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Individual-level loss aversion in riskless and risky choices[†]

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16 November 2010

Loss aversion can occur in riskless and risky choices. Yet, there is no evidence whether people who are loss averse in riskless choices are also loss averse in risky choices. We measure individual-level loss aversion in riskless choices in an endowment effect experiment by eliciting both WTA and WTP from each of our 360 subjects (randomly selected customers of a car manufacturer). All subjects also participate in a simple lottery choice task which arguably measures loss aversion in risky choices. We find substantial heterogeneity in both measures of loss aversion. Loss aversion in the riskless choice task and loss aversion in the risky choice task are highly significantly and strongly positively correlated. We find that in both choice tasks loss aversion increases in age, income, and wealth, and decreases in education.

Keywords: Loss aversion, endowment effect, field experiments
JEL codes: C91, C93, D81

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1. Introduction

Loss aversion – the psychological propensity that losses loom larger than equal-sized gains relative to a reference point – can occur in riskless and in risky choices, as argued in two seminal papers by Amos Tversky and Daniel Kahneman (Kahneman and Tversky 1979; Tversky and Kahneman 1991). An example for loss aversion in riskless choice is the 'endowment effect' – the observation that experimental subjects who are randomly endowed with a commodity, ask for a selling price that exceeds substantially the buying price of subjects who merely have the possibility to buy the commodity (see Kahneman et al. 1990 for a very influential study). An example of loss aversion in risky choices is the observation that people reject small-scale gambles that have a positive expected value but may involve losses (e.g., Rabin 2000; Fehr and Goette 2007; Tom et al. 2007; see Wakker 2010, for a comprehensive review of models and empirical relationships).[1]

Our paper makes two contributions to this literature on loss aversion. First, we measure loss aversion in a riskless *and* a risky choice task. This will allow us to provide evidence on whether loss aversion in riskless choice is related to loss aversion in risky choices. To our knowledge nothing is known about this relationship. The riskless task we employ is an endowment effect experiment where we elicit the 'willingness-to-accept' (WTA) *and* the 'willingness-to-purchase' (WTP) from the *same* individual. The gap between WTA and WTP has been interpreted as evidence for loss aversion in riskless choice (e.g., Tversky and Kahneman 1991). The risky choice task consists of six simple lotteries with a 50-50 chance of a fixed gain of €6 and losses that vary from €-2 to €-7. Subjects simply have to indicate for each of the six lotteries whether they want to play this lottery or not (in case they reject a lottery their payoff is zero). This lottery choice task arguably measures loss aversion in risky choices (e.g., following Rabin 2000; Wakker 2005). While there are strong theoretical reasons why these two measures should be correlated, there are several reasons that might suggest a limited correlation. First, the idea that preferences are constructed (see e.g., the collection by Lichtenstein and Slovic 2006) challenges the idea that we would see significant correlations

[1] Loss aversion has been invoked to explain many economic phenomena that are hard to understand under the assumption of reference-point independence. Prominent examples comprise behavior in financial markets (Benartzi and Thaler 1995; Odean 1998; Haigh and List 2005); selling patterns in housing markets (Genesove and Mayer 2001; Einiö, et al. 2008); coordination (Cachon and Camerer 1996); choice bracketing (Read, et al. 1999; Rabin and Weizsäcker 2009); consumption behavior (Bowman, et al. 1999; Heidhues and Koszegi 2008); medical decision making (Bleichrodt and Pinto 2000; Bleichrodt and Pinto 2002); marketing practices (Hardie, et al. 1993; Carmon and Ariely 2000); trade policy (Tovar 2009); labor supply (Camerer, et al. 1997; Goette, et al. 2004; Fehr and Goette 2007) and the importance of defaults and the status-quo bias in decision making (Samuelson and Zeckhauser 1988; Johnson and Goldstein 2003). Camerer (2004) provides an overview of the field evidence, and Starmer (2000) a survey of theoretical explanations. See Sugden (2003), Schmidt, et al. (2008), and Köszegi and Rabin (2006) for recent theoretical frameworks of reference-dependent preferences that can explain many of these phenomena.

across different ways of measuring loss aversion. For instance, numerous experiments have demonstrated that preferences differ across response modes. The endowment effect experiment involves two pricing tasks, while the lotteries involve a series of choice tasks. These two response modes are central to the classic demonstrations of preference reversals. It is plausible that they trigger different cues or different weighting schemes for the attributes (Tversky et al. 1988). Second, research in psychology has shown that different measures of another preference characteristic, risk attitude, is often not highly correlated across different elicitation methods and domains (Johnson and Schkade 1989; Weber et al. 2002). Similar evidence exists in experimental economics (e.g., Benz and Meier 2008).

Our second contribution is to provide novel evidence on the degree of individual heterogeneity in loss aversion in riskless choices.[2] The elicitation of both valuations from the same individual distinguishes us from previous literature that focused predominantly on aggregate-level measures from between-subject designs. In these experiments different respondents were asked *either* the WTA *or* the WTP question. Thus, unlike most of previous literature on the endowment effect, we can address the importance of individual differences in loss aversion because we can investigate individual not only aggregate WTA-WTP gaps. To understand how our within-subject measurement of the individual WTA-WTP gap affects valuations we also run a between-subject study (akin to previous ones) where we elicit WTA and WTP from two different groups of respondents.

We also examine the robustness of our findings by investigating the relationship between socio-demographic variables and loss aversion. In most studies the experimental participants are undergraduates who share very similar socio-demographic backgrounds (exceptions are Kovalchik et al. 2005, Booij and van de Kuilen 2009, and Dohmen et al. forthcoming). Using undergraduates precludes any inference about how socio-demographic variables affect loss aversion. By contrast, the participants of our experiments are a random sample of 660 customers of a German car manufacturer.[3] Our subjects comprise a large age, education, income and wealth spectrum. Of course, car customers may not be representative for the population at large, but we can answer how in our sample socio-demographic variables affect loss aversion both in riskless and in risky choices.

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[2] A few papers have looked at individual differences in loss aversion in risky choices (Abdellaoui 2000; Abdellaoui, et al. 2007; Schmidt and Traub 2002; Fehr-Duda, et al. 2006; Booij and van de Kuilen 2009; Harrison and Rutström 2009; Bruhin, et al. 2010) and in the context of medical decision making (Bleichrodt and Pinto 2000; Bleichrodt and Pinto 2002).

[3] The experiments were part of a survey on motives to buy a car and on hypothetical valuations for certain product attributes of a car (see Johnson, et al. 2006 for the details).

Our most important results are as follows. First, the individual WTA/WTP ratios are positively correlated with the individual switching points in the riskless choice task. We interpret this as evidence that people who exhibit loss aversion in a riskless choice task are also more likely to exhibit loss aversion in a risky choice task. The correlation between the two measures is 0.635 and significant at any conventional level. We believe this result is interesting for several reasons. From a methodological point of view it is comforting to know that we can measure loss aversion with two instruments that appear quite different to the subjects but arguably tap the same underlying theoretical construct. Measuring the same phenomenon with two different instruments provides also a methodologically valuable 'cross-validation'. The positive correlation also mutually reinforces the interpretation of the results of the two tasks in terms of loss aversion. Furthermore, we see the fact that choice behavior in the lottery task and the valuation gap in the endowment effect task are highly significantly correlated as evidence against arguments that the WTA-WTP gap is mainly due to subject misconception of the task (e.g., Plott and Zeiler 2005). If subject misconception would explain our WTA-WTP gap then we see no reason why the gap should be strongly correlated with choice behavior in the even simpler lottery choice task.[4]

Second, our two tasks also give us novel information about individual heterogeneity in loss aversion. This is in particular true for our endowment effect experiment. Before we describe our results, recall that most studies on the endowment effect only looked at aggregate level outcomes from between-subjects designs – e.g., whether the *average* WTA of a group of owners exceeds the *average* WTP of another group of buyers. Across many studies the typical ratio of average WTA to average WTP is around 2.[5] We replicate this classic finding in our benchmark between-subject study. We also show that the valuations in our main within-subject study are not significantly different from the valuations in the benchmark between-subject study. Our within-subjects design study reveals substantial heterogeneity in riskless individual-level loss aversion. We find that WTA/WTP = 2 for the median individual; the average individual has a WTA/WTP ratio of 2.62. Yet, there is a large variation in loss aversion: The standard deviation across individuals is 2.28. For 78 percent of individuals it holds that $1 < \text{WTA/WTP} \leq 4$. Ten percent of individuals have a ratio above 4 and for the rest the ratio is at most 1. The implied values for loss aversion in risky choices are lower than those for riskless choices: the mean (median) is 1.63 (1.5) and the inter-quartile range of loss aversion is [1.2, 2] compared to [1.33, 3] in loss aversion in riskless choices.

[4] We do not claim that task misconception plays no role at all, just that it may not be the only reason behind the WTA-WTP gap. See our concluding section for an extensive discussion.
[5] See, for instance, the meta-analyses by Horowitz and McConnell (2002) and Sayman and Onculer (2005).

Finally, we find that the socio-demographic variables affect both measures of loss aversion very similarly. Females appear to be slightly more loss averse than males, but the difference becomes insignificant once we control for other variables. The older cohort in our sample appears to be more loss averse than younger people. Higher education decreases, but does not eliminate, loss aversion. Higher income and higher wealth are both positively correlated with loss aversion. In sum, the socio-demographic variables affect both measures of loss aversion in a strikingly similar way. We see this finding mainly as support for the robustness of our observations.

2. Methods

In total, 660 randomly selected customers of a large German car manufacturer participated in our two studies. All participants are German speaking and live in Austria, Germany and Switzerland. The data were collected in collaboration with a market research company. Data collection was done in personal interviews in 30 Austrian, German and Swiss cities. The interviews took place at the respondent's home or at the local car dealer. All of our subjects had recently bought a car from this manufacturer. The subjects were randomly selected from an address file and recruited by telephone for a study on motives of buying a particular type of car. To cover their opportunity costs of participation and to induce them to participate at all every subject received a flat payment of €50. In addition to this we paid participants according to their decisions in the experiments.

Twelve professional interviewers collected the data. They all received extensive training to familiarize them with the research design. Each respondent was always alone with an interviewer, undisturbed by car dealers or other customers. The experiment was embedded in this market research interview that lasted about one hour. While familiar with the experimental protocol, all interviewers were naïve about the experimental hypotheses.

We conducted two separate studies, which involved two separate sets of participants. Both studies involved the elicitation of WTA and WTP of a toy car model from this manufacturer. The aim of Study 1 was to replicate procedures and results of previous WTA-WTP studies in a between-subjects design. The novelty of this benchmark study is to provide a measure of *aggregate* loss aversion, derived from the WTA-WTP disparity in a large non-student subject pool (300 customers of this manufacturer). This benchmark is important given the fact that our research did not take place in a laboratory, and to ensure the comparability of our within subject estimates of loss aversion to the usual between subject measures. The goal of Study 2 was to measure loss aversion at the *individual* level in a within-subject design. We complement our individual measure of loss aversion in riskless choice with one from a risky choice task, to answer the question whether these measures are correlated. All subjects who participated in the within-subject design study also took part in the lottery choice task. We now describe our designs in detail.

In Study 1, in which 300 customers participated, half of the respondents were randomly assigned to answer the WTA valuation task and the other half the WTP task. Our procedure is very similar to most previous experiments on WTA and WTP elicitation tasks. We adapted the procedure by Kahneman et al. (1990), who used coffee mugs for their evaluation task, for our purposes.

Specifically, subjects in the WTA valuation task were given a miniature model car and told that it was theirs. They were then asked to specify the price at which they would be willing to sell the car to the organizers of the scientific study. Subjects were shown a list of prices, varying from € 0 to € 10, with € 0.50 increments. For each of the prices they had to indicate whether they want to sell or not to sell their model car at this price. The format of each of the choices was as follows:

If the price is **€ x** …	… I am **ready** to sell ___ I am **not ready** to sell: ___

To give subjects an incentive to report their true valuation, we applied the Becker et al. 1964 mechanism. After subjects had made their choice for all potential prices, a price was determined randomly. If the randomly selected price was one for which the respondent had indicated that they would sell the toy car, the model car was returned to the experimenter and the randomly determined price in cash was given to the respondent. If the respondent indicated that the chosen price was one at which they were not prepared to sell, they kept the model car. The respondents were aware of this procedure.

The procedures for the respondents in the WTP valuation task were identical, except that they were not endowed with a toy car. Instead they were shown a toy car and told that it could be theirs. They had to indicate for each of the prices between € 0 and € 10 whether they were prepared or not to buy at that price. Again, a random device determined the offered price and the indicated choice for that price was implemented accordingly. The exact wording of the valuation task is documented in the appendix.

The results from Study 1 can be used to measure aggregate-level loss aversion. If we replicate with our subject pool and procedure the results from similar previous experiments, we should, on average, find a positive WTA-WTP difference. Such a difference has been interpreted as evidence for loss aversion (Tversky and Kahneman 1991; Bateman et al. 1997; Novemsky and Kahneman 2005).

Our Study 2 involved an additional 360 randomly selected customers of the same car manufacturer. Here, the WTA and WTP valuation experiments were well integrated into a larger survey study. The purpose of our second study is to use the same procedures to measure *individual-level* loss aversion. If an individual's relative value of WTA and WTP is a useful measure of individual-level loss aversion, then we must obtain both WTA and WTP from each respondent. Therefore respondents now answered both the WTA and the WTP valuation task. Thus, we have a within-subject design.[6]

Specifically, subjects were informed that we randomly assigned them a model car or not, and that an envelope containing their status as buyers or sellers would be opened at the end of the study. We applied the strategy method by asking the subjects to give us both their WTA in the case that they would own the model car and their WTP in the case they would not own it. Subjects were told that one of the transactions would occur, depending upon whether the envelope assigned them to the buyer or seller role. The order in which a particular respondent answered the two tasks was randomly determined. Half of the subjects started with the WTA valuation task, followed by the WTP valuation task; for the other half it was the other way round. The valuation tasks were separated by several market research survey questions related to the features of cars.

We used the same questionnaire and procedures as in the between-subjects study but adapted the explanation to our within-subject design. For instance, if a participant started with the WTA task, he or she was told to make the decisions for the case that he or she would own this toy car. Later in the survey, the participants were confronted with the WTP task and asked to make their choices in case they would not own this toy car but were instead given the possibility to buy it. Again they were told that whether they would actually own the toy car or would be given the opportunity to buy it would be determined randomly at the very end of the study. Thus, our application of the strategy method to the WTA and WTP evaluation task allows us to obtain within-respondent estimates of loss aversion.

The potential drawback of this within-subject elicitation procedure is that the answer on the first task may influence the answer on the second one. Therefore, the WTA and WTP

[6] All previous endowment effect studies with riskless choice we are aware of used a between-subject design (akin to our benchmark study). There are a few studies which employ a within-subject design for eliciting WTA and WTP for *lotteries*. Examples include Harless (1989), Kachelmeier and Shehata (1992), and Eisenberger and Weber (1995).

results from the between-subjects elicitation of our first benchmark study serve as an important control.

Our second goal is to measure loss aversion in *risky* choices. For that purpose we adapt a simple lottery choice task from Fehr and Goette (2007) that arguably measures loss aversion as well. In this choice task individuals decide for each of six lotteries whether they want to accept (that is, play it) or reject it (and receive nothing). In each lottery the winning price is fixed at 6 and only the losing price is varied (between 2 and 7). At the end of the experiment we randomly selected one lottery for pay (Cubitt et al. 1998). Figure 1 reproduces the decision sheet of the lottery choice task as presented to subjects.

Figure 1 The lottery choice task

Lottery	Accept	Reject
#1. If the coin turns up heads, then you lose €2; if the coin turns up tails, you win €6.	O	O
#2. If the coin turns up heads, then you lose €3; if the coin turns up tails, you win €6.	O	O
#3. If the coin turns up heads, then you lose €4; if the coin turns up tails, you win €6.	O	O
#4. If the coin turns up heads, then you lose €5; if the coin turns up tails, you win €6.	O	O
#5. If the coin turns up heads, then you lose €6; if the coin turns up tails, you win €6.	O	O
#6. If the coin turns up heads, then you lose €7; if the coin turns up tails, you win €6.	O	O

Following Rabin (2000), Rabin and Thaler (2001), Schmidt and Zank (2005), Wakker (2005), Köbberling and Wakker (2005) and Fehr and Goette (2007), suggests that this task measures loss aversion rather than risk aversion. Rabin (2000), for instance, argues that risk aversion cannot plausibly explain choice behavior in small-stake risky prospects like ours. Risk aversion (i.e., a concave utility of wealth function) in such small-stakes lotteries would imply absurd degrees of risk aversion in high-stake gambles. Therefore, Rabin (2000) argues that under EU, people in such gambles should be risk neutral. In our risky choice task, people should therefore accept lotteries #1 to #5, which all have a non-negative expected value. If we nevertheless observe rejections of low-stake gambles with a positive expected value, then this might indicate loss aversion rather than risk aversion. This interpretation would certainly be vindicated if choice behavior in the lottery task would be correlated with the WTA-WTP gap as measured in the riskless valuation task.

We can determine loss aversion in the risky choice task by applying cumulative prospect theory (Tversky and Kahneman 1992). A decision maker will be indifferent between accepting and rejecting the lottery if $w^{+}(0.5)v(G) = w^{-}(0.5)\lambda^{\text{risky}}v(L)$, where L denotes the loss in a given lottery and G the gain; $v(x)$ is the utility of the outcome $x \in \{G, L\}$, λ^{risky} denotes the coefficient of loss aversion in the risky choice task; and $w^{+}(0.5)$ and $w^{-}(0.5)$ denote the probability weights for the 0.5-chance of gaining G or losing L, respectively. If we assume that the same weighting function is used for gains and losses, $w^+ = w^-$ as proposed by Prelec 1998, equation (3.1), p. 503, only the ratio $v(G)/v(L) = \lambda^{\text{risky}}$ defines an individual's implied loss aversion in the lottery choice task. A frequent assumption on $v(x)$ is linearity ($v(x) = x$) for small amounts, which gives us a very simple measure of loss aversion: $\lambda^{\text{risky}} = G/L$. We later relax some of these assumptions.

3. Results

We organize the presentation of our results as follows. We will first compare the valuations from our within- and between subjects designs in our riskless choice task.[7] Our second step will then be to describe the heterogeneity in individual-level loss aversion. Our third step examines loss aversion in a risky choice task and its relationship to loss aversion in riskless choice. Finally, we will look at the impact of socio-demographic characteristics on loss aversion.

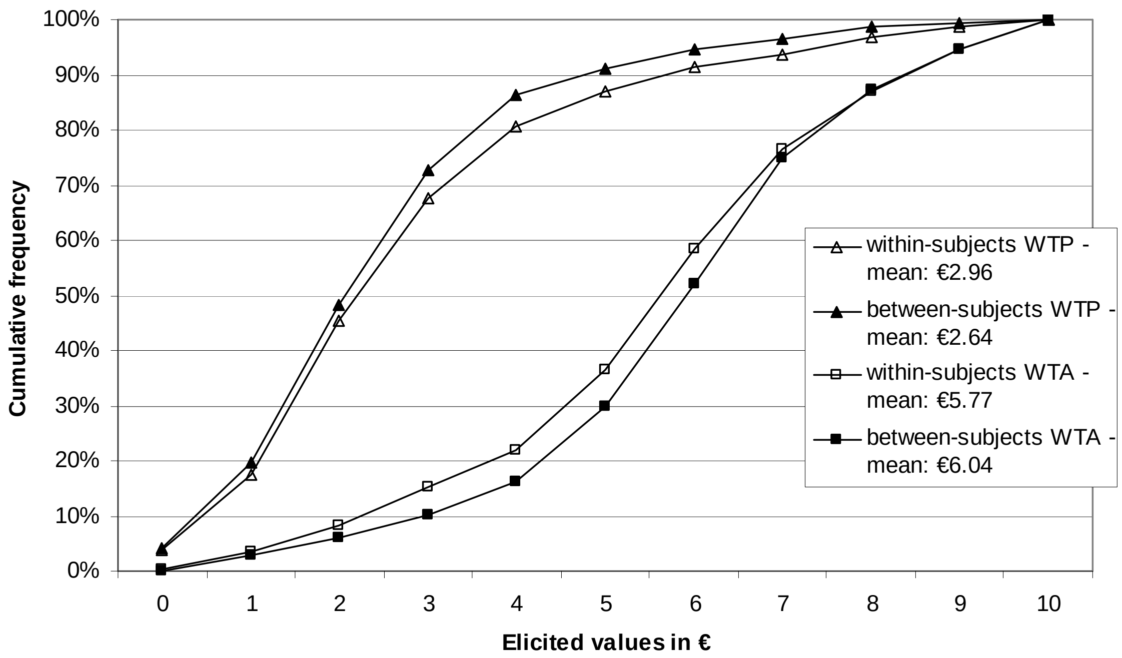
Result 1: *The method of eliciting WTA and WTP from the same person in our within-subject design did not change the answers systematically relative to a between-subjects control in which respondents only answered either a WTA question or a WTP question.*

Support: Figure 2 provides the main support for Result 1. It shows the cumulative frequency distributions of the elicited WTA and WTP measures. We distinguish whether the respective measure is elicited from the same person ("within-subject") or from another participant of the study ("between-subject").

We find only small differences between the elicited values in Study 1 and Study 2. In the WTP valuation problems, the mean elicited WTP in the between-subjects mode of Study 1 is €2.64, versus €2.96 in the within-subject mode of Study 2. For WTA we find slightly higher values in the between-subjects mode than in the within-subjects mode (€6.04 vs. €5.77). Yet, Kolmogorov-Smirnov tests (which compare distribution functions and not only means) find that the differences are very small and not significant ($p>0.63$).

[7] For this analysis we discard the observations from subjects who submitted non-monotonic valuations (10 percent in the between-subjects elicitation mode of Study 1 and 10.3 percent in the within-subjects elicitation mode of Study 2).

Figure 2 Elicited values of WTA and WTP in the within- and between-subjects design



Next we check for sequence effects in the within-subject design. We do this in two ways. First, we compare whether WTA and WTP depends on whether WTA (or WTP) came first or second (i.e., we compare $WTA_{first} = WTA_{second}$; and $WTP_{first} = WTP_{second}$). We find no significant sequence effect of our within-subject elicitation in neither WTA nor WTP (p-values > 0.63, Kolmogorov-Smirnov tests). Second, we can compare the second stage measures, whether they be WTA or WTP to the same measure in our between-subjects study, where respondents only answered a single question. Kolmogorov-Smirnov tests do not find any differences. The WTA of the participants of our between-subjects study is not significantly different from the potentially biased WTA of the participants of our within-subjects study who answered WTA after WTP (p = 0.438). A similar conclusion holds for WTP (p=0.372). We also ran a OLS regression (with robust standard errors clustered on subjects), pooling data from Study 1 and Study 2, that confirms that WTA and WTP are significantly different (p < 0.0001), but that there was no difference due to study or sequence (all p > 0.14).

Our next result documents the often-reported average WTA-WTP disparity.

Result 2: *There is a large difference between WTA and WTP. The ratio* (*mean WTA/mean WTP*)$_{between}$ = 2.29, and the ratio (*mean WTA/mean WTP*)$_{within}$ = 1.95.

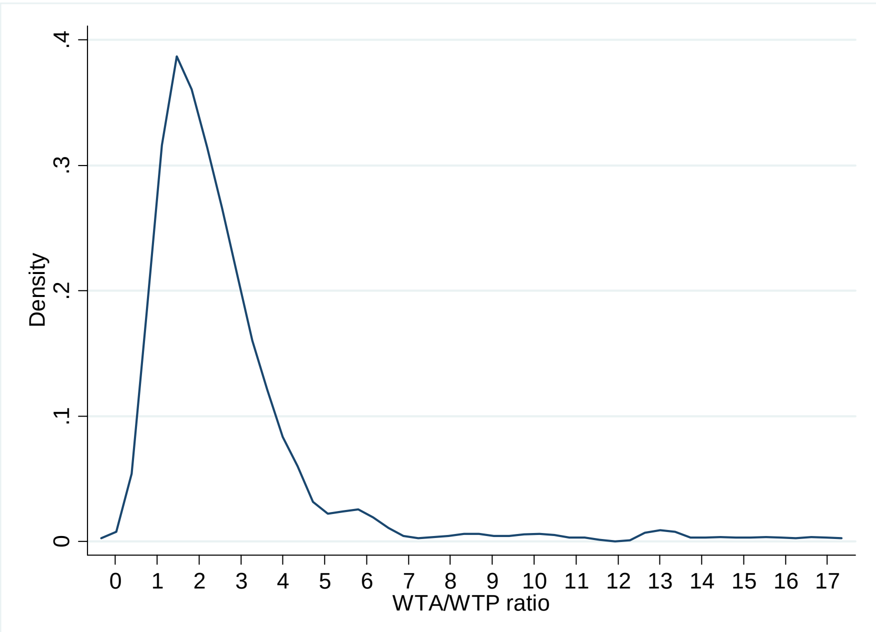
Support: Figure 2 provides the main support for this result. In the between-subjects elicitation mode, the mean WTA is €6.04 whereas the mean WTP value is €2.64 (which implies a WTA/WTP-ratio of 2.29). The difference is highly significant according to both a two-sided t-test (p<0.001) and a Kolmogorov-Smirnov test (p<0.0001). In the within-subject elicitation mode, the mean WTA is €5.77 and the mean WTP is €2.96; thus, the aggregate WTA-WTP ratio is 1.95. The median WTAs and WTPs are identical in both the between-subjects and the within-subjects elicitation modes, 6 and 2.5), respectively,. Thus, the median valuation gives a ratio of 2.4 in both elicitation modes.

Because the same person answered both valuation problems we applied a matched-pairs t-test. The difference between WTA and WTP is significant at all conventional levels (p<0.0001); the non-parametric Wilcoxon matched pairs test returns the same result (p<0.0001).

Thus, on average the between-subjects mean WTA is 2.29 times higher than the mean WTP. The mean within-subject WTA is 1.95 times higher than the mean WTP. These results are in line with previous findings of studies which also elicited between-subject WTA's and WTP's (see Kahneman et al. 1990, Table 1). Kahneman et al. find WTA/WTP relations of 2.21 in their mug experiments (Table 2). Knetsch (1989) reports a WTA/WTP relation of 2.09. See Horowitz and McConnell (2002) and Sayman and Onculer (2005) for reviews. We conclude that our elicitation methods lead to results that are highly regular and consistent with previous findings from the laboratory.

Our next result concerns the individual-level differences in the WTA/WTP ratios of Study 2. Figure 3 depicts the distribution (kernel density) of the individual WTA/WTP-ratios.

Figure 3 The distribution of individual WTA/WTP-ratios



We will interpret an individual's WTA/WTP ratio as a measure of loss aversion. Since our valuation task did not involve any risk, we denote the WTA/WTP-ratio as $\lambda^{\text{riskless}}$ to distinguish it from a risky measure of loss aversion introduced above. If an individual is not loss averse, then his or her WTA should equal his or her WTP, that is, WTA/WTP ≡ $\lambda^{\text{riskless}} = 1$. For a loss-averse individual it holds that WTA > WTP, that is, $\lambda^{\text{riskless}} > 1$, for WTP > 0. Out of the 323 respondents with monotonic evaluations, 310 individuals (that is 96 percent) report a WTP > 0.

Result 3: *Eighty-eight percent of individuals display loss aversion. That is* $\lambda^{\text{riskless}} \equiv$ *WTA/WTP* > 1. *The mean* $\lambda^{\text{riskless}}$ *is* 2.62 *and the median* $\lambda^{\text{riskless}}$ *is* 2.0. *The interquartile range is* [1.33, 3]. *The standard deviation is* 2.28.[8]

Support: We find that less than five percent of our subjects report $\lambda^{\text{riskless}} < 1$, that is, these people report WTA < WTP. For 7.1 percent $\lambda^{\text{riskless}} = 1$, as would be predicted by the standard economic argument that the reference point should not matter for the elicitation of reservation prices (neglecting income effects). For 88 percent of our respondents, $\lambda^{\text{riskless}} > 1$, that is, these individuals show some degree of loss aversion. Ten percent of them are very strongly loss averse in the sense that their $\lambda^{\text{riskless}} > 4$; the highest $\lambda^{\text{riskless}}$ is 17. If we only classify those individuals as loss averse whose WTA differs by more than 20 (50) percentage points from their WTP, we find that 80.7 (67.1) percent of the respondents are loss averse.

Our analysis has neglected diminishing sensitivity as assumed in prospect theory. We believe this is justified given the small stakes involved in our experiment and the findings in an experiment with comparable stakes by Fehr-Duda et al. (2006) who found that the vast majority of their subjects exhibit linear value functions. When we nevertheless incorporate diminishing sensitivity and assume a power utility function $v(x) = x^{\alpha}$, $\alpha < 1$ (see Wakker 2008 for a discussion), the observed mean individual $\lambda^{\text{riskless}}$ is reduced. If we use the $\alpha = .88$ estimate by Tversky and Kahneman (1992), the mean [median] individual $\lambda^{\text{riskless}} = 2.30$ [1.84]. More recent estimates by Booij and van de Kuilen (2009) who have data from a large representative subject pool most comparable to ours, suggest values of α around 0.95. In the latter case the mean [median] $\lambda^{\text{riskless}} = 2.50$ [1.93].[9]

Our third step is to look at loss aversion in risky choices. Recall that in our lottery choice task in general $\lambda^{\text{risky}} = (w^{+}(0.5)/w^{-}(0.5))(v(G)/v(L))$. As for $\lambda^{\text{riskless}}$ we only consider

[8] The 99-percent confidence interval (bootstrapped standard errors, 1000 replications) is [2.29, 2.96].

[9] See Schmidt, et al. (2008), Abdellaoui, et al. (2007), Harrison and Rutström (2009) and Bruhin, et al. (2010) for further discussions of plausible α values. For simplicity we have also assumed that WTP (WTA) is the maximal (minimal) price at which someone switches from buying (selling) to not trading.

monotonic acceptance decisions (91 percent of subjects display monotonicity). Table 1 records the results of four different assumptions on probability weights and diminishing sensitivities for gains and losses. The rationale of these four models is to vary assumptions on probability weighting and diminishing sensitivities for gains and losses systematically to see their differential impact on implied levels of loss aversion. The benchmark case (model (1)) is that both probability weighting and diminishing sensitivity are unimportant. Model (2) assumes that differential probability weighting for gains and losses is unimportant (that is, $w^{+}(0.5)/w^{-}(0.5) = 1$) but allows for diminishing sensitivities for gains and losses (we take the median estimates of Booij and van de Kuilen 2009). Model (3) assumes diminishing sensitivity is unimportant but allows for differences in probability weights for gains and losses. We take the estimates of Abdellaoui (2000) (Table 9) who reports that $w^{+}(0.5) = 0.394$ and $w^{-}(0.5) = 0.456$ for the median individual, which is one of the largest differences between $w^{+}(0.5)$ and $w^{-}(0.5)$ found in the literature (implying $w^{+}(0.5)/w^{-}(0.5) = 0.86$).[10] It therefore provides an upper bound for the importance of differential probability weightings of gains and losses for the median individual in our context. Model (4) assumes that both probability weighting and diminishing sensitivities matter.

According to Table 1, 12.58 percent accepted all lotteries with a non-negative expected value and only rejected lottery #6, which has a negative expected value. Hence, according to the benchmark model (1) their implied $\lambda^{risky} = 1$. Slightly more than sixteen percent of our respondents also accepted lottery #6, which has a negative expected value, that is, in model (1) their $\lambda^{risky} < 0.87$. Most participants rejected gambles with a positive expected value. Specifically, 70.86 percent of our respondents rejected at least lottery #5 or already some lottery #1 to #4. A few respondents (1.84 percent) rejected all six lotteries; for these people $\lambda^{risky} > 3$. The median respondent's cutoff lottery was #4: he or she accepted lotteries #1 to #4 and rejected lotteries #5 and #6, which in the benchmark model implies $\lambda^{risky} = 1.2$. The various assumptions on probability weighting and diminishing sensitivity change the values of implied λ^{risky}. However, the median individual is loss averse according to all four models.

[10] See Bleichrodt and Pinto (2000), Table 1 for a summary of parameter estimates reported in the earlier literature. For instance, for the weighting function proposed by Tversky and Kahneman (1992), estimated parameters imply $w^{+}(0.5)/w^{-}(0.5) = 0.933$. Fehr-Duda, et al. (2006) report $w^{+}(0.5)/w^{-}(0.5)$ between 0.91 and 0.964 (calculated from their data in Table III). The estimates in Bruhin, et al. (2010, Table IX) range from 0.82 to 1.04. Abdellaoui, et al. (2008) cannot reject that $w^{+}(0.5)/w^{-}(0.5) = 1$ in their data.

Table 1 Acceptance rates of the different lotteries in the lottery choice task and implied $\lambda^{risky} = \omega*(6^{\alpha}/L^{\beta})$, $\omega \equiv w^{+}(0.5)/w^{-}(0.5)$

Acceptance behavior (lottery choice category):	Per-cent	Implied accept-able loss	Implied λ^{risky} under various assumptions of probability weights and diminishing sensitivities for gains and losses			
			(1)	(2)	(3)	(4)
Parameters:			ω=1 α=1 β=1	ω=1 α=0.95 β=0.92	ω=0.86 α=1 β=1	ω=0.86 α=0.95 β=0.92
7) Reject all lotteries	1.84	€ <2	>3.00	>2.90	>2.49	>2.58
6) Accept lottery #1, reject lotteries #2 to #6	9.51	€ 2	3.00	2.90	2.49	2.58
5) Accept lotteries #1 and #2, reject lotteries #3 to #6	15.95	€ 3	2.00	2.00	1.72	1.72
4) Accept lotteries #1 to #3, reject lotteries #4 to #6	25.77	€ 4	1.5	1.53	1.32	1.29
3) Accept lotteries #1 to #4, reject lotteries #5 to #6	17.79	€ 5	1.2	1.25	1.07	1.03
2) Accept lotteries #1 to #5, reject lotteries #6	12.58	€ 6	1.00	1.06	0.91	0.86
1) Accept all lotteries	16.56	€ ≥7	≤0.87	≤0.92	≤0.79	≤0.73
Median			1.50	1.53	1.32	1.29
Interquartile range			1.2-2.0	1.25-2.0	1.07-2.49	1.03-1.72

Notes: (1) benchmark parameters: no probability weighting, and no diminishing sensitivity. (2) no probability weighting, but diminishing sensitivity. (3) Probability weighting, but no diminishing sensitivity. (4) Probability weighting and diminishing sensitivity. Parameters on diminishing sensitivity taken from Booij and van de Kuilen (2009); parameters on ω taken from Abdellaoui (2000).

A comparison with $\lambda^{riskless}$ also suggests that the implied λ^{risky} are lower. Our next result addresses the question how the two measures of loss aversion are related. If the measures were correlated, then they would mutually reinforce the interpretation that each respective measure of loss aversion provides convergent evidence. Result 4 summarizes the main result of our paper.

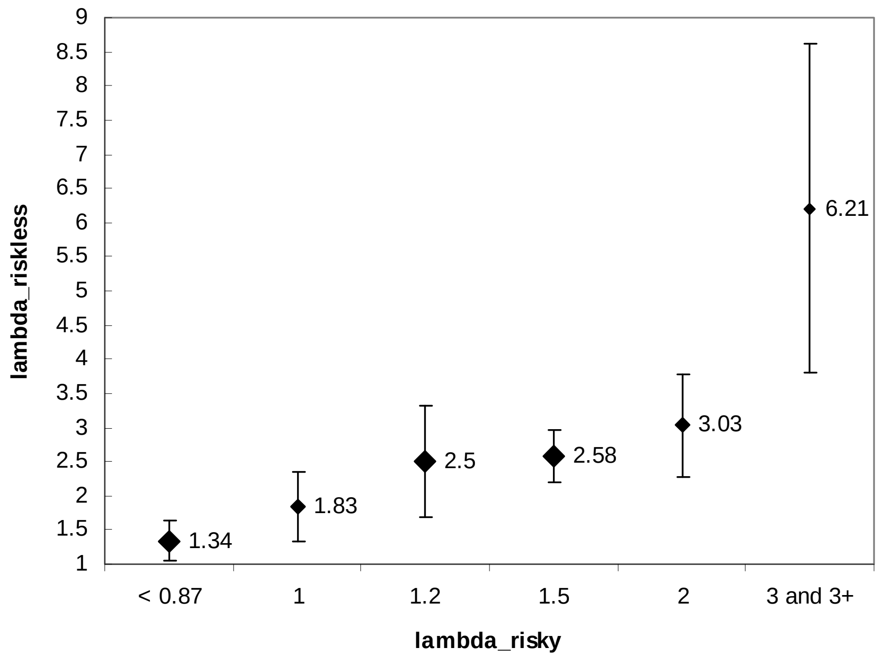
Result 4: *The WTA/WTP ratio is highly significantly positively correlated with the switch point in the lottery choice task. Hence, the implied levels of loss aversion are positively correlated. The implied levels of* λ^{risky} *are lower than those of* $\lambda^{riskless}$.

Support: Figure 4 illustrates Result 4. For our graphical illustration we use the assumptions of model (1) in Table 1. On the *x*-axis this figure shows the λ^{risky}-measure as implied by the switch point of the risky choice task (see Figure 1 and Table 1, model (1)). On the *y*-axis we depict the mean $\lambda^{riskless}$ (WTA/WTP ratio under the assumption that $\alpha = 1$) from Study 2. We indicate the mean of $\lambda^{riskless}$ and the 99-percent confidence bounds (bootstrapped standard errors, 1000 replications). The size of symbols is proportional to the number of underlying observations (see Table 1 for details).

Figure 4 shows that $\lambda^{riskless}$ and λ^{risky} are clearly positively correlated. For instance, individuals who have an average $\lambda^{risky} < 0.87$ have a $\lambda^{riskless} = 1.34$ on average. Individuals who have a $\lambda^{risky} = 2$ have an average $\lambda^{riskless} = 3.03$. A Spearman rank order correlation between the two measures confirms the relationship observed in Figure 4 (Spearman's $\rho = 0.635$; $p<0.0001$; n=281). This also holds if we exclude the 'outlier' $\lambda^{riskless} = 6.21$ for people with a $\lambda^{risky} \geq 3$. A regression analysis confirms this conclusion.[11]

To our knowledge, this is the first evidence that loss aversion in riskless choice and loss aversion in risky choices are positively correlated at the individual level. Notice that the fact that $\lambda^{riskless}$ and λ^{risky} are correlated does *not* depend on whether one believes in the exact value of $\lambda^{riskless}$ or λ^{risky} as we have determined them in Table 1 as measures of loss aversion. The correlation simply confirms that a subject's WTA/WTP-ratio and his or her acceptance behavior in the lottery choice task are highly significantly related.

Figure 4 Relationship between loss aversion in risky and riskless choice under linear utility and relative probability weighting of 1



Three remarks are in order in interpreting this result. First, if the often noted WTA-WTP disparity were largely due to subject misconception of the task (Plott and Zeiler 2005) then

[11] An OLS regression using the assumptions of model (1) in Table 1 returns the following: $\lambda^{riskless} = 0.066(0.564) + 1.737(0.400)*\lambda^{risky}$, $R^2 = 0.21$, robust standard errors in parentheses. Controlling for socio-demographics (see below) does not change this relationship significantly but reduces the coefficient of λ^{risky} to 1.522.

there would be no reason why $\lambda^{riskless}$ and λ^{risky} are positively correlated. Second, in our view, the positive correlation provides convergent evidence for loss aversion. If we assume that the lottery choice task reveals loss aversion, then the fact that $\lambda^{riskless}$ and λ^{risky} are positively correlated reinforces the interpretation that the endowment effect is due to loss aversion. A similar argument holds vice versa. Third, we note that this relationship is observed across two different response modes, suggesting that the underlying construct of loss aversion account exists across both a pair of judgment tasks (WTA and WTP) and a risky choice task.

As indicated above, Figure 4 reveals that $\lambda^{riskless}$ and λ^{risky} are not the same. $\lambda^{riskless}$ exceeds λ^{risky} for all levels of λ^{risky}. If $\lambda^{riskless}$ would be identical to λ^{risky} then $\lambda^{riskless}$ would be on the diagonal, which is clearly not the case; λ^{risky} is highly significantly lower than $\lambda^{riskless}$ (Wilcoxon matched pairs test, $z=11.1$, $p<0.0001$; see also footnote 12). Why this is the case is a task left for future research. One possibility is that λ^{risky} which involves choices, measures only loss aversion for money, and there is evidence that loss aversion for money is lower than for commodities (Novemsky and Kahneman 2005; the extent is debated, however (Bateman et al. 2005)). Because it uses a tradeoff, $\lambda^{riskless}$ reflects loss aversion for both money and the model car. Another possibility is that there is an emotional attachment to the car, a factor that increases loss aversion (Sokol-Hessner et al. 2009).

The final step in our analysis concerns the impact of socio-demographic factors on loss aversion. Since our subject pool is only representative of one group of customers but not for the population at large we see this analysis mainly as robustness check whether the socio-demographic background of our subjects affects the two measures of loss aversion similarly.[12]

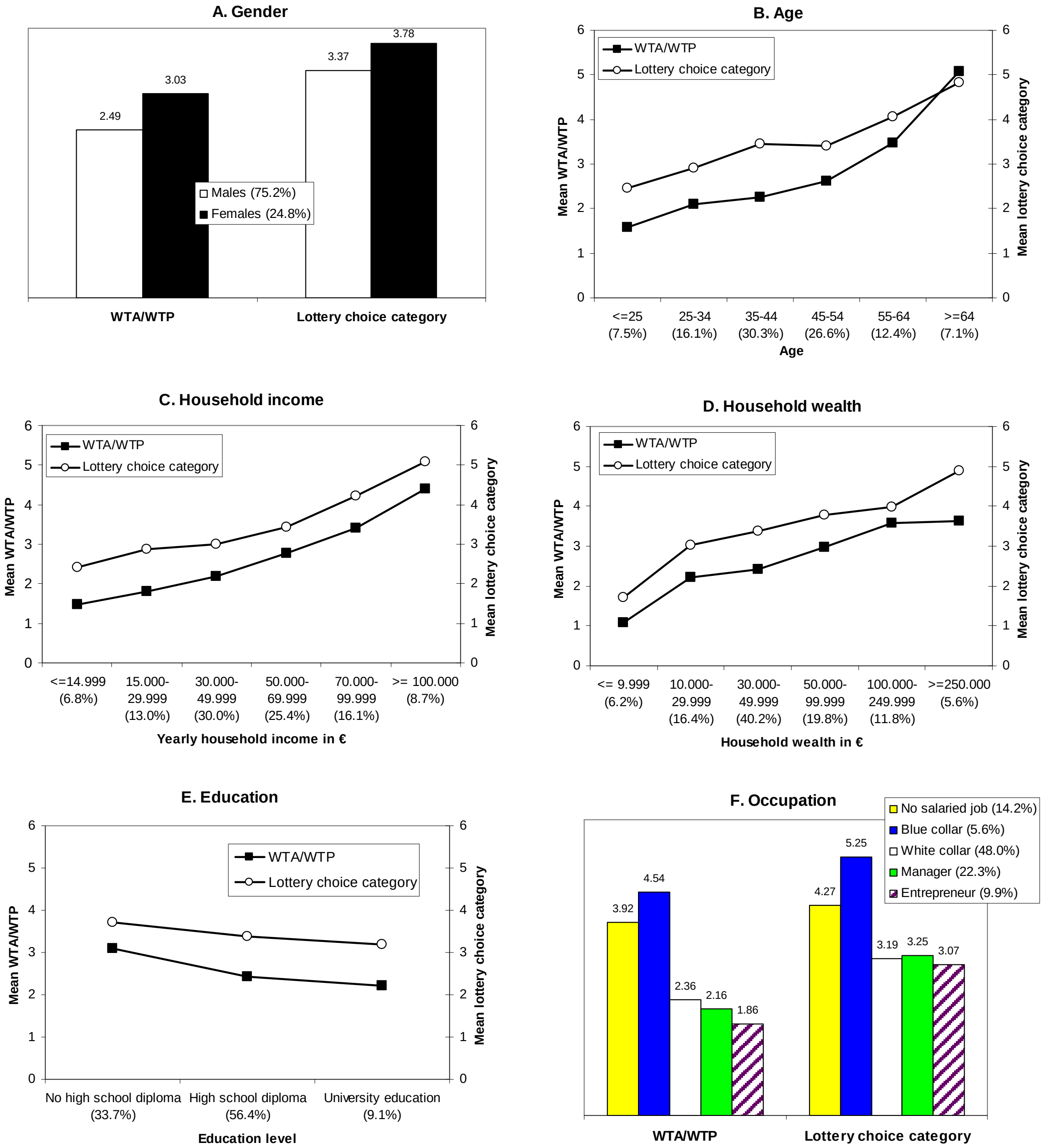
Figure 5 gives a first impression of the link between socio-economic variables and loss aversion by plotting the bi-variate relationships between the mean WTA/WTP ratio as a measure of riskless loss aversion and the mean lottery choice category (see Table 1) as an indicator of loss aversion in risky choices. For both variables higher values indicate more loss aversion. We look at six economically interesting variables: gender (panel A), age (panel B), household income (panel C), household wealth (panel D), education (panel E) and occupation (panel F). We also indicate in Figure 5 the fraction of participants who fall in a particular socio-demographic category.

Figure 5 reveals several striking observations. First, the qualitative patterns of both measures of loss aversion are very similar in all six panels. Second, we find a small but significant gender gap in both measures (panel A). According to both measures, females are

[12] Booij and van de Kuilen (2009) report experiments with a representative sample from the Dutch population. The gender and education effects we report below are consistent with their findings.

on average more loss averse than males. This gender gap is supported by two-sided Mann-Whitney tests, which return $p<0.05$ for both measures.

Figure 5 Bivariate relation between socio-economic variables and indicators of loss aversion



Notes: 1) Lottery choice category: 1 = no loss aversion, 7 = high loss aversion. See Table I for a description. 2) Percentages indicate the fraction of participants in a particular socio-economic category.

Third, as panel B shows, older people tend to be more loss averse in both their riskless valuations and in their risky choices (Spearman rank order correlations, $p<0.05$). Fourth, the higher the household income is, the higher is loss aversion (panel C). A similar conclusion holds for wealth (panel D).[13] Higher education seems to decrease loss aversion (panel E) in both measures (Spearman rank order correlations, $p<0.05$) but does not eliminate it. Different occupational groups have different degrees of loss aversion (Kruskal-Wallis tests, $p<0.0001$ for both measures). Finally, if we compare the implied λ^{risky} and $\lambda^{riskless}$ separately for each category of each variable (using model (1) of Table 1) we find that $\lambda^{riskless}$ is mostly significantly higher than λ^{risky}.

Of course, bi-variate correlations can be misleading. Therefore, we conduct a multiple regression analysis that controls for all available variables. The next result records our findings.

Result 5: *The socio-demographic variables affect both measures of loss aversion similarly. We find no gender effect and an increase of loss aversion across age cohorts. Higher education decreases loss aversion and household income and wealth are associated with increases in loss aversion.*

Support: We run regressions for both measures of loss aversion. We document the results in Table 2. We start with the WTA/WTP measure. We estimated three models, using OLS and calculating robust standard errors. In model (1) we only included a dummy for females and age dummies (taking the youngest group (age ≤ 34) as the reference group. We find that females are more loss averse than males but the difference is not significant (in contrast to the bi-variate analysis). Moreover, the older respondents are the more loss averse they get. The age effect is highly significant, in particular for people older than 55 years.[14] These strong age effects are interesting, both because they may affect financial decision-making across the lifespan (Agarwal et al. 2009) and because they may be related to well-documented decreases in memory performance (Salthouse 2004). Weber and Johnson (2006) have speculated that such deficits may increase loss aversion in older adults. Of course our analysis cannot separate these age effects from cohort effects.

Model (2) adds dummies for education and income. We find that higher education reduces loss aversion. Quite surprisingly, higher income is positively correlated with loss

[13] The Spearman rank order correlations are significantly positive at $p<0.0001$ for all four bi-variate correlations of income, wealth and WTA/WTP and lottery choice categories.

[14] At first sight, the result that older people are more loss averse stands in contrast to Kovalchik, et al. (2005) who do not find loss aversion in their subject pool of old people (age > 70 years). However, Kovalchik et al note that their old subjects are highly educated relative to their age group. Thus, since education reduces loss aversion, our results might be consistent with those of Kovalchik et al.

aversion.[15] Regression (3) includes wealth instead of income.[16] It turns out that higher wealth and loss aversion are also highly significantly positively correlated.

Models (4) to (6) replicate the analysis for our risky choice task using ordered probit estimation. We regress the lottery choice categories (see Table 1) on the same set of explanatory variables as in models (1) to (3). We get very similar results, qualitatively. The only difference arises in model (5) where the middle income category is not significant for the lottery choice tasks, whereas it is highly significant in the riskless task.

Table 2 Socio-economic characteristics and measures of loss aversion

Dependent variable	WTA_i/WTP_i			Lottery choice category		
Method	OLS			ordered probit		
	(1)	(2)	(3)	(4)	(5)	(6)
Female	0.267	0.070	0.297	0.171	0.075	0.168
	(0.286)	(0.274)	(0.271)	(0.127)	(0.128)	(0.131)
Age 35 – 54	0.492	0.123	0.455	0.451	0.235	0.392
	(0.212)**	(0.251)	(0.209)**	(0.169)***	(0.195)	(0.182)**
Age 55+	2.074	1.467	1.925	0.999	0.553	0.830
	(0.511)***	(0.471)***	(0.493)***	(0.193)***	(0.209)***	(0.204)***
High school degree		-1.045	-0.893		-0.405	-0.303
		(0.325)***	(0.320)***		(0.133)***	(0.126)**
University degree		-1.589	-1.249		-0.797	-0.550
		(0.409)***	(0.386)***		(0.229)***	(0.212)***
Income Euro 30k – 70k		0.792			0.320	
		(0.245)***			(0.216)	
Income Euro 70k+		1.845			1.216	
		(0.364)***			(0.240)***	
Wealth Euro 30k – 100k			0.483			0.449
			(0.229)**			(0.175)**
Wealth Euro 100k+			1.084			0.875
			(0.447)**			(0.235)***
Constant	1.865	2.092	2.055			
	(0.193)***	(0.235)***	(0.277)***			
Observations	310	310	310	326	326	326
R-squared	0.11	0.20	0.17			

Robust standard errors in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

We see the fact that the socio-economic variables affect the WTA/WTP-ratio and the lottery choice category in a qualitatively very similar way as further evidence that both measures reflect a similar underlying psychology – loss aversion. There are strong theoretical arguments why loss aversion underlies the endowment effect and decisions in the lottery choice task. Our dual finding that the WTA/WTP-ratios and the lottery choices are highly significantly correlated and that the socio-demographic variables affect both measures in a

[15] Income and education are positively correlated, but the correlation is surprisingly weak (ρ=0.225).

[16] Not surprisingly, income and wealth are highly significantly, and quite strongly, correlated (ρ=0.475).

qualitatively similar way, supports the interpretation of observed behavior in terms of loss aversion.

As mentioned, we see our analysis mainly as a robustness check, since our subject pool, while quite varied according to many socio-demographic dimensions, is not representative for the population at large. Many of the relationships may be specific to the particular sampling represented by the car company's customers, and the particular experience of each cohort in our sample. However, the fact that the socio-demographic variables affect choices in a very systematic way suggests that it is worthwhile to study loss aversion in a more representative sample (see for instance Dohmen et al. forthcoming for an investigation of risk attitudes and Booij and van de Kuilen (2009) for an investigation of prospect theory).

4. Discussion and Conclusions

In this paper we investigated loss aversion in riskless and risky choices. Our data are consistent with the existence of loss aversion both in riskless and risky choices. People who are loss averse in the riskless valuation task (by showing a WTA/WTP-ratio >1) are also loss averse in the risky choice task because they reject 50-50 gambles with positive expected payoffs. We see this finding – which comes from a large non-student sample – as the main contribution of this paper.

Our results emphasize that the degree of loss aversion can vary across situations and participants of different levels of experience. A natural question is what causes this variation. One possibility, raised by Plott and Zeiler (2005), is that respondents may have different degrees of misunderstanding across situations and tasks. However, two aspects of our results suggest that simple misunderstanding is not, by itself, responsible for all this variation.

First, these two measures are very different. The choice between gambles involves risk, and a single choice between the status quo and several options. The WTA and WTP task involves two valuations of the same single object, each from a different perspective. Despite these differences, they show a high degree of agreement. It is difficult to see what could be the common element of the two methods that is misunderstood. A misunderstanding of strategic considerations, for example, might play a role in the valuation question, but it is less apparent how it would produce similar results in the choice among gambles.

Second, the effect of demographics is very similar for these two measures. It seems difficult to reconcile this pattern occurring solely as a result of miscomprehension. We think a more profitable way of proceeding is not to doubt the existence of loss aversion in some economic choice, but to focus on understanding the boundary conditions surrounding loss aversion, such as whether it holds for ordinary transactions (e.g., Novemsky and Kahneman 2005, Bateman et al. 2005) or for experienced traders (e.g., List 2003).

Furthermore, neuroscientific evidence (Tom et al. 2007), evidence from non-human primates (Chen et al. 2006) and from young children (Harbaugh et al. 2001) suggests that loss aversion may be deeply rooted, which would imply that for many people it takes experience and learning to overcome loss aversion. Johnson et al. (2007) propose a cognitive account for loss aversion that focuses on the retrieval of aspects of the transaction from memory. Such a cognitive view seems consistent with the observed decrease of loss aversion with education and the increase with age, given the well documented evidence for cognitive decline.

We also note that the current design has two features that we believe are important to producing within-respondent estimates of loss aversion. The first is the separation of the elicitation of WTA vs. WTP by several intervening tasks such as standard market research surveys. We suspect that preventing simple recall of the prior price is crucial to obtaining within-subjects measures. The second is the use of a strategy method which allows the respondent to value the objects in two different frames, without actually knowing whether or not they are endowed. We cannot tell if either or both are necessary to produce within-respondent estimates, but suggest that without these, respondents may have remembered their first answer, and because of the need to appear consistent, would have produced WTA and WTP prices that were closer together.

APPENDIX: QUESTIONS FOR ELICITING WTA AND WTP

Eliciting WTA

"In the following question there are no right or wrong answers. Your response should only reflect your own preferences. As the other parts of the questionnaire this following question is part of a scientific research project on how people make economic choices.

We will give you the following little toy car which you can keep.

THIS TOY CAR IS FOR YOU TO KEEP!

If you do not want to keep the toy car, you can **sell** it to the organizers of this scientific study. In the table below please mark the minimum acceptable price at which you are willing to sell the car.

- If at our offer price you have indicated in the table that you are willing to sell the toy car, you will receive this amount in cash instead of the toy car.
- If at our offer price you have indicated in the table that you are not willing to sell the toy car, you will keep your toy car.

The price at which we will buy your toy car will be randomly determined and for sure be between €0 and €10. That is, our offered price will be determined by rolling dice after you have filled in the table below. All prices are equally likely. There is a scientific reason for proceeding this way. Since you cannot influence the price, which will be determined randomly, you have an incentive to state the price that corresponds to your **true preference**. Once you have made your choice, you cannot change it anymore. We will also not be able to negotiate about the price.

Price in €	Please make a cross in each line depending on whether you are ready or not to **sell** the toy car at the respective price to us.	
If the price is **€ 0** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 0.5** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 1.0** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 1.5** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 2.0** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 2.5** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 3.0** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 3.5** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 4.0** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 4.5** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 5.0** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 5.5** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 6.0** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 6.5** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 7.0** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 7.5** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 8.0** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 8.5** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 9.0** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 9.5** …	… I am **ready** to sell ___	I am **not ready** to sell: ___
If the price is **€ 10.0** …	… I am **ready** to sell ___	I am **not ready** to sell: ___

Eliciting WTP

The questionnaire for eliciting WTP was adapted accordingly.

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