarce, making it impossible to sustain the population in the long run. To prevent this Tragedy of the Commons, a better understanding of how people make decisions in social dilemmas helps policy design.

In the field of Behavioural Economics, game theory is used to gain more insights and understand the mechanisms that drive public choices. This study examines how people make decisions in The Public Goods Game (PGG). This game offers a game theoretical simplification of the environmental decision problem. The game is suitable for the common dilemma, since the PGG is a multiple player game in which the players anonymously and simultaneously have to make a decision. Each player receives an endowment and needs to decide how much to contribute to a public good and how much to keep privately. Full contribution of all players gives the socially efficient outcome (Andreoni, 1988). However, the payoff structure induces people to act according to their short-term self-interest and to not contribute at all. Because of these characteristics, the PGG is a good reflection of the conflict between a person's short-term self-interest and the collective benefit outlined in the environmental common dilemma, which is addressed in this paper (Dawes, 1980).

In games, traditional analyses assumed that all uncertainties can be modeled as risk. Risk refers to a situation where probabilities are known (von Neumann & Morgenstern, 1944). If probabilities are unknown, it refers to *ambiguity*. Since the contribution decision of others is unknown in the PGG, and assigning probabilities to this decision is challenging, the decision is studied as a decision under ambiguity. Empirical research stressed the importance to distinguish between attitudes towards risk and attitudes towards ambiguity (Ellsberg, 1961; Butler, Guiso, & Jappelli, 2014 Trautmann & van de Kuilen, 2015).

Ambiguity attitudes have been found to consist of two components; aversion and insensitivity (Baillon, Huang, Selim & Wakker, 2016; Li, Turmunkh, & Wakker, 2017). The first component, *ambiguity aversion*, is the tendency to avoid ambiguous events by rather choosing risky events. An ambiguity adverse subject is willing to pay a premium to avoid ambiguous prospects. The second component, *a(mbiguity)-insensitivity*, captures a subject's insensitivity to likelihoods (Abdellaoui, Baillon, Placido, & Wakker, 2011; Dimmock, Kouwenberg, & Wakker, 2016). A-insensitivity is also explained as perceived ambiguity for different likelihoods of an ambiguous event (Baillon et al., 2016; Dimmock et al., 2016).

Although many theoretical studies acknowledged the existence of ambiguity, experimental studies, concerning games, are not widespread. A possible reason for this is the difficulty to measure ambiguity, since it necessitates the control for subjective *beliefs*. Whereas, in artificial experiments, beliefs can be controlled by symmetries in the experimental design, for natural events (including social interactions), on the other hand, such symmetries are not available. Therefore, many experimental studies did not distinguish between beliefs and ambiguity attitudes, and assumed beliefs to be ambiguity neutral additive probabilities (Andreoni & Sanchez, 2014; Rubinstein & Salant, 2016).

To better understand how people make decisions in the environmental common dilemma, this study analyses behaviour by the use of a PGG. The purpose of this study is to investigate people's ambiguity attitude and beliefs about others' tendency to contribute, and how these affect their own decisions. In this study, a recently introduced method of Baillon et al. (2016) is used, which measures ambiguity attitudes, without the need for a symmetric experimental design. Li et al. (2017) extended the method of Baillon et al. (2016) to games. This method allows for the separation of beliefs and ambiguity attitudes, which is needed to draw more realistic predictions about people's behaviour.

In this study, the following research question is answered:

What is the role of ambiguity attitudes and beliefs about others' tendency to contribute in the Public Goods Game, in someone's own contribution decision?

This research is structured as follows: First, a literature review is presented whereby the literature on social dilemmas, the PGG, and ambiguity are summed up. In Section 3 the method of this study is explained. The results of the experiment are presented in Section 4. Section 5 discusses the methodological limitations and recommendations for further research. Finally, in Section 6, the conclusions of the study are drawn.

2 Literature review

This section serves to discuss the related literature and elaborates on the hypotheses. This section starts with an explanation of a social dilemma, related to the environmental issue addressed in this research. Second, the PGG is briefly explained. This is followed by a link between the game's characteristics and its suitability to analyse behaviour in social dilemmas. Section 2.3 discusses the literature behind ambiguity attitudes, its specific components, and its impact on behaviour. Some studies are reviewed that did not take ambiguity attitudes into account. The impact of belief measurements without controlling for ambiguity is discussed. Finally, the hypotheses are formalised.

2.1 Social dilemmas

As mentioned in Section 1, a social dilemma describes a situation in which individually reasonable behaviour is not aligned with collectively rational behavior. Many challenging problems we encounter are in their core social dilemmas. Although everyone would be best off if all cooperate and make the socially cooperative choice, the individual payoff is higher when neglecting the collective benefit (Dawes, 1980). As a result, this individually reasonable, or self-interested, behaviour can result in a situation in which everyone is worse off (Kollock, 1998).

The protection of the global climate concerns a common dilemma. Common resources are susceptible for overuse and it is costly to exclude others from benefiting from it (Kollock, 1998). Typically, overuse makes these common resources prone to the Tragedy of the Commons. Back to the example of Hardin (1968), in which herders use a common resource to graze their animals on. Every herder receives the benefits of an additional animal, but the costs of using the grazing land are shared by all herders. It is individually reasonable for the herders to increase short-term benefits by having as many animals as possible. However, if all make this individually reasonable decision, the common grazing land will be destroyed. Due to overuse, the grazing land is not beneficial anymore when it has no time to renew. Hence, in the long run it is necessary to protect the grazing land for overuse. This social dilemma explains the particular case of a common dilemma. Similar to the grazing land is the use of common global resources. And, consequently, overusing common resources do eventually destroy the sustainability of the global climate.

It is a challenge to manage our common resources together. To solve common dilemmas, several distribution rules have been proposed. For example, one person owns the common and makes sure others' use it properly. Private, state, or institutional ownership to control the resources sounds simple, but is not always successful in practice (Ostrom, Dietz, Dolšak, Stern, Stonich, & Weber, 2002). As rules and norms formulated by institutions are bounded, overlapped, or mingled, regionally and globally, no common consensus exists concerning the use of common resources (Deryugina & Shurchkov, 2016; North, 1981). Inadequate governance, or conflicting interests, when sharing the commons, may lead to inefficient long run decision making and results in dilution of common resources. Successful protection of the commons by property rights seems difficult and is not always possible (Dietz et al., 2003). Individual sacrifices are required in efforts to mitigate the effects of global warming (Milinski, Sommerfeld, Krambeck, Reed, & Marotzke, 2008).

Experimental games are widely used in order to understand behaviour. Better understanding of human behaviour and its implications is prudent for better policy design. The common dilemma addressed in this research is best explained with the use of The Public Goods Game, which is elaborated on next.

2.2 Public Goods Game

This research employes the PGG to study how people make decisions in the environmental decision problem. In the standard PGG, there are multiple players. To increase the value of the public pot, players need to cooperate. The public good is non-excludable (no one can be excluded from its use) and non-rivalrous (use of the good does not diminish the avalability of the good to others) (Daly & Farley, 2011; Dawes, 1980). In practice, many public goods are not non-excludable or non-rivalrous. A typical rival good is referred to as a common good. Generally, common goods are natural or common resources (Archetti & Scheuring, 2012), which relates to the topic discussed in this research.

In the general design of the PGG, each player receives a private endowment of tokens. Subjects secretly choose how many of the private tokens to contribute to a group account. This group account acts as the public good. The total amount of tokens contributed in the group account is multiplied and equally divided among the players (Kagel & Roth, 1995). This multiplication factor is always higher than one, so that groups of cooperators are better off than groups of defectors (Szabó & Hauert, 2002). Hence, the outcome when everyone chooses to fully cooperate is preferable from every player's point of view compared to when everyone fully defects. Full cooperation is the Pareto-efficient outcome, in which no one's situation can be better off without making others' situation worse. However, this game rarely ends in the Pareto-efficient outcome, since the dominant strategy for all subjects is not contributing at all, which is the Nash equilibrium. Specifically, the private return of not contributing at all exceeds the private return from the public good, regardless of what others do (Andreoni, 1988).

The PGG illustrates the environmental common dilemma in a good way for several reasons (Dawes, 1980). First, more than two players are involved. Typically, the protection of the global climate involves the whole world. Second, anonymity is ensured, since the outcome of the game does not reveal the action(s) of others. Others' behaviour concerning the environment is hard to trace. Furthermore, players of the game cannot control outcomes of others and it is impossible to influence others' behaviour. Full control of the sustainment of the global climate is not possible. Taking actions to sustain the global climate is necessary, however, there is uncertainty about what others do and the value of private sacrifices are unknown. Finally, the costs of free-riding are shared by all players. If not enough efforts are provided to sustain the global climate, by limiting the use of common resources, there is a cost of global warming/dilution of common resources (Ostrom et al., 2002).

Although its simplification, controlled experiments shed light on the important factors that induce subjects to cooperate (Archetti & Scheuring, 2012). Classical game theory predicts equilibrium of zero contribution in the PGG, since the possibility that others might free-ride, while you contribute, is costly. Subjects that contribute below average are defecting on the collective benefit and are called free-riders. As a matter of fact, in reality, this game rarely ends in this equilibrium, but people have the tendency to cooperate (Andreoni, 1995). Cooperators are subjects that contribute equal to or above average. This deviation from the Nash equilibrium would be optimal when all players fully cooperate, to reach the Pareto-efficient outcome.

Many studies addressed the deviation from the zero predicted contribution. Most people are conditionally cooperative and tend to choose the collective interest if they believe that many others' will do the same (Brandts & Schram, 2001; Fischbacher & Gächter, 2006; Fischbacher, Gächter, & Fehr, 2001; Keser & Van Winden, 2000). According to Andreoni (1995), it is important to shift focus from showing under what circumstances people cooperate to the development of models that explain preferences for cooperation. Typically, the decision to cooperate in the PGG is a decision under ambiguity. Therefore, next, this study elaborates on ambiguity attitudes and the importance to analyse social interactions with models for ambiguity.

2.3 Ambiguity attitudes

Since many decisions are made under uncertainty, ambiguity attitudes affect many decisions. Knight (1921) and Keynes (1921) were the first to distinguish between measurable and unmeasurable uncertainty. Measurable uncertainty is called risk, which involves uncertainty over future outcomes with known probabilities. Unmeasurable uncertainty, nowadays known as ambiguity, describes uncertainty over future outcomes with unknown probabilities.

Initially, research only focused on ambiguity aversion, mentioned earlier, as the first component of ambiguity attitudes. Ellsberg (1961) showed the impact of ambiguity on decision making in an experiment using two urns, the known and the unknown urn. Both urns consist of the same amount of balls. For the known urn, the proportion of red and black balls is visible and equally divided, whereas this information is not visible for the unknown urn. The decision maker wins €10 when a red ball is drawn from one of the urns. Drawing a red ball from the known urn has an objective probability of 0.5 and drawing a red ball from the unknown urn has a subjective probability of anywhere between 0 and 1. In this experiment, Ellsberg (1961) controlled for subjective *beliefs*, since the simple structure induced people to reason towards the symmetry of balls and urns that, eventually, made both events equally likely. If a subject chooses the known urn, this reveals that he or she believes that the probability for a red ball in the known urn is larger than 0.5. Then, if the subjective probabilities are additive, the probability for a black ball is smaller than 0.5, and the unknown urn should be chosen when asking for a black ball.

However, empirical evidence showed that, again, the known urn is the more preferred source of uncertainty. In fact, people tend to be *ambiguity averse* and prefer the risky, known urn over the ambiguous, unknown urn (Ellsberg, 1961). This incompatibility of preferences shows a violation of expected utility. Savage's (1954), Expected Utility Theory is based on the Bayesian approach that dictates additivity of subjective probabilities and assumes that people base their decision on these probabilities. So, according to the Expected Utility Theory, subjects are indifferent between the two urns. Ellsberg (1961) showed the systematic violations with Bayesian (ambiguity neutral) additive probabilities. Preferences are influenced by subjective beliefs and attitudes towards ambiguity (Gilboa & Schmeidler, 1989).

The elegance of Ellsberg's (1961) symmetry of the balls and urns is misleading, since many situations exist in which there is no possibility for symmetry. To illustrate, natural events, including social interactions, are subject to high degrees of uncertainty that are not easily quantified (Gilboa & Marinacci, 2016). Therefore, in addition to the ambiguity aversion hypothesis, Heath and Tversky (1991) and Fox and Tversky (1995) showed the idea of sources of uncertainty. Different sources of uncertainty affect subjective probability judgements and the weightings of these beliefs. A source of uncertainty is a group of single events plus its composites with the same characteristics i.e. belong to the same context. Heath and Tversky (1991) found support for the competence hypothesis, which is a particular kind of source preference. Competence theory states that a subjects' knowledge and competence influences preferences between uncertain prospects in the domain of gains (Ghosh & Ray, 1997). To illustrate, the AEX-index differs from the Euro-index. A Dutch person is likely to prefer betting on the AEX, since he or she feels more competent and knowledgeable about her home county. Heath and Tversky (1991) and Fox and Tversky (1995) distinguished between a person's beliefs and preferences.

To relate this competence theory to the Ellsberg (1961) example, the average subject felt unknowledgeable and incompetent about the unknown urn, and chose the known urn. However, people do not always prefer known over unknown probabilities. Fox and Tversky (1995) showed that basketball fans prefer to bet on the outcome of the game (ambiguous event) rather than on a matched chance event (risky event). The reason that they prefer to bet on knowledge rather than on luck is that they feel competent. This competence differs between decision contexts, as well as the perceived ambiguity (Gilboa & Schmeidler, 2003).

Although first it was thought that there was no possibility to model probabilities in order to make better universal models of ambiguity, Chew and Sagi (2008) succeeded to model source preferences. They allowed for pessimistic or optimistic weighting of the assigned probability to an uncertain event. The weighting depends on the source of uncertainty. As with the Ellsberg (1961) example, you can assign a subjective probability of 0.5 for drawing a black ball from the unknown urn and still prefer the known urn where the probability of drawing a black ball is 0.5 as well. So the judged probability of 0.5 for the unknown urn is weighted more pessimistically than the objective probability of 0.5. When a person is ambiguity neutral he or she is indifferent between the two sources. A person's ambiguity attitude drives the preference for the known urn. Baillon et al. (2016) called the assigned subjective probability the a(mbiguity)-neutral probability, which is a quantification of *beliefs*. So, when a person is ambiguity neutral, in making a decision, he or she is entirely guided by these beliefs.

Initially research focused on ambiguity aversion in general as the first components of the ambiguity attitude. *Ambiguity aversion* is driven by the emotional feeling of (dis)liking an ambiguous event (Li, 2016). Knowledge about an event can increase the feeling of liking as seen by the preference of the known over the unknown urn.

In recent years, another component of the ambiguity attitude became more recognised. This second component, based on the inverse probability weighting function found for risk, is insensitivity to likelihood changes (Fehr-Duda & Epper 2012; Gonzalez & Wu 1999). After empirical proof, the insensitivity is extended to cases of ambiguity. Baillon et al. (2016) used the term *a(mbiguity)-insensitivity* to refer to the cognitive inability to assign subjective probabilities to ambiguous events (Dimmock et al., 2016; Li, 2016). An *a-insensitive* individual perceives higher ambiguity and has lower discriminatory power towards likelihood events. All ambiguous events are perceived as one big blur, described by the perceptual phenomenon of regression to the mean, and are taken as 50-50 (Abdellaoui et al., 2011; Dimmock et al., 2016; Trautmann & van de Kuilen, 2015). Predictions can go in the wrong direction when we only focus on the first component, *ambiguity aversion* (Trautmann & van de Kuilen, 2015). Variations in the two components, *ambiguity aversion* and *a-insensitivity*, induced by sources of uncertainty and levels of likelihoods, predict different behaviour for the same individual.

Although many theoretical studies acknowledged the existence of ambiguity, many experimental studies concerning games are not catching up enough with the theory. One reason for that is the difficulty to deal with ambiguity. Natural events or strategic interactions are subject to high degrees of uncertainty that are not easily quantified (Gilboa & Marinacci, 2016). Baillon et al. (2016) introduced a method that quantifies ambiguity attitudes, without the need for symmetries of beliefs. Li et al. (2017) extented the method of Baillon et al. (2016) to quantify this ambiguity in games and find a significant effect of ambiguity attitudes on the decision to trust.

Some research has shown that ambiguity aversion has a meaningful effect (Ellsberg, 1961; Fox & Tversky, 1995; Maccheroni, Marinacci, & Rustichini, 2006; Abdellaoui et al., 2011; Trautmann & van de Kuilen, 2015; Dimmock et al., 2016; Li et al., 2017; Li, 2016). On the other hand, some studies still assume ambiguity neutrality. For example, Rubinstein and Salant (2016) asked the subjects to report their beliefs about others' decisions and assumed ambiguity neutrality when examining self-similarity in strategic interactions. A subject is influenced by self-similarity if she beliefs that the others player will choose the same action to a greater extent than a subject who chooses another action. This contradicts strategic justification, which predicts a subject to choose an action that is optimal with respect to beliefs. Andreoni and Sanchez (2014) elicit stated and revealed beliefs of subjects in the trust game. They find a big gap between revealed and stated beliefs for selfish players. Selfish subjects lied about their beliefs about others' actions to justify their own action. The revealed beliefs were in line with strategic justification. Andreoni and Sanchez (2014) did not take ambiguity attitudes into account, which could be responsible for the differences between these beliefs. This necessitates investigation of the role of beliefs while correcting for ambiguity attitudes.

2.4 Hypotheses

Taking the research question and the reviewed literature in mind, I formulated three hypotheses. The hypotheses incorporate subjects' contribution decision in the PGG and the role of their ambiguity attitudes and beliefs about others' tendency to contribute in this decision. Since context matters, the uncertainty is framed as environmental uncertainty. *Ambiguity aversion* and *a-insensitivity* are both quantified by an index, which I elaborate on in the next section. Optimistic *beliefs* about others' tendency to contribute are quantified as well. With these quantifications I examine the determination of subjects' contribution decisions.

There is not much research yet that distinguish between the two components of ambiguity attitudes in games with social interactions. Li et al. (2017) analysed the role of ambiguity attitudes and beliefs about others' trustworthiness, in the decision to trust in the Trust Game. It is found that *ambiguity aversion* has a significant negative effect on the decision to trust.

In this study, the contribution decision in the PGG is examined, and, relating this to previous findings, I expect subjects to feel vulnerable in a situation facing social uncertainty about what others shall decide. If you put efforts into sustaining the global climate by contributing private tokens to the common good and your opponents do not, you lose private benefits over the collective interest (Ostrom et al., 2002). Therefore, I expect subjects to feel more vulnerable when they dislike ambiguity and detain contribution. The first hypothesis is proposed:

H1: Ambiguity aversion decreases contribution in the PGG.

Many studies show that beliefs about others' decisions have a significant effect on behaviour in games (Andreoni & Sanchez, 2014; Croson, 2007; Rubinstein & Salant 2016). Most people are conditionally cooperative and tend to choose the collective interest if they believe that many others' will do the same (Brandts & Schram, 2001; Fischbacher & Gächter, 2006; Fischbacher et al., 2001; Keser & Van Winden, 2000).

However, as explained before, these belief measurements do not correct for ambiguity attitudes. Therefore, the relationship between a subject's optimistic beliefs about others' tendency to contribute and her own contribution decision is tested with the method of Baillon et al. (2016) that quantified ambiguity neutral beliefs. This leads to the second hypothesis:

> ***H2:*** Optimistic beliefs about others' tendency to contribute increases contribution in the PGG.

The last hypothesis is formed based on the study of Li et al. (2017). They suggested a relation between the second component of the ambiguity attitude, a-insensitivity, and ambiguity neutral beliefs' about others' trustworthiness. Indeed, the positive effect of optimistic beliefs about others' trustworthiness on someone's own trust decision, was weakened by a subjects' a-insensitivity. An a-insensitive subject is less capable of assigning subjective probabilities to an ambiguous event; all events are perceived as if they have fifty-fifty chance of occurrence. A-insensitive subjects deviate from ambiguity neutrality and perceive higher levels of ambiguity. This increases a subject's tendency to be guided by ambiguity attitudes, instead of relying on beliefs. As explained before, ambiguity neutrality predicts complete reliance on beliefs. When attitudes deviate from neutrality, beliefs are less pronounced in the decision to contribute.

Brandts and Schram (2001), in line with Keser and Van Winden (2000), use a partner and stranger treatment in their PGG-studies. Partners cooperate more compared to strangers. However, in the partner design, subjects have more information about the strategies of others. More information makes it easier to assign subjective probabilities to the actions of others. I assume that information decreases the perceived ambiguity, and therefore, that it is easier for the subjects to be guided by their beliefs about others' tendecy to contribute. Indeed, Fischbacher et al. (2001) found support for conditional cooperators, but expected that higher uncertainty increases free-riding behaviour. Therefore, I assume that optimistic beliefs about others do not always imply higher contribution levels for conditional cooperators, as this positive effect might be weakened by a-insensitivity. This result in the third hypothesis:

> ***H3:*** A-insensitivity decreases the effect of optimistic beliefs about others' tendency to contribute in the PGG.

3 Method

In this section, I present the specific PGG I employ in this research. Since I am interested in strategic interactions between individuals concerning the sustainment of the global climate, this game is framed in an environmental manner. Thereafter, I elaborate on the method to measure *ambiguity aversion*, *a-insensitivity* and a-neutral *beliefs*. In Section 3.3, the indices for ambiguity aversion and a-insensitivity are explained in detail, as well as the index for a-neutral beliefs. Finally, the last section describes how the matching probabilities are elicited.

3.1 The game

A one-shot linear Public Goods Game, examined by Fischbacher et al. (2001), is used to illustrate the common dilemma (environmental frame). The public good is called the *climate account*. Money collected on the climate account is dedicated to research and campaigns concerning the sustainability of the global climate, i.e. the earth. Four players are randomly grouped together and each player receives an endowment of 11 tokens. Each player decides how much tokens to contribute to the climate account, and how much to keep for themselves. The total contribution to the climate account is doubled and divided over all players. The final payment to each player is:

$$Payoff_i = 11 - g_i + 0.5 * \sum_{j=1}^{4} g_j,$$

where g_i is the contribution of player i to the climate account and the sum of g_j is the total group contribution to the climate account. Hence, the level of g_j displays the extent to which players contribute to the climate account. So, consequently, subjects contribute to research and campaigns in order to preserve the global climate. The marginal benefit of a token kept privately exceeds the marginal benefit of a token contributed to the climate account. The private marginal payoff of contributing 1 token to the public good is 0.5 token, whereas the private payoff of not contributing is 1 token.

3.2 Matching probabilities

To use the method of Baillon et al. (2016), the condition of mutually and exhaustive events must be satisfied. Two events cannot happen at the same time; only one of the events (can) take place. For instance, it cannot rain and not rain at the same time. Instead, it will either rain or not rain, tomorrow at 4 o'clock. A *single event* is defined as E_i and a *composite event* is defined as E_{ij} , where $(i \neq j)$. Single and composite events are complements, which is denoted by $E_i \cup E_j$, so either event i or j. In this study, the possible contributions of the other three players to the *climate account* are events, which are defined by three single events. Since every player has knowledge about his or her own contribution, the ambiguous events are defined by the sum of tokens contributed by the other three group members. With an endowment of 11 tokens per player, the total contribution of the other three players is minimally 0 tokens and maximally 33 tokens. The actual event is the true contribution of the three opponent players. All possible contributions of the others players are categorized in three single events and three composite events. Table 1 defines the single events and Table 2 the composite events.

Table 1. *Single PGG-outcome events.*

Single events	Event E_1	Event E_2	Event E_3
The sum of tokens contributed by the other three group members	(0 - 10)	(11 - 22)	(23 - 33)

Table 2. *Composite PGG-outcome events.*

Composite events	Event E_{12}	Event E_{23}	Event E_{13}
The sum of tokens contributed by the other three group members	(0 - 22)	(11 - 33)	(0 - 10) or (23 - 33)

A convenient way for measuring ambiguity attitudes, while controlling for risk attitudes, is the elicitation of a subject's matching probabilities. Matching probabilities capture the ambiguity attitudes (Dimmock et al., 2016 Theorem 3.1). Baillon et al. (2016) elaborated on this method: they made it possible to measure ambiguity attitudes for natural events and added a control for subjective beliefs.

DEFINITION 1. Matching probability m_E of an event is the probability that makes the decision maker indifferent between an ambiguous and a risky prospect:

Receiving € x under event E (receiving nothing otherwise) is equivalent to receiving € x with probability m_E (receiving nothing otherwise), i.e. $(E, x) \sim (m_E, x)$.

x is the value of the lottery and is similar for both sources of uncertainty. In the experiment, x is fixed at €10. m_E is the matching probability of event E, which captures the subjective probability a decision maker assigns to event E, distorted by the ambiguity attitudes. Ambiguity neutrality would imply that the matching probabilities of the single and composite event will add up to 1, and the decision maker is entirely guided by beliefs. In that case, the matching probability is equal to the additive subjective probability. However, Figure 1 shows that matching probabilities most of the time deviate from the subjective probability assigned to an event, $m_E \neq P(E)$, showing non-additivity of probabilities. Figure 1 gives a good understanding of the two components mentioned earlier, *ambiguity aversion* and *a-insensitivity*. Deviation from the dotted line represents the overall deviation from neutrality; this stems from both ambiguity aversion and a-insensitivity. The willingness to bet on a risky event is not linearly increasing in probabilities, i.e. the subjective beliefs weights are non-linear. Low likelihoods are overvalued and high likelihoods are undervalued (see Figure 1), i.e. people tend to be ambiguity seeking for low probability events $(m_E > P(E))$ and ambiguity averse for high probability events $(m_E < P(E))$, whereas for the intermediate probabilities, attitudes are closer to ambiguity neutrality. So, moving away from moderate likelihood events give different implications (Fox & Tversky, 1995; Tversky & Kahneman, 1992; Tversky & Wakker, 2015).

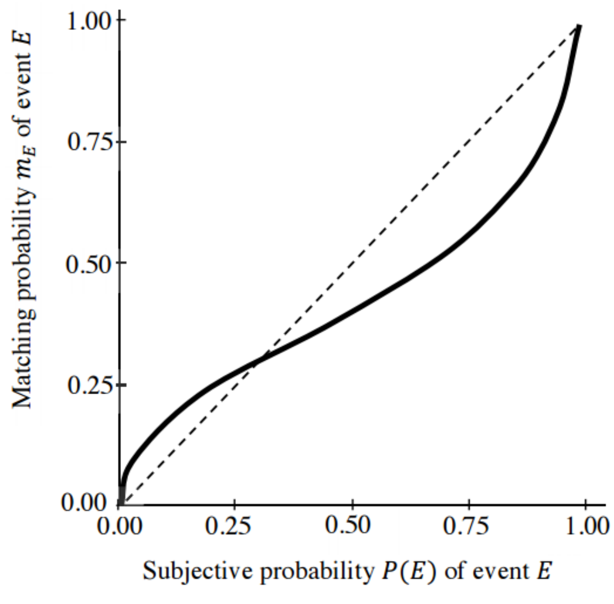


Figure 1. Commonly observed matching probabilities.

Note: Reprinted from *Ambiguity in Social Dilemmas* (No. 684) by U. Turmunkh, 2017.

A-insensitivity is reflected by the steepness/flatness of the black line. As mentioned in the literature review, research shows that variations in the perceived likelihood of an event induce different ambiguity attitudes for the same subject. Indeed, ambiguity attitudes solely depending on ambiguity aversion, might give wrong implications (Fox & Tversky, 1995; Tversky & Kahneman, 1992). A*mbiguity aversion* and *a- insensitivity* are presented in two indices, on which is elaborated on next.

3.3 Defining the indices

The indices consist of the average matching probabilities of all single events, $E_1,\ E_2,\ E_3$, and the average matching probabilities of the three composite events, $E_{12},\ E_{23},\ E_{13}$. The matching probabilities are written down as m_1 = $m(E_1)$, m_{12} = $m(E_{12})$, etcetera, $\overline{m}_s = the\ average\ of\ all\ single\ events$, and $\overline{m}_c = the\ average\ of\ all\ composite\ events$. The first index captures the emotional component (*ambiguity aversion*) and the second index captures the cognitive component (*a-insensitivity*).

DEFINITION 2. The *ambiguity aversion* index is defined as:

$$b = 1\ - (\overline{m}_s +\ \overline{m}_c).$$

DEFINITION 3. The *a(mbiguity-generated)-insensitivity* index is defined as:

$$a = 3 *\ (\tfrac{1}{3} - (\overline{m}_c - \overline{m}_s)).$$

The decision maker is ambiguity neutral if both indices are zero. This is known without controlling for subjects' beliefs. The first index shows the degree of aversion: an increase in ambiguity aversion results in a higher index. If the sum of the average matching probabilities of the single and composite events is smaller than one, $b > 0$, which implies that a subject is willing to pay a premium in order to avoid the ambiguous prospect. A person is maximally ambiguity averse when all matching probabilities are zero and $b = 1$. If the sum of the average matching probabilities is higher than one, $b < 0$, which indicates that a subject is ambiguity seeking.

The second index captures the perceived level of ambiguity that allows for different attitude expressions, for low and high likelihood events. A person that is not able to discriminate between the likelihoods of single and composite events, $\overline{m}_c = \overline{m}_s$, is perfectly insensitive, $a = 1$, and treats all ambiguous events as 50-50. Hence, a subject perceives the same level of ambiguity for each source of ambiguity even if the underlying information about the event changes. When the difference between $\bar{m}_c$ and $\bar{m}_s$ becomes bigger, the subject is more able to assign different levels of likelihoods to single and composite events. Most people find it hard to deal with ambiguous events and tend to be ambiguity insensitive to some extent. A higher a-insensitivity index implies more perceived ambiguity by a subject. This finding shows the importance of the a-insensitivity index as already emphasised by Abdellaoui et al. (2011) and Dimmock et al. (2016) in their empirical studies. Measuring the two components separately results in more reliable conclusions when examining decision making under uncertainty.

Besides the above indices, Baillon et al. (2016) control for subjective probabilities, without knowing this probability. A-neutral probabilities, i.e. additive subjective probabilities, are calculated after the correction for ambiguity attitudes. The a-neutral probabilities can be interpreted as the a-neutral *beliefs* about others' tendency to contribute to the climate account. Under certain assumptions[1] we can calibrate the a-neutral probabilities of all events with the information of the two introduced indices:

$$p_i = \frac{3(\bar{m}_c - \bar{m}_s) + 3m_i - 3m_{jk} + 2(1-\alpha)}{6(1-\alpha)},$$

where $\{i, j, k\} = \{E_1,\ E_2,\ E_3\}$.

With this equation, it is possible to estimate subjects' degree of optimistic a-neutral *beliefs* ($-1 \leq p_{E3}$-$p_{E1} \leq 1$) about others' tendency to contribute: an increase in optimistic beliefs result in a higher index. For instance, $p_{E3} > p_{E1}$, implies that E_3 is seen as more probable compared to E_1, this subject has optimistic beliefs. If, $p_{E3} < p_{E1}$, it means that E_1 is seen as more probable than E_3. This subject has more pessimistic beliefs.

3.4 The elicitation of matching probabilities

There are multiple ways of eliciting matching probabilities. Just asking people for probabilities can give biased results, because people in general have difficulties to come up with probabilities by themselves or they simply do not know it (Wakker & Deneffe, 1996). Binary choice is commonly used to overcome this difficulty. Choice lists and bisection are two ways of presenting binary choices. With the use of choice lists indifference is derived by the switching point between lists of choices. The first disadvantage of this method is the increased possibility of inconsistent answers, since a subject is only allowed to switch once. Another disadvantage is a bias towards the middle value of the lists of options (Andersen, Harrison, Lau, & Rutstrom, 2006). Baillon et al. (2016) used choice lists

[1] Violations of monotonicity often resulted in non-additive a-neutral probabilities. By calculating the interval and relative distance, additive a-neutral probabilities could still be calculated properly.

to elicit matching probabilities, whereas, others employed bisection (Abdellaoui et al., 2011; Li et al., 2017; Dimmock et al., 2016). Bisection is more efficient compared to the use of choice lists, since subjects encounter one choice at the time, which decreases noise (Johnson et al., 2015). Therefore, in this study, bisection is employed.

Experiments consisting of multiple tasks might suffer from wealth effects. Subjects accumulate earnings and the diminishing marginal return to money may change behaviour. Subjects might hedge the individual decision tasks with each other, perceiving it as a grand meta-lottery. Random lottery incentives are suited to solve this problem (Baltussen, Post, van den Assem, and Wakker, 2012). Although, theoretically it is argued that using random lottery incentives still provokes strategic answering and subjects do not perceive every decision task as isolated, this problem is not supported empirically (Cubitt, Starmer, & Sugden, 1998; Hey & Lee, 2005). Therefore, I combine bisection with a random lottery incentive system. I elaborate on this in the next section.

4 Experimental design

Subjects. A total of 147 subjects is recruited from the Erasmus University of Rotterdam and the University of Amsterdam to participate in the experiment. Only students participated, as homogeneity of the sample increases power. Other characteristics, such as age, gender, nationality, whether subjects volunteer or donate to charity and how often they eat fish or meat were asked. I did not control for other characteristics other than these demographic controls. Of the total of 147 participated subjects, 112 finished all the questions. Since all the answers were needed to calculate the indices, I only included the 112 observations that were fully complete.

Pilot Experiment. The implementation of the experiment was restricted to an online version. The online experiment needed to be simplified, since there were no resources available to implement the experiment in the lab, where experimenters have more control over the participants. Duration could not be too long, otherwise subjects would defect, and the tasks must be as easy as possible to read for consistent results. To test for effectiveness and understandability of the online version, a pilot survey was implemented, whereby ten individuals were asked to participate. Before participation, they received an email with feedback points like duration, payoff structure, and textual flow, to pay attention to. After the feedback was received and incorporated, one last check was done with three new participants to make sure the final version was ready to be distributed. The average duration of the online experiment was 12 minutes.

In order to examine the difference in understandability between Economic students and students from other fields, half of the pilot experiment participants have graduated in Economics and the other half has graduated in other fields, for example, Art, Nutrition and Health, and Policy, Communication and Organisation. The feedback session, as well as the control questions, made clear that everyone understood the choice situations, so I did not restrict the data collection to only Economics students.

Incentives. A random lottery incentive system was implemented to incentivise participants to reveal their true preferences. A between-subject randomisation was used to incentivise, meaning that out of all participants, one group of four participants was randomly selected to get paid according to one of their choices, after the experimental period. This was made clear at the beginning of the online experiment. Subjects played with tokens that were valued €1 per piece and they could earn a maximum of €22. Subscription of an email address at the end of the experiment enrolled the participants automatically into the random lottery.

In the introduction, the subjects were told that their earnings depended on one of the decisions made. Since there was a chance that one decision was paid out for real, they were asked to answer truthfully to get what they wanted. It was explained to the subjects that they were matched to three other players throughout the experiment, and so, formed a group of four. Payoffs were based both on their own and their opponents' decisions. It was clear that choices were simultaneously made in PART I. This outcome needed to be taken into account for the decision situations in PART II. Anonymity was ensured and subjects knew that opponents would never find out who they were.

To make sure the incentive system was incentive compatible, four participants instead of only one participant were paid out. Increasing the probability of winning increases subjects' incentives to answer truthfully (Ariely, Gneezy, Loewenstein, and Mazar, 2009). In this experiment, subjects encountered multiple choices. Hedging opportunities were eliminated by explaining the subjects that they were paid, if selected, according to one out of a total of 25 decisions encountered in PART I and PART II together.

Stimuli. The online experiment consisted of two parts. All participants faced the same decision context. The subjects encountered several decision situations, divided into two parts. In PART I, the subjects started by playing a four-player PGG. In PART II, the subjects faced several blocks, including lists of binary choices in order to elicit the matching probabilities. After every block of choice situations, concerning the same event, some non-incentivised demographic questions were asked.

PART I. The PGG: Sustaining the Earth (Figure 2) was encountered. The PGG was explained in the introduction and framed as if the players needed to sustain the global climate, the earth, as an open resource, together. The private payoff of 1 token stayed the same when a subject did not contribute and it became 0.5 token when the subject did contribute. The collective payoff was doubled and divided between the players. There were two payoff functions, namely, the final payoff of the participant and the climate account payoff, which was donated to Greenpeace. So, the collective part of subjects' payoff function, the total group contribution in the climate account, was actually produced. The standard PGG does not do this. The instructions stressed free choice of contribution. Subjects were asked to make their contribution decision, when everything was clear to them.

PART I. SUSTAINING THE EARTH

Every group member receives 11 tokens privately. You can contribute your tokens to a climate account. The climate account is responsible for research and campaigns concerning the sustainability of the earth. Tokens that you do not contribute will stay in your private account.

The total amount of tokens contributed to the climate account by the group will be doubled and equally divided between all group members. Your final payoff depends on your own contribution and that of others'. It will be:

Your final payoff =
(11 - your contribution) + ¼ * (2 * total group contribution in the climate account),

where the total group contribution is your contribution plus the sum of contributions from the other 3 group members.

Climate account payoff =
2 * total group contribution in the climate account.

The climate account payoff is donated to Greenpeace.

This decision may be paid out for real, so please answer truthfully, no answer is right or wrong.

Now decide how much tokens you contribute to the climate account in order to sustain The Earth:

0 1 2 3 4 6 7 8 9 10 11

Amount of tokens

Figure 2. Decision context of the first part of the experiment.

PART II. Subjects faced various lists of choice situations to elicit the matching probabilities. A four-step bisection was implemented for each single and composite event. Each single and composite event formed a block, so a total of six blocks indicated a total of 24 decision tasks per subject. Each decision task included a binary choice between an ambiguous event, public good-contingent money (option 1), and a risky event, probability-contingent money (option 2). When a subject instructed the experimenter to pay according to option 1, the outcome of the game determined the payoff, and when the subject instructed the experimenter to pay according to option 2, a random number determined the payoff. Since subjects knew their own contribution, option 1 was presented as the sum of the other three group members' contribution. Before subjects faced the real decisions lists, two examples were presented to make the payoff structure clear (Figure 3). After the example the subjects encountered two control questions to check for understandability.

PART II. EXPLANATION

Suppose the real choice situation selected for you is the one below.

Option 1:
We pay you €10 if the sum of the other 3 group members' contribution is between 0-10 tokens in the previous game.

Option 2:
We pay you €10 with 50% probability.

Please instruct the experimenter according to which option you want to be paid out.

► If you choose option 1, then your payment is:

€10 if **the sum of the other 3 group members' contribution in the previous game is** between 0-10 tokens, and €0 otherwise.

For instance, if the sum of contribution was 10 tokens, you will get €10; but if the sum was 20 tokens, you get €0.

► If you choose option 2, then your payment is:

€10 if a **random number drawn** between 1 and 100 is no bigger than 50, and €0 otherwise. Your group members' contribution in the previous game plays no role.

For instance: if the number drawn is 80, you get €0; but if it is 30, you will win €10.

To ensure you have a good understanding of the experiment, some control questions are asked next.

Figure 3. The explanation of the real decision situations.

Subjects now encountered the real choice situations. To ensure people did not engage in strategic answering, every decision task was presented as if it was the real choice situation (Figure 4). One question could not manipulate other questions and subjects could not manipulate the outcome. Each question was isolated as if this was the only one and paid for real. The ambiguous event stayed the same during one block, while the risky event was adjusted in each subsequent list of choice situations, depending on the given answer before. Every block started with a probability of 50%. Figure 4 shows the first decision situation for the single event E_3. Subjects' choice for option 2 when probability is 50% automatically implies a preference for option 2 for every $p > 50\%$, so the probability of winning in the next decision task decreased to make the ambiguous event more attractive. This adjustment of the probability between each decision task shirked for each step, which resulted in an indifference point within ±0.03 bounds after the fourth choice (Figure 5). In this way the following matching probabilities were elicited:

$$(E_1, €10) \sim (m_1, €10)$$
$$(E_2, €10) \sim (m_2, €10)$$
$$(E_3, €10) \sim (m_3, €10)$$
$$(E_1\ or\ E_2, €10) \sim (m_{12}, €10)$$
$$(E_2\ or\ E_3, €10) \sim (m_{23}, €10)$$
$$(E_3\ or\ E_1, €10) \sim (m_{31}, €10)$$

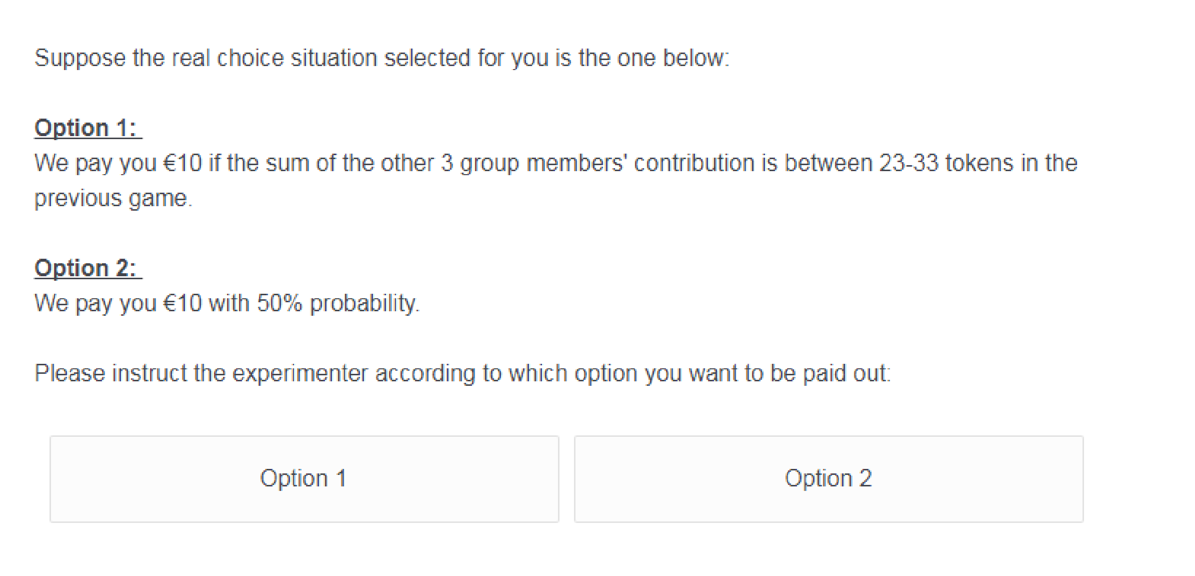
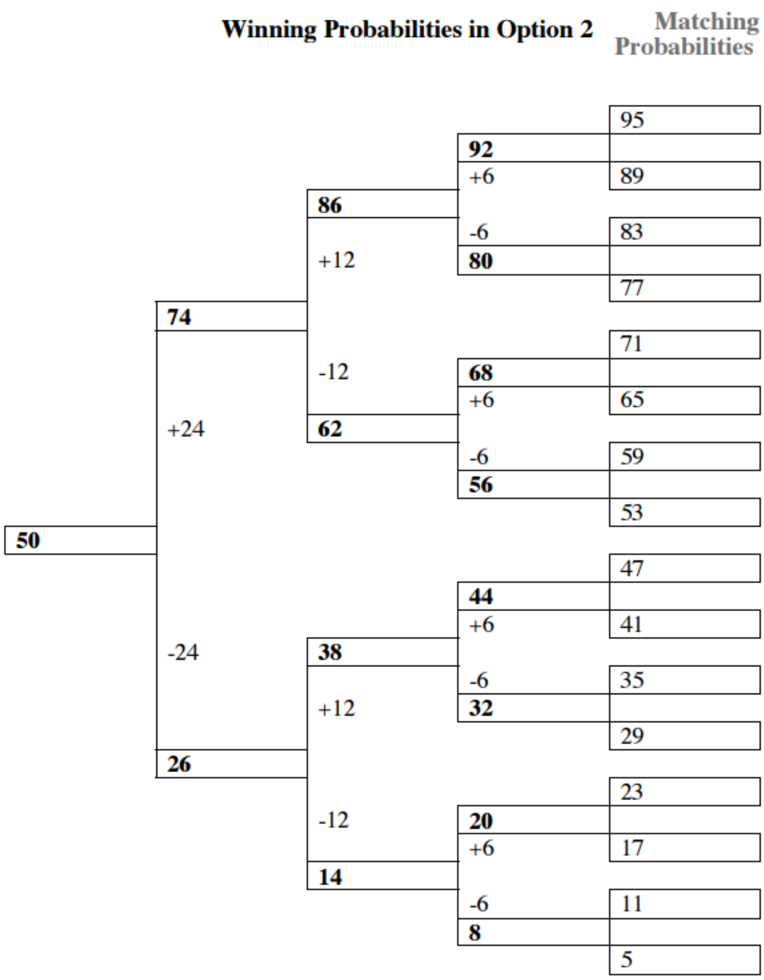


Figure 4. Binary choice between PG-contingent money and probability-contingent money.



Note: Every subject starts with the decision between public good-contingent money (option 1) and 50% probability-contingent money (option 2). Depending on the choice, the probability goes up or down after each subsequent question. For example, a subject choosing option 2 in each four decisions ends with a matching probability of 5%.

Figure 5. Determination of matching probabilities with bisection.

Note: Reprinted from Trust as a Decision under Ambiguity by C. Li, U. Turmunkh, & P.P. Wakker, 2017. Working paper.

The decision blocks were randomly presented to the subjects to control for order effects. The personal questions about age, gender, nationality, charity, volunteering and eating habits were asked to refresh subjects' thinking mode and appeared in random order as well.

Payment. After the experimental period, the total of 112 participants was randomly divided over 28 groups of four. One of the 28 groups was randomly selected to be paid out. This group was determined by drawing a number ranged from 1 to 28, using the true random number generator[2]. After determining the winning group, one out of 25 decisions was randomly selected for each subject individually. All payoffs depended on one of the choice situations. The decision in the selected real choice situation determined the payoff for the subject. If the subject instructed the experimenter to play the outcome of the game for this particular list, the participant earned €10 when the outcome of the game in PART I is between the given amount of tokens and €0 otherwise. If the subject instructed the experimenter to pay according to option 2, a random number was drawn which determined the payoff. A choice for option 2, with for example 50% probability, paid out €10 if random number was below 50[3], and otherwise nothing. In addition, the total payoff was calculated per subject and emails were sent with personal information about the private payoff and the total group contribution in the climate account, which is doubled and donated to Greenpeace.[4] The participants that were not selected to be paid out, received an email to inform them about the total Greenpeace donation[5].

5 Results

In total, 112 participants completed the online experiment. First, I started to analyse the 112 collected observations by means of monotonicity. Second, the remaining data was analysed by means of descriptive statistics, to get a better understanding of the examined variables. Lastly, non-parametric tests and multiple regression analyses were used to examine the hypotheses.

5.1 Monotonicity

The decision tasks encountered by the subjects in the online experiment required cognitive ability. For this reason, I performed the pilot survey, incorporated two control questions and only recruited university students. Despite these control measures, a part of the participants failed monotonicity tests, which means that these subjects were not able to fully understand the decision tasks.

[2] https://www.random.org/
[3] Two 10-sided dices determined the number.
[4] See Figures 16&17 (Appendix A).
[5] See Table 5 (Appendix A). table 5

The example of the decision situation and two control questions encountered in the beginning of PART II checked for understandability. Control question 1 is answered correctly by 88% of the subjects and 87% of the subjects answered control question 2 correctly (Figure 6). Only three subjects answered both questions incorrect. That is why, in general, I assumed that subjects understand the choice situations they encountered in the online experiment.

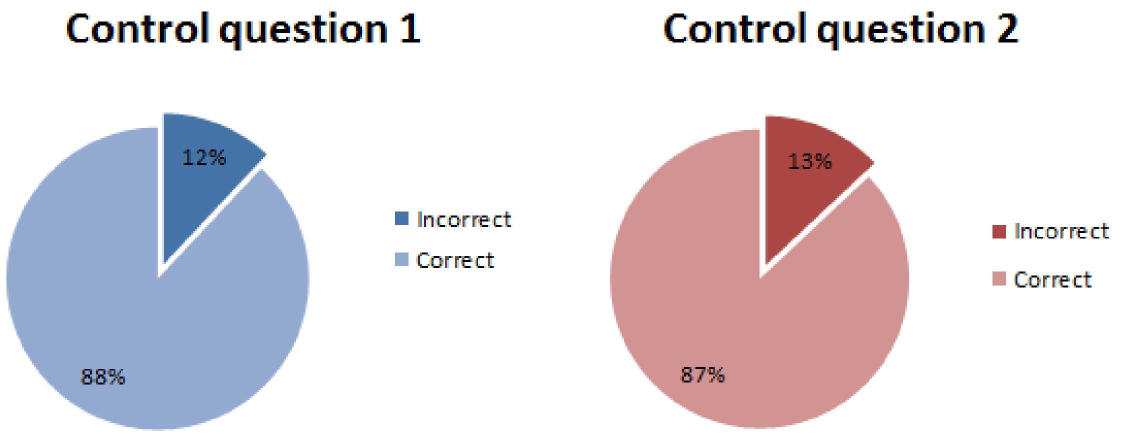


Figure 6. Percentage of correct and incorrect answers per question.

In order to see whether participants failed monotonicity, the matching probabilities were calculated per single and composite event. The matching probabilities of a composite event should not be lower than the matching probabilities of the two single events in that composition. For example, m_{12} should be equal or bigger than m_1. If this condition is not met, the subject fails at least one of the six monotonicity tests. Monotonicity was not met when subjects failed at least two of the six tests. Thirty participants (27%) failed this test and were removed from the sample for the analysis in this part.[6] The data from the remaining 82 participants was used to test the hypotheses. None of these participants answered both control questions falsely.

5.2 Descriptive statistics

Table 3 presents the summary statistics. Slightly more females participated in the experiment and the average age of the sample is 24 years old. The Dutch nationality represented 70% of the participants. The median participant contributed 6 tokens to the climate account, was slightly ambiguity seeking, a-insensitive and believed the three other players to contribute between 11-22 tokens. The median participant was slightly optimistic and least believed her opponents to

[6] See appendix C for the same analysis with the inclusion of participants who failed monotonicity.

contribute between 0-10 tokens. Most participants eat fish or meat four times a week and donate to charity. Forty-four percent of the participants are involved in volunteering work.

Table 3. *Summary statistics.*

Variable	Mean	Median	Std.	Min	Max	IQR
$\overline{m}_s$	0.39	0.39	0.12	0.05	0.73	[0.33, 0.47]
$\overline{m}_c$	0.62	0.65	0.15	0.05	0.87	[0.57, 0.71]
cont	6.17	6	3.53	0	11	[3, 9]
b	-0.02	-0.03	0.25	-0.60	0.90	[-0.20, 0.10]
a	0.26	0.28	0.36	-0.80	1.00	[0.10, 0.58]
p_{E1}	0.25	0.22	0.21	0.00	1.00	[0.08, 0.33]
p_{E2}	0.46	0.44	0.22	0.00	0.96	[0.33, 0.60]
p_{E3}	0.29	0.25	0.21	0.00	1.00	[0.18, 0.38]
p_{E3}-p_{E1}	0.04	0.04	0.36	-1.00	1.00	[-0.15, 0.21]
age	24	23	2.85	19	28	[21, 25]
gender (female=1)	0.54	1	0.50	0	1	[0, 1]
Dutch	0.70	1	0.46	0	1	[0, 1]
non-Dutch_European	0.21	0	0.41	0	1	[0, 1]
other	0.09	0	0.30	0	1	[0, 1]
vol (yes=1)	0.44	0	0.50	0	1	[0, 1]
char (yes=1)	0.56	1	0.50	0	1	[0, 1]
fishmeat	5.20	4	3.81	0	14	[2, 7]

Note: $\overline{m}_s$ and $\overline{m}_c$ are the average matching probabilities of the single and composite events. Cont are the contributed tokens in the PGG. b is the index for ambiguity aversion and α the index for a-insensitivity that together indicate the ambiguity attitude. p_{E1}, p_{E2}, $p_{E3}$are the a-neutral probabilities for all three events. p_{E3}-$p_{E1}$is the index for beliefs from pessimistic to optimistic. Age is the subject's age in years. Gender=1 if subject is female. Dutch, non-Dutch European and other are dummy variables for nationality. If Dutch=1, non-Dutch_European and other equal zero. Vol=1 if subject is volunteering and 0 if not. Char=1 if subject gives to charity and 0 if not. Fishmeat is the answer to the question how many times a week the subject eats fish or meat and can take values from 0 to 21.

Most subjects contributed between 4-8 tokens (46%). The maximum amount of tokens is contributed by 21% of the participants, whereas only nine percent contributed 0 tokens[7]. The majority of the participants is ambiguity seeking, but not to an extreme degree, since the lowest index value is -0.6.[8] This means that most subjects liked and preferred the ambiguous option to a certain extent. The majority of the participants is a-insensitive, which means that they perceived ambiguity. Only 14.64% of the participants is not sensitive towards ambiguity and perceived ambiguity at a lower extent[9]. Not one subject had zero value for both indices, so no one is perfectly ambiguity neutral and fully guided by beliefs.

5.2.1 Gender

Figure 7 show the difference in contribution to the climate account between females and males is shown. Females contribute around the mean contribution (6.03) and median (6.00) contribution level of the whole sample, as well as males. Although males' contributions to the climate account are much more skewed compared to women's contribution level, especially towards contribution levels above the mean, there is no significant difference in contributions between males and females (p-value = 0.62; Mann-Whitney U test).

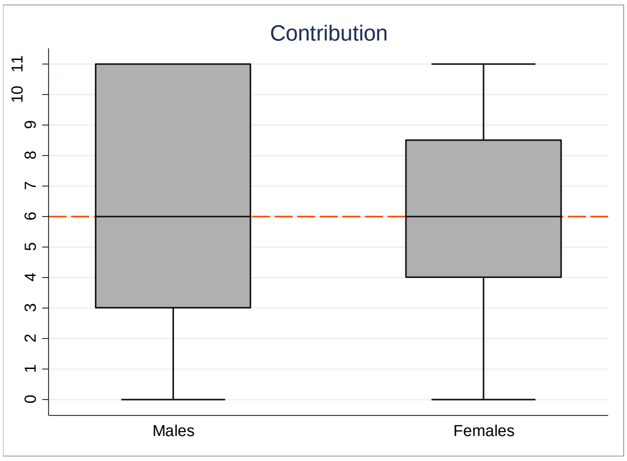


Figure 7. Contribution distribution by gender.

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[7] See Table 7 (Appendix B).
[8] See Table 8 (Appendix B).
[9] See Table 9 (Appendix B).

Figure 8 show the distribution of the ambiguity aversion index, valued from minus 1 to plus 1, for males and females. The sample mean (-0.02) and median (-0.03) value of the ambiguity aversion index are close together. The level of ambiguity aversion for males is slightly below the sample median, whereas the ambiguity aversion level for females is slightly above the sample median level.

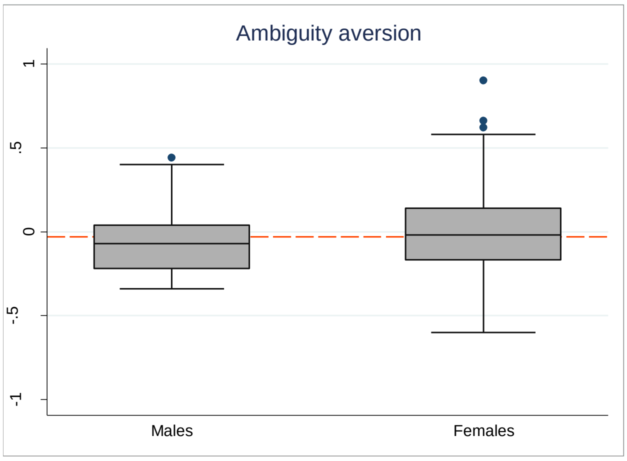

Figure 8. Ambiguity aversion distribution by gender.

The distribution of the ambiguity aversion index is more clustered around the median for males. Despite the more extreme values of the ambiguity aversion index for males, there is no significant difference between males and females (p-value = 0.19; Mann-Whitney U test).

Figure 9 shows the distribution of the a-insensitivity index, valued from minus 1 to plus 1, for males and females. The median female is more insensitive than the median male. The level of a-insensitivity for females is above the sample median, while the level of a-insensitivity for males is more clustered around the median. Although both distributions are not very skewed, the distribution of females' a-insensitivity is more skewed and consists of more observations in the direction of minus 1, which indicates least a-insensitive. This observed difference is not significantly different (p-value = 0.20; Mann-Whitney U test).

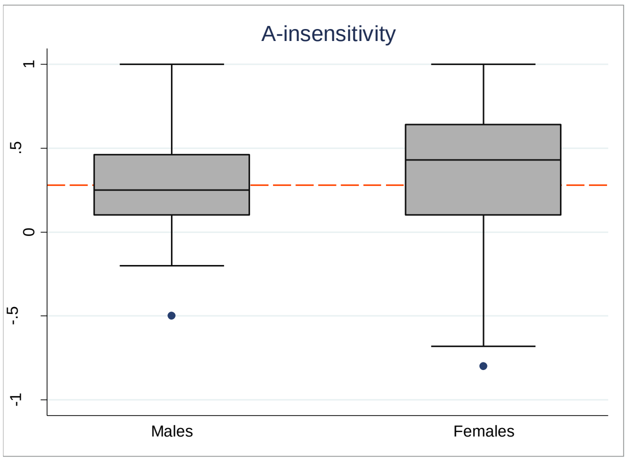

Figure 9. A-insensitivity distribution by gender.

5.2.2 Nationality, volunteering, charity and eating habits

Figure 10 represents the distribution of contribution by nationality. The contribution decisions of Dutch and non-Dutch subjects are highly skewed. Dutch subjects are more clustered around the sample median (6.00), whereas the contribution of non-Dutch Europeans is more clustered around higher contribution levels. The median non-Dutch European contributed approximately 2 tokens more than a median Dutch subject. Subjects with other nationalities from outside Europe contributed remarkably less compared to Europeans and have a distribution of contributed tokens far below the median contribution level. Despite this observed difference, testing for this gives no significant results. So, consequently, there is no difference in contributed tokens between the Dutch, non-Dutch Europeans and subjects with other nationalities (p-value = 0.15; Kruskal-Wallis test).

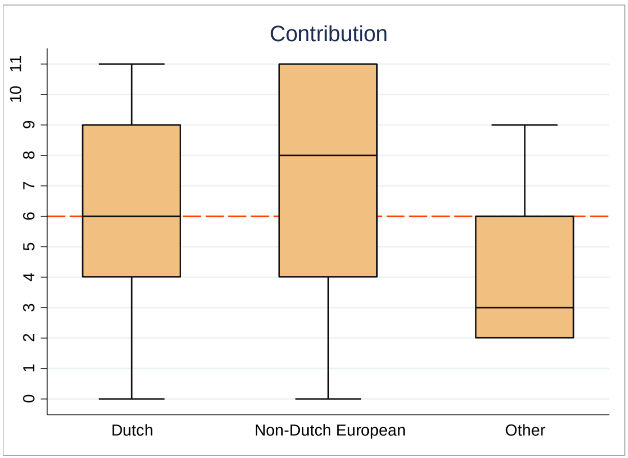

Figure 10. Contribution distribution by nationality.

Figure 11 indicates the difference in contribution level between subjects that give to charity and subjects that do not give to charity. Both distributions are maximally skewed, however, the distribution of charity givers is far more distributed around higher level contributions. The median contribution of charity givers is far above the median of non-charity givers. The level of contributed tokens of non-charity givers lay around the middle values. Charity givers contribute significantly more compared to non-charity givers (p-value = 0.02**[10]; Mann-Whitney U test).

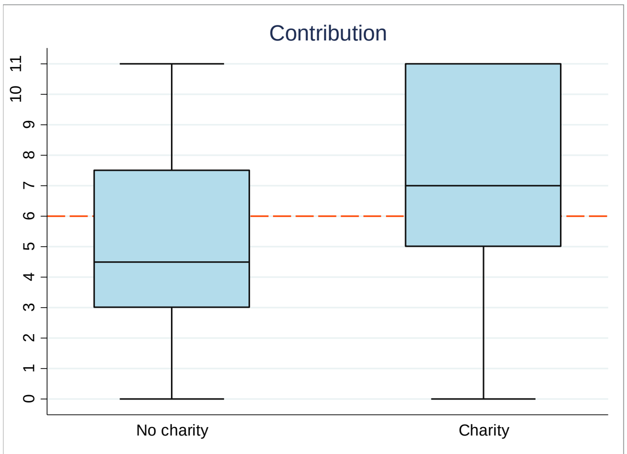

Figure 11. Contribution distribution of non-charity and charity givers.

[10] *Significant at a 10% level; **significant at a 5% level; ***significant at a 1% level.

Figure 12 presents the difference in contribution between volunteering subjects and non-volunteering subjects. The contribution level of volunteering subjects is more clustered around the total sample median, whereas the distribution of contribution for non-volunteering subjects is more skewed to higher as well as lower levels of contribution, with a lower median contribution level compared to the whole sample and to volunteering subjects. The difference in contribution levels between volunteering subjects and non-volunteering subjects is not significant (p-value = 0.38; Mann-Whitney U test).

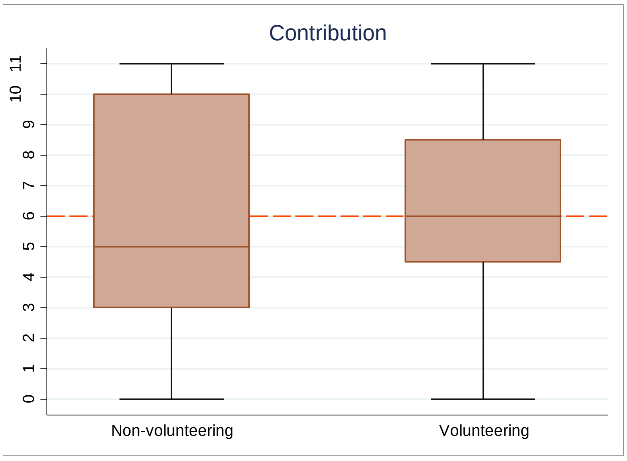

Figure 12. Contribution distribution of non-volunteers and volunteers.

Figure 13 categorises subjects'eating habits into 0-3 times fish or meat a week, 4-7 times a week or 8-14 times a week. Subjects that eat fish or meat on a relatively less frequent basis have higher median contribution levels and are more skewed towards higher contribution levels. The moderately fish and meat eaters are clustered around the sample median with equal deviations to lower and higher levels of contribution. Subjects that eat fish or meat on a relatively frequent basis contributed less tokens to the climate account compared to the other two groups (p-value = 0.06*[11]; Kruskal-Wallis test).

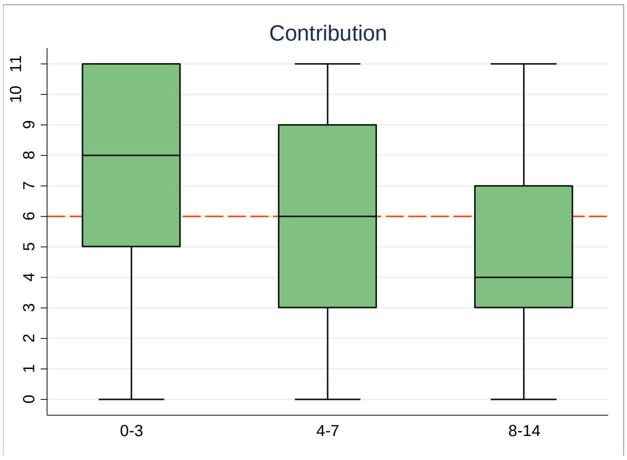

Figure 13. Contribution distribution per fish and meat eating habits.

[11] *Significant at a 10% level; **significant at a 5% level; ***significant at a 1% level.

5.3 Ambiguity attitudes and beliefs as a determinant of contribution

The main independent variables are indices b and a, which proxy *ambiguity aversion* and *a-insensitivity* respectively, and $p_{E3} - p_{E1}$ which proxy a-neutral *beliefs* about others' tendency to contribute.[12] To see whether a subject's ambiguity attitude and beliefs about others' tendency to contribute to the climate account are determinants of own contribution, Spearman rank correlation tests were used to test for independence. Thereafter a regression analyses was performed to increase validity of the results.

5.3.1 Non-parametric tests for independence

The first hypothesis predicts a negative relation between ambiguity aversion and contribution level. Unless the negative coefficient, the level of a subjects' *ambiguity aversion* and the level of *contribution* are not significantly associated (Spearman's rho = -0.02; p-value = 0.86). The correlation between *a-insensitivity* and *contribution* is not significant. Subjects' a-neutral *beliefs* (p_{E3}-p_{E1}) about others' tendency to contribute are strongly related to their own contribution decision (Spearman's rho = 0.53; p-value = 0.00). This finding is in line with H2, which predicts a positive relation between a-neutral optimistic *beliefs* (p_{E3}-p_{E1}) and the level of *contribution*. To examine H3, *a-insensitivity* and *beliefs* were tested for independence. The relationship between *a-insensitivity* and *beliefs* was expected to be independent, since beliefs are a-neutral probabilities. Since these probabilities are already determined, the question was how people are influenced by these beliefs. This influence was expected to depend upon a-insensitivity. This is elaborated on in the regression analyses. The Spearman rank test confirms independence (Spearman's rho = 0.14; p-value = 0.22).

5.3.2 Regression analysis

Since contribution is normally distributed[13], the following linear regression model is examined with OLS, to further analyse the relationship between the dependent and independent variables:

$$Contribution = \beta_0 + \beta_1 * Ambiguityaversion + \beta_2 * A - insensitivity + \beta_3 * Beliefs + \beta_4 * (A - insensitivity * Beliefs) + \text{Controls} + \varepsilon$$

[12] See Table 6 (Appendix B) for a variable overview.
[13] See test result in Appendix C.

The results from the regression analysis, shown in Table 4, are consistent with the results from the non-parametric tests. In the first model I include the indices that reflect subjects' ambiguity attitudes, *ambiguity aversion* and *a-insensitivity* (Model 1). Both variables do not significantly determine the contribution decision. The negative relation between *ambiguity aversion* and *contribution* predicted by H1[14] is not supported.

In the second model, only *beliefs* were included. The extent of optimism in *beliefs* has a significantly positive effect on the *contribution* decision. So the more optimistic beliefs became, the more a subject contributes, ceteris paribus[15]. This relation stays significant with the inclusion of the ambiguity attitude indices (Model 3) and the inclusion of the interaction term (Model 4&5). Hypothesis 3 is supported by all regression models.

The interaction term is included in the regression to test for H4, which predicts a weakened effect of *beliefs* due to subjects' *a-insensitivity*. Model 5 includes all independent variables and demographic control variables and confirms a lower tendency to contribute when a subject's a-insensitivity increases. The a-insensitivity index is the cognitive explanation of an individual's ambiguity attitude. High a-insensitivity (high values of the index a) implies that subjects had difficulties to assign subjective probabilities to the possible contribution of their opponents. The increase in contribution due to an additional increase in optimistic beliefs is diminished by an increase in a-insensitivity[16].

I compared two subjects with equal beliefs about others' tendency to contribute and different levels of a-insensitivity, the 25th and 75th percentiles index values 0.10 and 0.58. The contribution level of the more a-insensitive subject is almost twice as low compared to the subject with less strong a-insensitivity. In fact, a-insensitivity decreases the effect of beliefs on contribution and H4 is supported.

[14] See F-test results in Table 10 (Appendix B).
[15] See F-test results in Table 11 (Appendix B).
[16] See F-test results in Table 12 (Appendix B).

Table 4. *Determinants of the decision how much tokens to contribute to sustain the global climate.*

		Dependent Variable:			
		Contribution			
	(1)	(2)	(3)	(4)	(5)
ambiguity aversion	0.01		-0.50	-0.02	0.78
a-insensitivity	1.51		1.00	0.88	0.43
beliefs		5.55***	5.47***	6.97***	7.67***
a-insensitivity*beliefs				-4.56	-6.82**
Demographic controls	No	No	No	No	Yes
Observations	82	82	82	82	82
R-squared	0.02	0.33	0.34	0.35	0.48

Note: Demographic controls are age, gender, nationality, and whether a subject gives to charity and volunteers, and how many times a week someone eat fish or meat.
*p<0.1, **p<0.05, ***p<0.01

5.4 Beliefs

Figure 14 present the density plot of the a-neutral probabilities for each single event. Symmetric beliefs constructed in artificial experiments are no longer plausible for strategic interactions. In this case of strategic interaction, when trying to sustain the global climate together without knowing the others' decisions, the belief that others would contribute between 11-22 tokens (p_{E2}) was the strongest. The least cooperative event, contributions between 0-10 tokens (p_{E1}) was least believed in. In this ambiguous situation of strategic interaction, subjects were most likely to belief others were moderately cooperative, as I showed before. The median subject is moderately optimistic about the others' tendency to contribute to the climate account.

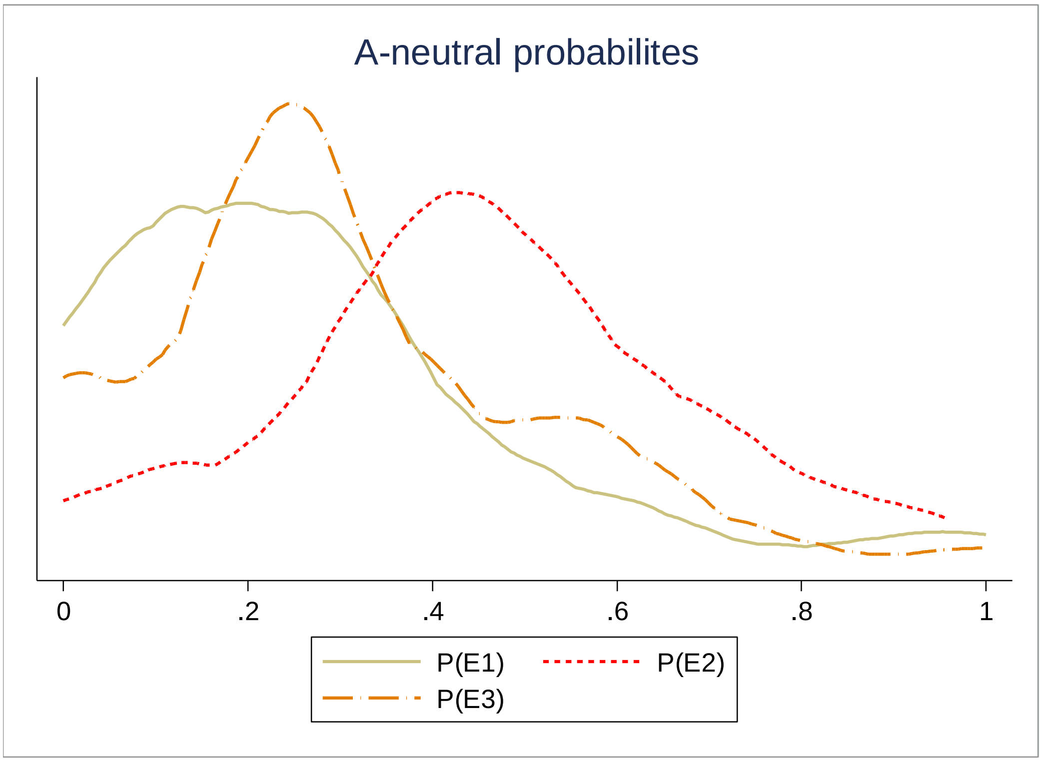

Figure 14. Density plot a-neutral probabilities for all three single events.

H3 predicts that optimistic beliefs about opponents' tendency to contribute increase someone's own contribution. This hypothesis is supported by the non-parametric and parametric tests. Hence, a person's optimistic beliefs about others are associated with the level of contribution to the climate account. Figure 15 shows this relation with a dot plot. Subjects with a higher value on the beliefs index, i.e. more optimistic, have a higher contribution level. This is supportive for the findings of Rubinstein and Salant (2016) about self-similarity, with the correction for ambiguity attitudes. High contributors, or highly cooperative people, believe others to cooperate as well and vice versa.

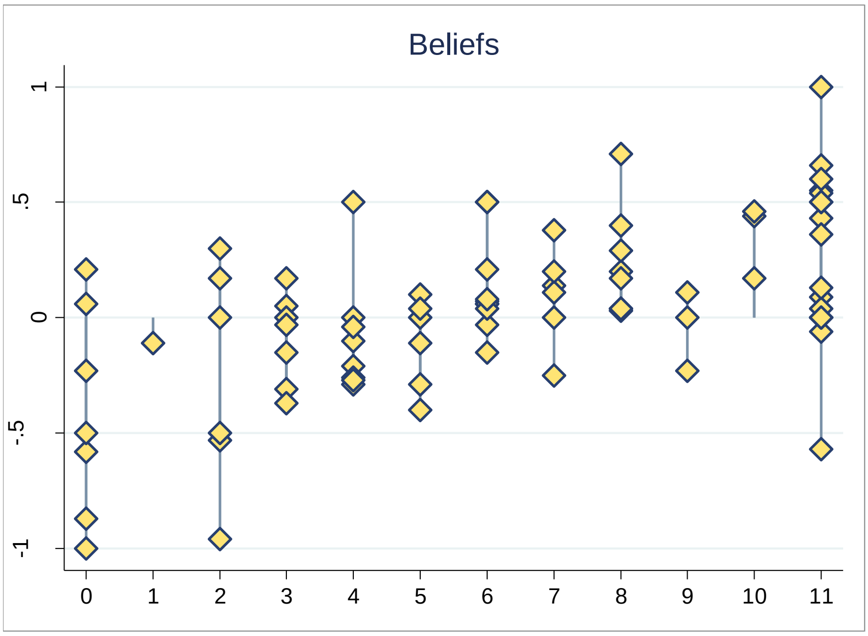

Figure 15. From pessimistic (-1) to optimistic (+1) beliefs per contribution level.

The more a subject contributes, the more he or she cooperates with his or her opponents to increase the climate account and sustain the global climate. As mentioned in Section 2, studies found support for conditional cooperation: people tend to be cooperative if others will be cooperative as well. Most subjects with high contribution levels believed others would do the same. There are two possible explanations for this relation. First, overly optimistic beliefs about others contribution induce subjects to contribute high levels by themselves as reasoned by conditional cooperation (Brandts & Schram, 2001; Fischbacher & Gächter, 2006; Fischbacher et al., 2001; Keser & Van Winden, 2000;). Or highly cooperative people are more optimistic and their actions are not determined by these beliefs, but the beliefs are determined by actions, like Andreoni and Sanchez (2014) suggest.

6 Discussion

I first discuss the methodological limitations of the research. Right after, the related literature is discussed in combination with the results and finally I conclude with recommendations for further research.

6.1 Methodological limitations

The online experiment is implemented via Qualtrics, because the limited availability of time and money. Ideally, the experiment would be implemented in the lab, with more monetary incentives available, so that there would be maximum control over subjects. Implementation via Qualtrics induces several limitations. I utilise Smith's (1982) precepts to list the methodological limitations of this research to see whether and how the limited control in this economic experiment decreased the reliability of the results.

The first precept, nonsatiation, is satisfied when the monetary payoff is increasing in its utility. One alternative will always be chosen over the other identical alternative, when the first yields a higher monetary reward. This precept is likely to be met, because a participant prefers more over less for the private as well for the collective payoff, since they both increase a person's payoff. Saliency is satisfied when choice affects earnings and when subjects are not deceived (no information is hold back). Indeed, incentives should be sufficiently large to induce truthful answers. Dominance is satisfied when the psychological costs of thinking are offset by the monetary reward. Harrison (1994) argued that the more choices in a random lottery incentive, the smaller the chance that the choice is selected. So, the probability a given task is selected as the real task becomes very small, resulting in a low expected monetary payoff. Privacy means that the subject only receives information that is relevant for their own payoff structure. This precept is met, since every subject participated in one treatment, including information that relied on their possible earnings.

Given the online implementation of the experiment and the limited amount of money available some of the precepts are hard to fully satisfy. Saliency is hard to satisfy in this experiment since the random assignment of the groups, the random lottery incentive as well as the payment itself are implemented after the experimental period. This might induce different behaviour. Ideally, to increase incentive compatibility, the real choice situation was randomly selected and handed out in an envelope prior to the subjects encountering the decision situation. This is called a prior incentive system introduced by Johnson et al. (2015). Also, the random assignment of the groups after the experimental period is not as real as in a lab experiment where everyone is present at the same time.

The ambiguity perceived due to strategic interaction might be weakened by this. Knowing that every other participant in the lab is in a similar situation at the same time may increase the feeling of interaction, despite anonymity. In regard to saliency, implementing the random lottery incentive and the payments after the experimental period, might evoke a feeling of deception unless the true implementation. In a real lab, participants receive a participation fee and the payoff is paid out right after the experiment. As a result, the participants are 100% sure about payment, whereas here it is based on trust. There might be participants that did not trust the story or did not take the task seriously. Given that I ran an online experiment, I did not encounter the participants in real, and could not implement this. Another precept that is hardly satisfied is dominance. Besides the fact that a higher payout increases thinking, the same goes for the compulsory time spent on a task. In the lab, the time spent on a task is controlled by supervision of the experimenters. With the online implementation, participants are tempted to quickly go through the experiment and pay less attention, since there is no time control.

As opposed to ambiguity, anonymity might be perceived more truly in this online experiment, since other players and experimenter(s) are present when conducting a lab experiment. This might give the feeling the experiment is not as anonymous as it seems. On the other hand, the online experiment has limited anonymity, since email addresses are needed for the payments. After all, the subjects are not anonymous to the experimenter. Ideally, the subjects would be anonymous to the other players as well as the experimenter. The limited anonymity might have increased contribution due to the desire to show socially accepted behaviour.

If the data collection had been less distorted by means of more control, with a higher number of observations, the results would be more reliable. Another limitation is the incentivisation with low stakes: the question is what happens if the stakes are higher. The level of the stakes induce different behaviour. Furthermore, the environmental framing of the Public Goods Game can induce different behavior, compared to other contexts. One reason is the connotation with Greenpeace, since Greenpeace is more than climate change. They spend a lot of money on other things concerning nature and animals. It can be questioned what the relation between the decision maker and Greenpeace is and how this influences the decision. In the next paragraph I elaborate more on the environmental frame.

Lastly, the demographic questions are not incentivised. With more resources available these questions can be incentivised by the Bayesian truth serum (Prelec, 2004) to induce truthful answering instead of socially desirable answers.

6.2 Related literature and further research

This paper employed a new technique for measuring ambiguity attitudes and beliefs about others' in strategic interactions (Baillon et al., 2016). I examined strategic interactions by using the PGG. This paper sheds new light on the role of ambiguity attitudes and beliefs about others in the context of an environmental social dilemma. The findings show that ambiguity aversion did not significantly influence the decision to contribute. However, Li et al. (2017) found that ambiguity aversion decreased the decision to trust. The difference between these findings could be due to a discrepancy between attitudes towards ambiguity about others' decision to contribute and attitudes towards ambiguity about others' trustworthiness. In the Trust Game, the wellbeing of the decision maker depends on the action of one other person, while in the PGG, the decision depends on three others. Thereby, in the PGG, apart from the decision maker's contribution level, the public good is always divided among all players. In the Trust Game, the division of the money depends on the decision maker's trust level and the trustworthiness of the other. It would be interesting to analyse behaviour of the same subjects in the PGG and the Trust Game to examine the differences.

Various studies have shown that context matters for experimental results. It could increase altruistic giving (Eckel & Grossman, 1996) or change behaviour by the use of different words (Liberman, Samuels, & Ross, 2004). On one hand, for this particular domain, external validity is higher. However, the effect of the environmental frame itself needs to be taken into account. It could be that the environmental context induced feelings of altruism that overshadowed the effect of ambiguity aversion. It might be that, in this strategic situation, the actions of others were perceived as less important, so that the influence also weakened. Consequently, a subject's vulnerability in a decision facing social uncertainty about what others shall decide might strongly depend on the context of the game. This perceived strategic interaction is likely to be diminished by the latter and by the limitations concerning the incentive compatibility of the experiment. Since subjects did not lose money it might be easy to give and bet on the ambiguous event. For further research it would be interesting to observe behaviour in a field experiment where people really receive money and need to decide how much to give away in order to sustain the global climate (Knetsch, 1989). On the other hand, the amounts of money in the experiment were too low to satisfy dominance. It could be that higher stakes induce more selfish behaviour, since there is more to lose. And ambiguity aversion might increase due to higher stakes. It would be interesting for further research to examine ambiguity attitudes in with higher stakes.

Ellsberg (1961) already noted that models that examine beliefs, without the acknowledgement of ambiguity, are not suited to examine behaviour. The finding shows that subjects are not ambiguity neutral, which is in line with prior research. This study sheds light on the measurement of beliefs, while controlling for ambiguity attitudes, and found that a subject's beliefs about others' tendency to contribute is positively related to the person's own contribution. Hence, beliefs are in line with contribution decisions. This might be due to self-similarity as found by Rubinstein and Salant (2016). Self-similarity predicts that subjects choose a certain contribution level, because they believe that others will choose the same action. This is also in line with conditional cooperation that states that people contribute when they believe that many others will do the same (Brandts & Schram, 2001; Fischbacher & Gächter, 2006; Fischbacher et al., 2001; Keser & Van Winden, 2000). Strategic justification on the other hand predicts that subjects take optimal actions with respect to their beliefs about others. In the PGG, this would imply that whether beliefs about others tendency to contribute are optimistic or pessimistic, subjects are induced to contribute less.

An interesting area of research is the direction of the relationship between beliefs and actions. It could be that actions are determined before beliefs are formed. Specifically, afterwards, the action determines beliefs in a self-confirming way. This could be due to the confirmation bias, where people tend to overconfidently reason in their favored hypotheses (Nickerson, 1998). Rubinstein and Salant (2016) found that when beliefs were reported ex-ante people behave in line with self-similarity to a smaller extent, compared to reporting beliefs ex-post. Asking for beliefs before a subject makes a decision might induce people to think more strategically and beliefs determine actions. In this study, subjects started with the PGG and thereafter, the beliefs were elicited with bisection. Subjects are expected to contribute more intuitively and might confirm their beliefs afterwards. Subjects who find the environment important, want to have faith in the good intentions of others. Further research could investigate the causal relation between beliefs and actions.

Another recommendation is to further analyse the environmental social dilemma in a more controlled experiment that measures beliefs, while controlling for ambiguity attitudes, and incorporate more variables that determine the decision to contribute. When the power of the model is increased, results will become more reliable and valid. If a-insensitivity weakens the positive effect of optimistic beliefs on contributions, it is important to look for ways to decrease a-insensitivity. In this research, only university students were recruited, and income and education for example, were held constant. For further research it would be interesting to find out what the effect of income and education is on cooperation, but also ambiguity attitudes, in an environmental setting. Li (2017) did an experiment between poor and rich Chinese adolescents. Poor people were more averse and insensitive to ambiguity. For example, further research can examine differences in contributions and ambiguity attitudes between students and high educated workers or between two groups based on differences in household income. These give better insights for policy design. Policy design might be more influential when it is tailored, based on specific groups, to respond to different characteristics between people. Additionally, further research can investigate more extreme values and add more possible events.

7 Conclusion

In this research I examined the role of ambiguity attitudes and beliefs about others' tendency to contribute in the environmental PGG, in a subject's own contribution decision. To answer the research question, I proposed three hypotheses. I could not find a statistically significant association between the motivational component (*ambiguity aversion*) and the cognitive component (*a-insensitivity*) of a subject's ambiguity attitude and the level of contribution to the environmental related public good, i.e. the earth. The data did support the predicted positive association between a subject's optimistic *beliefs* about others' tendency to contribute to the public good and his or her own contribution. The cognitive part of ambiguity, a-insensitivity, weakens the positive relation with optimistic beliefs about others' tendency to contribute and someone's own contribution. With the inclusion of subjects who failed monotonicity checks results stay the same. The findings about beliefs suggest further research to the causal relation between beliefs and their formation. It would be interesting to further analyse ambiguity attitudes between different contexts and groups of people.

8 Appendices

8.1 Appendix A

After the experimental period, the payment was calculated of the randomly selected group. All four players of the group were paid based on a random lottery. One decision of the total of twenty-five decisions was selected to be paid out. In the table below is described which decision situation is selected per subject, and based on their decision, how much they earned. One decision was based on the contribution of the other three players, which totaled up to 21 tokens. The subjects that were paid out according to the decision of drawing a random number, were paid out according to the numbers of the 10-sided dice. The private payoff of the subject according to the game was computed with the final payoff calculation and the total group contribution to the climate account was doubled and paid out to Greenpeace.

Table 5. *Payment scheme of selected group.*

Contribution	Selected decision	Decision	Drawn probability	Private payment	Greenpeace donation
2	10	Pay €10 if outcome of the game is between 23-33 tokens.		€ 0	
4	3	Pay €10 with 62% probability.	6[17]	€ 10	
9	5	Pay €10 with 50% probability.	63[18]	€ 0	
6	1	Contribution of 6 tokens.		€ 15.50	€42[19]
21					€42

[17] The numbers of the 10-sided dice were 3 and 2, so the probability 3 x 2 = 6 was used for the payment.
[18] The numbers of the 10-sided dice were 7 and 9, so the probability 7 x 9 = 63 was used for the payment.
[19] 21 x 2 x €1 = €42.

Outcome online experiment

Dear Participant,

You participated in my online experiment and your group is selected to be paid out for real.

Your contribution: 4 tokens.
Total group contribution: 21 tokens.

The randomly selected decision situation for you is:

Option 1:
We pay you €10 if the sum of the other 3 group members' contribution is between 0-10 tokens in the game.

Option 2:
We pay you €10 with 62% probability.

You chose Option 2.

The random number drawn is 6, so your private payoff is €10.

One of your group members is paid out according to the 1st decision, the game.
Therefore, the climate account payoff is donated to Greenpeace.
Thanks to you and your group members, the total donation to Greenpeace is 21 x 2 x €1 = €42.

Thank you again for helping me.

Best,

Eva Verhoef

P.S. Please sent me your bank account details, so I can transfer the money.

Figure 16. Sent email to participant that was selected to be paid out.

Outcome online experiment

Dear Participant,

You participated in my online experiment and your group is unfortunately not selected to be paid out for real.

According to the decisions of the 4 selected participants, the total donation to Greenpeace is 21 x 2 x €1 = €42.

Thank you again for helping me.

Best,

Eva Verhoef

Figure 17. Sent email to all participants that were not selected to be paid out.

8.2 Appendix B

8.2.1 Descriptive statistics

Table 6. *Variables.*

Name	Description
Dependent variable	
contribution	A continuous variable that can take values 0-11.
Independent variables	
ambiguity aversion	A continuous variable that proxies a subject's degree of ambiguity aversion, $-1 \leq b \leq 1$.
a-insensitivity	A continuous variable that proxies a subject's degree of a-insensitivity, $-1 \leq a \leq 1$.
beliefs	A continuous variable that proxies a subject's degree of optimism in a-neutral beliefs, $-1 \leq p_{E3}$-$p_{E1} \leq 1$.
Control variables	
age	A continuous variable that indicates the age of a subject.
female	A dummy variable for gender. Female=1 indicates that the subject is female. Female=0 indicates that a subject is male.
Dutch	A dummy variable for nationality. Dutch=1 indicates that a subject has the Dutch nationality. Dutch=0 indicates that the subject is non-Dutch.
non-Dutch_European	A dummy variable for nationality. Non-Dutch_European=1 indicates that a subject has a non-Dutch European nationality. Non-Dutch_European=0 indicates that a subject is Dutch or from outside Europe.
other	A dummy variable for nationality. Other=1 indicates that a subject has a nationality from outside Europe. Other=0 indicates that a subject is European.
vol	A dummy variable for volunteering work. Vol=1 indicates that a subject is involved in volunteering work. Vol=0 indicates that a subject is not involved in volunteering work.
char	A dummy variable for charity. Char=1 indicates that a subject gives to charity. Char=0 indicates that a subject does not give to charity.
fishmeat	A continuous variable for fish and meat eating habits. Fishmeat can take values 0-21 and indicates how many times a week a subject eat fish or meat.

Table 7. *Descriptive statistics contribution.*

contribution	Frequency	Percentage
0	7	8.54
1	1	1.22
2	6	7.32
3	7	8.54
4	8	9.76
5	6	7.32
6	10	12.20
7	6	7.32
8	8	9.76
9	3	3.66
10	3	3.66
11	17	20.73
Total	82	100.00

Table 8. *Descriptive statistics ambiguity aversion.*

ambiguity aversion	Frequency	Percentage
-0.60	1	1.22
-0.34	5	6.10
-0.32	2	2.44
-0.3	1	1.22
-0.24	3	3.66
-0.22	5	6.10
-0.2	6	7.32
-0.18	1	1.22
-0.16	2	2.44
-0.12	5	6.10
-0.1	3	3.66
-0.08	5	6.10
-0.06	1	1.22

-0.04	1	1.22
-0.02	5	6.10
0	4	6.10
0.02	1	1.22
0.04	4	4.88
0.06	2	2.44
0.08	3	3.66
0.1	4	4.88
0.12	2	2.44
0.14	3	3.66
0.16	1	1.22
0.18	2	2.44
0.24	2	2.44
0.26	1	1.22
0.36	1	1.22
0.40	1	1.22
0.44	1	1.22
0.58	1	1.22
0.62	1	1.22
0.66	1	1.22
0.9	1	1.22
Total	82	100

Table 9. *Descriptive statistics a- insensitivity.*

a-insensitivity	Frequency	Percentage
-0.8	1	1.22
-0.68	1	1.22
-0.5	1	1.22
-0.26	1	1.22
-0.2	3	3.66
-0.14	1	1.22
-0.02	4	4.88
0.04	3	3.66
0.1	9	10.98
0.16	6	7.32
0.22	5	6.10
0.28	7	8.54
0.34	4	4.88
0.4	4	4.88
0.46	6	7.32
0.52	2	2.44
0.58	6	7.32
0.64	6	7.32
0.7	5	6.10
0.76	2	2.44
0.82	1	1.22
0.88	1	1.22
0.94	1	1.22
1	2	2.44
Total	82	100

8.2.2 F-tests

Table 10. *F-statistics effect ambiguity aversion on contribution.*

ambiguity aversion
F(1, 79) = 0.00
Prob > F = 0.9930

Note: $H_0: b = 0$ *is not rejected on a* 1% *significance level.*

Table 11. *F-statistics effect beliefs on contribution.*

beliefs
F(1, 79) = 36.96
Prob > F = 0.0000

Note: $H_0: p_{E3}\text{-}p_{E1} = 0$ *is rejected on a* 1% *significance level.*

Table 12. *F-statistics effect interaction on contribution.*

a-insensitivity*beliefs
F(1, 79) = 6.78
Prob > F = 0.0112

Note: $H_0: \alpha * p_{E3}\text{-}p_{E1} = 0$ *is rejected on a* 5% *significance level.*

8.3 Appendix C

8.3.1 Normality tests

Since, the dependent variable is normally distributed I support the non-parametric test by a parametric linear regression. The assumptions for parametric tests are met, when the sample size is big enough and when the dependent variable is normally distributed. I first show the distribution with a normal density plot (Figure 8). Thereafter, the Sharpiro-Wilk test was performed to test for normality.

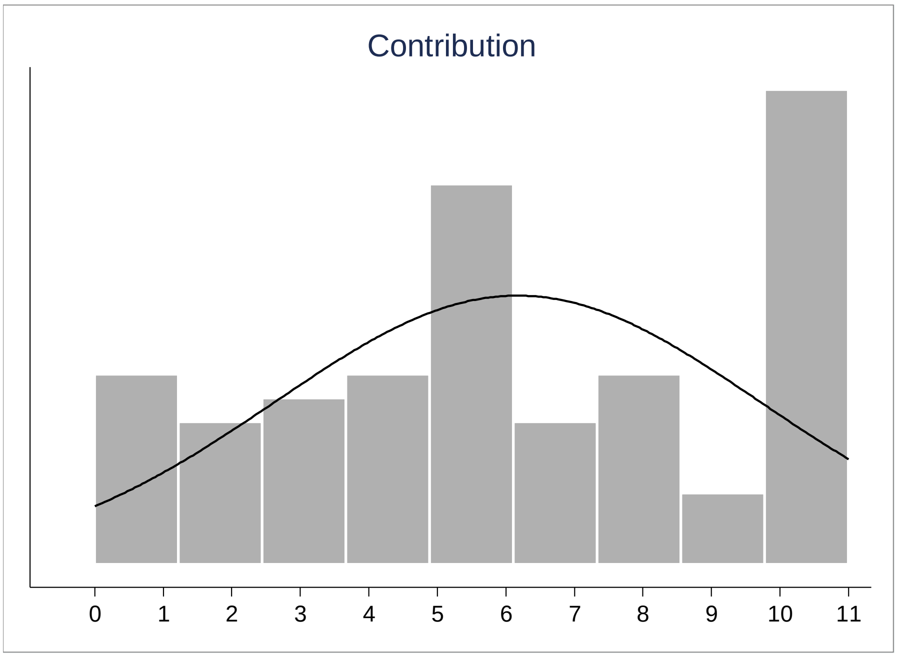

Figure 18. Distribution of contribution with a normal density plot.

Table 13 shows the results of the normality test of contribution. V = 1 means normally distributed, however, around 1 means approximately normally distributed, which is enough. The null hypothesis that contribution is normally distributed is not rejected.

Table 13. *Sharpiro-Wilk test for normality.*

Variable	Obs	W	V	z-value	p-value
contribution	82	0.99	0.49	-1.55	0.94

Note: The Sharpiro-Wilk test is used when 5≤ N ≥5000 to test if the mean is around the median and if the 25th and 75th quantile are symmetric. $H_0 = contribution\ is\ normally\ distributed.$
*p<0.1, **p<0.05, ***p<0.01

8.4 Appendix D

8.4.1 Analysis with the inclusion of monotonicity failed observations

To see whether the results differ if the observations that failed at least two of the six monotonicity checks are included, the data was cleaned first. When calculating the matching probabilities, the indices and the a-neutral probabilities, not all participants ended up with additive and positive a-neutral probabilities. Many participants who failed monotonicity ended up with non-additive and sometimes negative a-neutral probabilities. For these participants, I set the negative probability at zero and calculated the suited probabilities on the basis of the interval and the relative distance between the probabilities (p_{E1}, p_{E2}, p_{E3}). Now, the observations all have positive and additive a-neutral probabilities and can be included in the analyses. The same non-parametric and parametric analyses[20] as in paragraph 5 are performed with a total of 112 observations.

The summary statistics in Table 14 present almost the same statistics as without the inclusion of the participants who failed monotonicity. Only the a-insensitivity coefficient made a notable jump from mean 0.26 to 0.44 and median 0.28 to 0.46. Basically, participants that failed monotonicity are very a-insensitive, so this is in line with the expectation. The mean contribution decreases with 0.15 tokens with the inclusion of the very a-insensitive subjects.

[20] Contribution is normally distributed (p-value = 0.85, Sharpiro Wilk test).

Table 14. *Summary statistics.*

Variable	Mean	Median	Std	Min	Max	IQR
$\overline{m}_s$	0.42	0.43	0.12	0.05	0.73	[0.33, 0.51]
$\overline{m}_c$	0.59	0.63	0.15	0.05	0.87	[0.51, 0.69]
cont	6.02	6	3.50	0	11	[3, 9]
b	-0.01	-0.03	0.24	-0.60	0.90	[-0.20, 0.10]
α	0.44	0.46	0.38	-0.80	1.00	[0.16, 0.70]
p_{E1}	0.27	0.25	0.24	0.00	1.00	[0.07, 0.40]
p_{E2}	0.43	0.43	0.23	0.00	1.00	[0.32, 0.56]
p_{E3}	0.30	0.25	0.24	0.00	1.00	[0.15, 0.49]
p_{E3}-p_{E1}	0.03	0.04	0.42	-1.00	1.00	[-0.24, 0.33]
age	24	23	2.70	19	30	[21, 25]
female	0.57	1	0.50	0	1	[0, 1]
Dutch	0.71	1	0.46	0	1	[0, 1]
non-Dutch_European	0.19	0	0.40	0	1	[0, 1]
other	0.11	0	0.31	0	1	[0, 1]
vol (yes=1)	0.44	0	0.50	0	1	[0, 1]
char (yes=1)	0.54	1	0.50	0	1	[0, 1]
fishmeat	5.20	4.00	3.86	0	19	[2, 7]

Note: $\overline{m}_s$ and $\overline{m}_c$ are the average matching probabilities of the single and composite events. Cont are the contributed tokens in the PGG. b is the index for ambiguity aversion and α the index for a-insensitivity that together indicate the ambiguity attitude. p_{E1}, p_{E2}, p_{E3} are the a-neutral probabilities for all three events. p_{E3}-p_{E1} is the index for beliefs from pessimistic to optimistic. Age is the subject's age in years. Gender=1 if subject is female. Dutch, non-Dutch European and other are dummy variables for nationality. If Dutch=1, non-Dutch European and other equal zero. Vol=1 if subject is volunteering and 0 if not. Char=1 if subject gives to charity and 0 if not. Fishmeat is the answer to the question how many times a week the subject eats fish or meat and can take values from 0 to 21.

The results from the Spearman rank correlation tests give the same interpretation as in Section 5. The level of a subjects' ambiguity aversion and the level of contribution are not significantly associated (Spearman's rho = -0.05; p-value = 0.57). Optimistic beliefs are strongly related to the contribution decision (Spearman's rho = 0.51; p-value = 0.00). The Spearman rank test confirms independence of a-insensitivity and beliefs (Spearman's rho = 0.09; p-value = 0.0.37).

The results from the regression analysis, shown in Table 15, are consistent with the results from the non-parametric tests and the regression analysis in Section 5, unless the significance of the regression coefficient of charity in the Model 5. Charity is positively related with the decision to contribute. Charity givers have higher contribution levels, compared to non-charity givers. Someone's eating habits with regard to fish and meat is negatively related to contribution. Although the effect of optimistic beliefs is lowered in Model 2 and 3, the effect is higher in Model 4 and 5, and still significant. In Model 4, the interaction is significant and almost equal to the coefficient in Model 5. This has the same explanation as given for the interaction effect in Model 5. Without the inclusion of the demographic controls, the positive effect of optimistic beliefs is higher and the diminished effect due to the interaction term is lower compared to Model 5 where the demographic controls are included.

Table 15. *Determinants of the decision how much tokens to contribute to sustain the global climate.*

	Dependent variable				
	contribution				
	1	2	3	4	5
ambiguity aversion	-0.40		-0.96	-0.29	0.39
a-insensitivity	0.61		0.32	0.23	-0.14
beliefs		4.40***	4.43***	8.11***	7.94***
a-insensitivity*beliefs				-7.30***	-7.53***
age					-0.13
female					-0.45
Dutch					0.43
non-Dutch_European					0.98
vol					0.37
char					1.07*
fishmeat					-0.24***
Demographic controls	No	No	No	No	Yes
Observations	112	112	112	112	112
R-squared	0.00	0.28	0.28	0.35	0.48

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

Table 16. *F-statistics effect ambiguity aversion on contribution.*

ambiguity aversion
F(1, 79) = 0.13
Prob > F = 0.7203

Note: $H_0: b = 0$ *is not rejected on a* 1% *significance level*.

Table 17. *F -statistics effect beliefs on contribution.*

beliefs
F(1, 79) = 63.32
Prob > F = 0.0000

Note: $H_0: p_{E3}\text{-}p_{E1} = 0$ *is rejected on a* 1% *significance level*.

Table 18. *F-statistics effect interaction on contribution.*

a-insensitivity*beliefs
F(1, 79) = 18.16
Prob > F = 0.0000

Note: $H_0: \alpha * p_{E3}\text{-}p_{E1} = 0$ *is rejected on a* 1% *significance level*.

Table 19. *F-statistics effect charity on contribution.*

charity
F(1, 79) = 3.58
Prob > F = 0.0613

Note: $H_0: char = 0$ *is rejected on a* 10% *significance level*.

Table 20. *F-statistics effect fish and meat on contribution.*

fish and meat per week
F(1, 79) = 8.08
Prob > F = 0.0054

Note: $H_0: fishmeat = 0$ *is rejected on a* 1% *significance level*.

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