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ABSTRACT

Individual-Level Loss Aversion in Riskless and Risky Choices*

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.

JEL Classification: C91, C93, D81

Keywords: loss aversion, endowment effect, field experiments

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I. 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, Knetsch and Thaler [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, Fox, Trepel and Poldrack [2007]).[1]

Our paper makes three 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]).

Second, we will provide novel evidence on the degree of individual heterogeneity in loss aversion. The elicitation of both valuations from the same individual distinguishes us from previous literature which focused predominantly on aggregate-level measures from

[1] Loss aversion has been invoked to explain many naturally occurring phenomena that are hard to understand under the assumption of reference-point independence. Prominent examples comprise behavior in financial markets (Benartzi and Thaler [1995]; Gneezy and Potters [1997]; Odean [1998]; Haigh and List [2005]); selling patterns in housing markets (Genesove and Mayer [2001]); consumption behavior (Bowman, Minehart and Rabin [1999]; Chua and Camerer [2004]); marketing practices (Hardie, Johnson and Fader [1993]; Carmon and Ariely [2000]); trade policy (Tovar [2006]); labor supply (Camerer, Babcock, Loewenstein and Thaler [1997]; Goette, Huffman and Fehr [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, Starmer and Sugden [2005], and Köszegi and Rabin [2006] for recent theoretical frameworks of reference-dependent preferences that can explain many of these phenomena.

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.

Third, we investigate how socio-demographic variables affect loss aversion. In most studies the experimental participants are undergraduates who share very similar socio-demographic backgrounds. This 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.[2] 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.

Our most important results are as follows. First, people who exhibit loss aversion in a riskless choice task are also much 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 psychology. 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.[3]

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

[2] 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, Gächter and Herrmann [2006] for the details).

[3] 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.

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.[4] 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 a 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 interquartile range of loss aversion is [1.2, 2] compared to [1.33, 3] in loss aversion in riskless choices.

Finally, we find that the socio-demographic variables affect both measures of loss aversion very similarly. Females appear to be more loss averse than males, but the difference turns out to be insignificant once we control for other variables. Older people are more loss averse than younger people. Higher education decreases loss aversion (but does not eliminate it). 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 as support for the robustness of our observations.

Our paper is organized as follows. In the next section we will describe our methods in detail. In Section III we will present our results. Section IV concludes.

II. METHODS

In total, 660 randomly selected customers 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 called up to ask for participation in a study on motives of buying a

[4] See, for instance, the meta-studies by Horowitz and McConnell [2002] and Sayman and Onculer [2005].

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 other customers or car dealers. The interviews, including the experiments, 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 the first study 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). The goal of the second study 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 our first study, 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, Knetsch and Thaler [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, De Groot and Marschak [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 the first study 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, Munro, Rhodes, Starmer and Sugden [1997]; Novemsky and Kahneman [2005]).

Our second study 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.[5]

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

[5] 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].

other way round. The valuation tasks were separated by several market research survey questions related to the features of autos.

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 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 [2002] 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, Starmer and Sugden [1998]). Figure I reproduces the decision sheet of the lottery choice task as presented to subjects.

FIGURE I

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], 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 $w^{+}(0.5)v(G) = w^{-}(0.5)\lambda^{risky}v(L)$, 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 $w^{+}(0.5) = w^{-}(0.5)$ (as it is for instance implied by the probability weighting function proposed by Prelec [1998]) only the ratio $v(G)/v(L) = \lambda^{risky}$ 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: $\lambda^{risky} = G/L$.

III. 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.[6] 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.

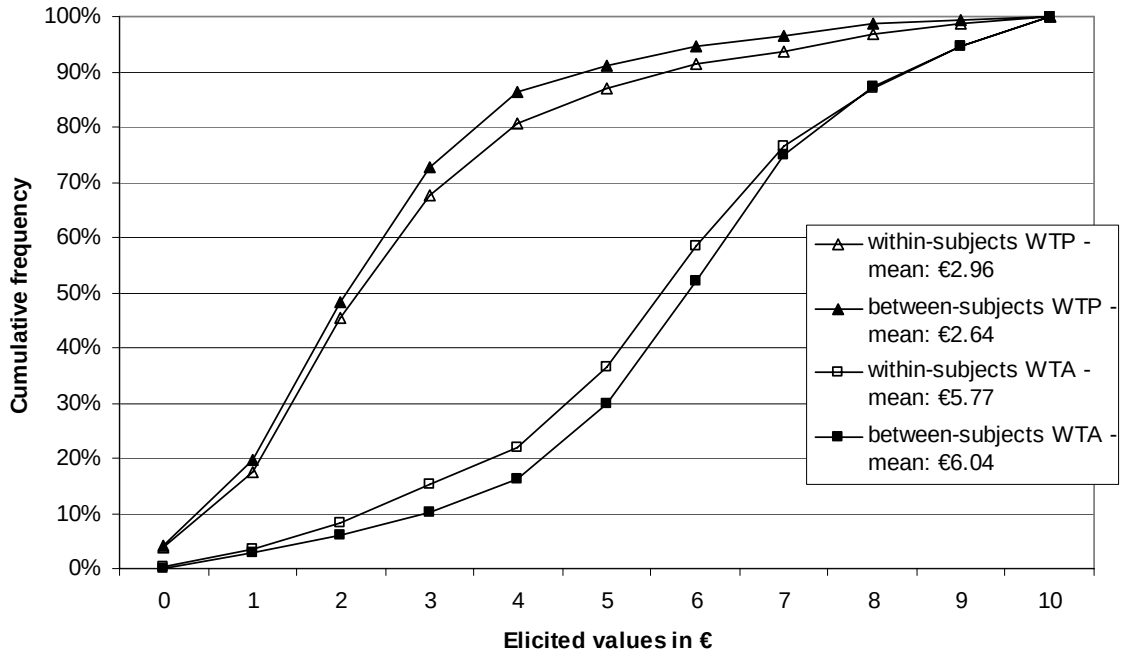
Result 1: *The method of eliciting WTA and WTP from the same person in our within-subject design did not change the answers systematically relative to a between-subjects control in which respondents only answered either a WTA question or a WTP question.*

[6] For this analysis we discard the observations from 12.6 percent of subjects who submitted non-monotonic valuations.

Support: Figure II 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").

FIGURE II

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



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, whereas in the within-subject mode of study 2 it amounts to €2.96. For WTA we find slightly higher values in the between-subjects mode than in the within-subjects mode (€6.04 vs. €5.77). Yet, the differences are very small and not significant (Kolmogorov-Smirnov tests, $p>0.63$).

We next 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).

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 II 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 appropriate test now is a matched-pairs test, because the same person answered both valuation problems. According to the 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, Knetsch and Thaler [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 overviews. We conclude that our elicitation methods lead to results that are highly regular and consistent with previous findings.

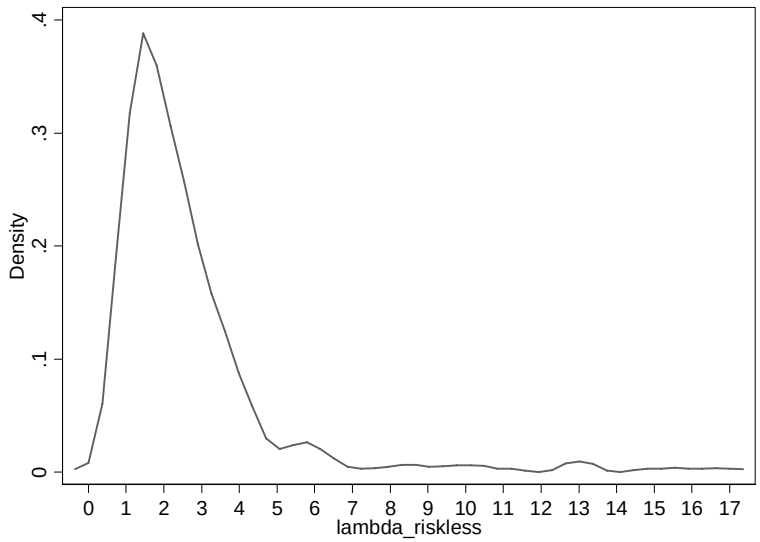
Our next result concerns the individual-level differences in the WTA/WTP ratios of study 2. We will interpret an individual's WTA/WTP ratio as a measure of loss aversion. Since our valuation task did not involve any risk, we denote the WTA/WTP-ratio as $\lambda^{riskless}$ to distinguish it from a risky 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 $\equiv \lambda^{riskless} = 1$. For a loss-averse individual it holds that WTA > WTP, that is, $\lambda^{riskless} > 1$, 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 in the sense of* $\lambda^{riskless}$ ≡ *WTA/WTP* > 1. *The mean* $\lambda^{riskless}$ *is* 2.62 *and the median* $\lambda^{riskless}$ *is* 2.0. *The interquartile range is* [1.33, 3]. *The standard deviation is* 2.28.[7,8]

Support: We find that less than five percent of our subjects report $\lambda^{riskless} < 1$, that is, these people report WTA < WTP. For 7.1 percent $\lambda^{riskless} = 1$, as would be predicted by the standard economic argument that the elicitation method should not matter for the elicitation of reservation prices (neglecting income effects). For 88 percent of our respondents it holds that $\lambda^{riskless} > 1$, that is, these individuals show some degree of loss aversion. Ten percent of them are very strongly loss averse in the sense that their $\lambda^{riskless} > 4$; the highest $\lambda^{riskless}$ is 17.[9] Figure III depicts the distribution (kernel density) of individual $\lambda^{riskless}$.

FIGURE III

The distribution of individual WTA/WTP-ratios



Our third step is to look at loss aversion in risky choices. Table I records the results. As for $\lambda^{riskless}$ we only consider monotonic acceptance decisions (91 percent of subjects display monotonicity).

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

[8] This analysis neglects diminishing sensitivity as assumed in prospect theory. When we incorporate diminishing sensitivity and assume a power utility function $v(x) = x^{\alpha}$, $\alpha < 1$, the observed mean individual $\lambda^{riskless}$ is reduced. If we use the $\alpha = .88$ estimate by Tversky and Kahneman [1992]), the mean individual $\lambda^{riskless} = 2.33$. More recent estimates, e.g., by Booij and Van de Kuilen [2006] who have data from a large representative subject pool, suggest values of α between 0.9 and 0.94. In the latter case $\lambda^{riskless} = 2.47$. For simplicity we have also assumed that WTP (WTA) is the maximal (minimal) price at which someone switches from buying (selling) to not trading. If we relax this assumption and assume that WTP (WTA) is the midpoint between the highest price at which somebody is prepared to buy (sell) and the next highest (lowest) price at which he or she is not prepared to buy (sell) then the mean individual $\lambda^{riskless}$ is 2.51 (2.25 under $\alpha = .88$).

[9] 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.

TABLE I

Acceptance rates of the different lotteries in the lottery choice task and implied λ^{risky}

Acceptance behavior (lottery choice category):	Percent	Implied acceptable loss	Implied λ^{risky} if $v(x) = x$
7) Reject all lotteries	1.84	€ <2	>3
6) Accept lottery #1, reject lotteries #2 to #6	9.51	€ 2	3
5) Accept lotteries #1 and #2, reject lotteries #3 to #6	15.95	€ 3	2
4) Accept lotteries #1 to #3, reject lotteries #4 to #6	25.77	€ 4	1.5
3) Accept lotteries #1 to #4, reject lotteries #5 to #6	17.79	€ 5	1.2
2) Accept lotteries #1 to #5, reject lotteries #6	12.58	€ 6	1
1) Accept all lotteries	16.56	€ ≥7	≤0.87

According to Table I, 12.58 percent behaved like risk-neutral decision makers because they accepted all lotteries with a non-negative expected value and only rejected lottery #6, which has a negative expected value. Hence, their implied $\lambda^{risky} = 1$. Slightly more than sixteen percent of our respondents also accepted lottery #6, which has a negative expected value, i.e., 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 implies $\lambda^{risky} = 1.2$.

This observation does not address the concordance of the two measures of loss aversion. 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.

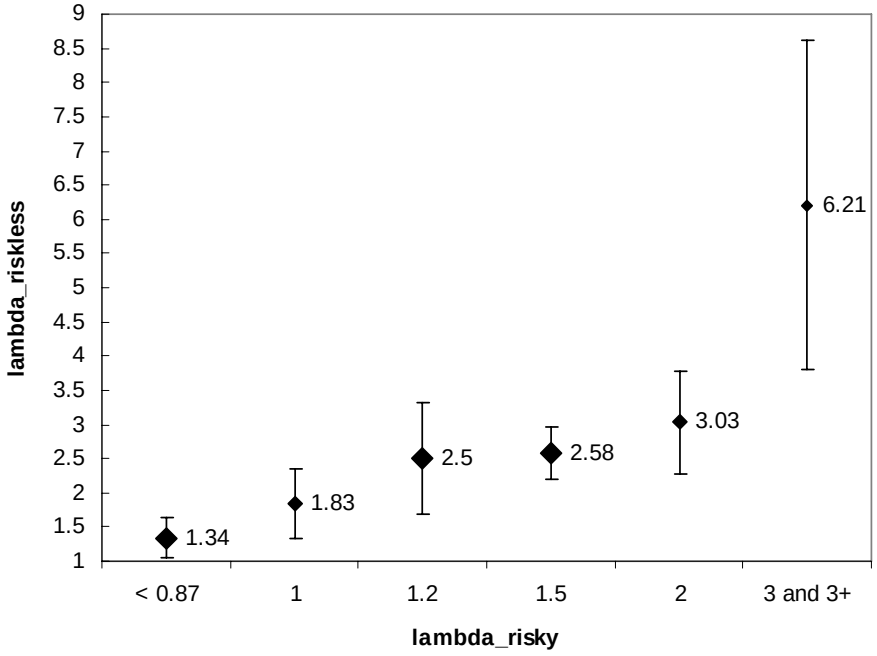
Result 4: *The measures of loss aversion in the valuation task, $\lambda^{riskless}$, and in the lottery choice task, λ^{risky}, are highly significantly and strongly positively correlated.*

Support: Figure IV illustrates Result 4. On the *x*-axis this figure shows the λ^{risky}-measure. On the *y*-axis we depict the mean $\lambda^{riskless}$ 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 I for details).

Figure IV 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 IV (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 $\lambda^{risky} \geq 3$.

FIGURE IV

Relationship between loss aversion in risky and riskless choice



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. 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 there would be no reason why $\lambda^{riskless}$ and λ^{risky} are positively correlated. Second, in our view, the positive correlation reinforces the interpretation that our lottery choice task measures loss aversion, because otherwise there would be no reason why $\lambda^{riskless}$ and λ^{risky} are positively correlated. Likewise, 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. Third, as Figure IV reveals, $\lambda^{riskless}$ and λ^{risky} are not the same, however. $\lambda^{riskless}$ 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). 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. Because it uses a tradeoff, $\lambda^{riskless}$ reflects loss aversion for both money and the model car. Finally, notice also 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 above as measures of loss aversion (based on assumptions derived from prospect theory). The correlation simply confirms that a subject's WTA/WTP-ratio and his or her acceptance behaviour in the lottery choice task are highly significantly related. Since there are strong *a priori* arguments why these measures reflect loss aversion, we interpret the positive correlation between riskless and risky choices as convergent evidence for loss aversion.[10]

The final step in our analysis concerns the impact of socio-demographic factors on loss aversion. Since we have very detailed data about our respondents, we can also look at the relation between socio-economic characteristics and loss aversion as measured by the valuation task and the lottery choice task. 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 a robustness check whether the socio-demographic background of our subjects affect the two measures of loss aversion similarly.[11]

Figure V 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 I) 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

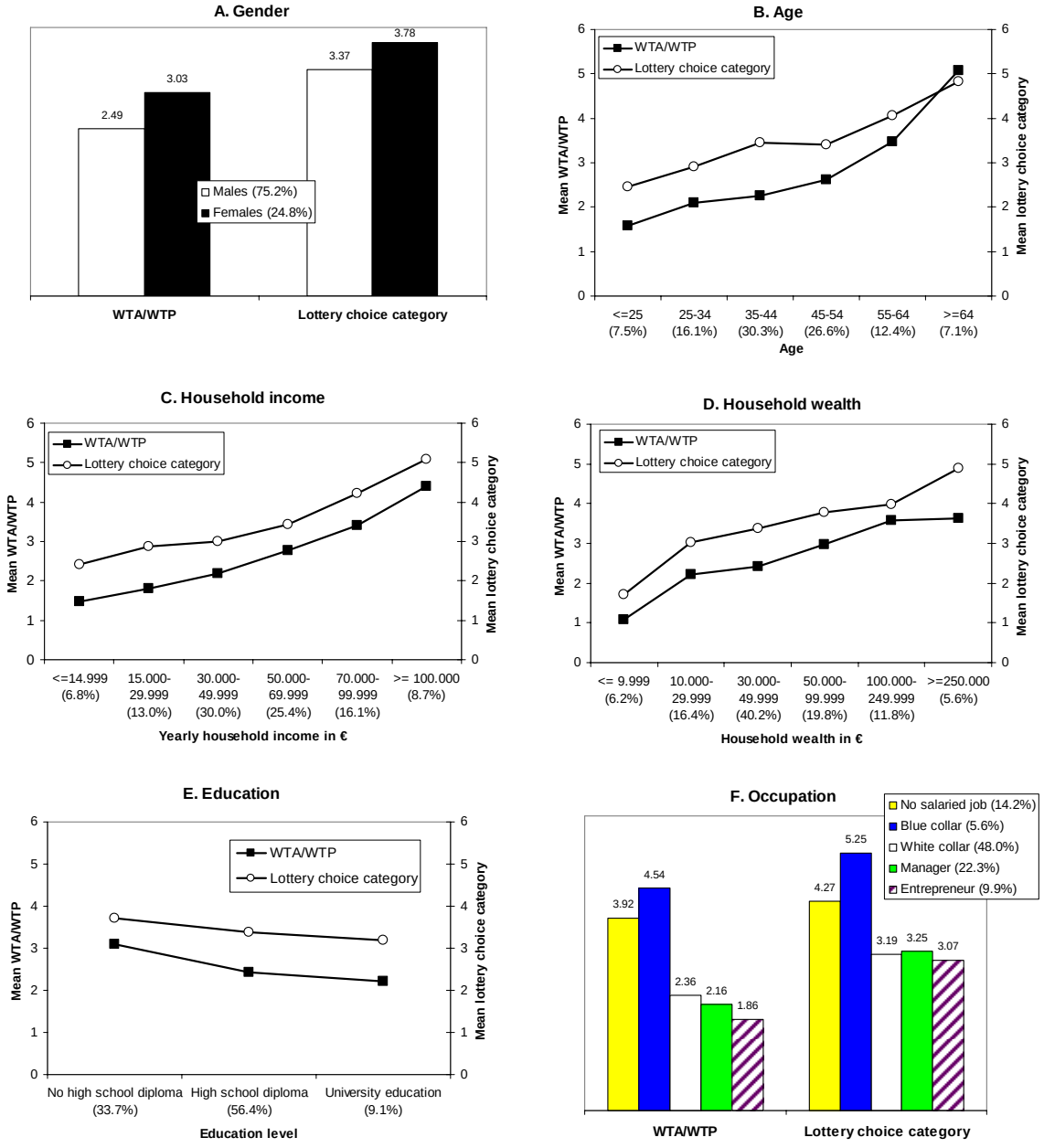
[10] In our analysis we have assumed linear value functions (no diminishing sensitivity) and no probability weighting. Although these assumptions do not matter for our main conclusion that the WTA/WTP-ratio and the lottery choices are correlated, one might be interested in how different assumptions on diminishing sensitivity and probability weighting affect the implied λ's. For instance, if one assumes $v(x) = x^{\alpha}$, with α=.88 the implied λ's in Table I change to > 2.68, 2.68, 1.84, 1.42, 1.17, 1, and ≤ 0.87 (from top to bottom). Recall that more recent estimates from a representative subject pool suggest that α is between 0.9 and 0.94 (Booij and Van de Kuilen [2006]). In this case the implied λ's are higher. See Schmidt, Starmer and Sugden [2005], and Abdellaoui, Bleichrodt and Paraschiv [in print] for further discussions of plausible α values. If, in addition, one believes that $w^{+}(0.5) \neq w^{-}(0.5)$, $v(G)/v(L)$ would need to be multiplied by $w^{+}(0.5)/w^{-}(0.5)$. See Bleichrodt and Pinto [2000], Table 1 for parameter estimates. For instance, for the weighting function proposed by Tversky and Kahneman [1992], estimated parameters imply that $w^{+}(0.5) = 0.42$ and $w^{-}(0.5) = 0.45$, so $w^{+}(0.5)/w^{-}(0.5) = 0.933$. This value is very close to unity, which suggests that probability weighting is most likely unimportant in our lottery choice task with its 50-50 chance of losing or winning. By implication, lottery choices in our experiment reflect loss aversion, not probability weighting. Furthermore, if one believes that the midpoint between accepting and rejecting a lottery is more appropriate to determine the acceptable loss, one loses the observations for acceptance cases 1) and 7) since the midpoint cannot be determined unambiguously. Under α = .88 the remaining values change to 2.4, 1.71, 1.33, 1.09 and 0.92.

[11] Booij and Van de Kuilen [2006] report experiments with a representative sample from the Dutch population. The gender and education effects we report below are consistent with their findings.

(panel F). We also indicate in Figure V the fraction of participants who fall in a particular socio-demographic category.

FIGURE V

Bi-variate 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.

Figure V 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

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. Third, as panel B shows, the older people are the more loss averse they are both in their riskless 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).[12] Higher education seems to decrease loss aversion (panel E) in both measures (Spearman rank order correlations, $p<0.05$) but does not eliminate it. Finally, different occupational groups have different degrees of loss aversion (Kruskal-Wallis tests, $p<0.0001$ for both measures).

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

Result 5: *The socio-demographic variables affect both measures of loss aversion similarly. We find no gender effect. Loss aversion increases in age. Higher education decreases loss aversion. Household income and wealth are positively correlated with loss aversion.*

Support: We run regressions for both measures of loss aversion. We document the results in Table II. 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 $\leq$ 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. These strong age effects are interesting, both because they may affect financial decision-making across the lifespan (Agarwal, Driscoll, Gabaix and Laibson [2007]) 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.[13] We find that higher education reduces loss aversion.[14] Quite surprisingly, higher income is positively correlated with loss

[12] 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.
[13] Income and education are positively correlated, but the correlation is surprisingly weak ($\rho=0.225$).
[14] At first sight, the result that older people are more loss averse stands in contrast to Kovalchik, Camerer, Grether, Plott and Allman [2005] who do not find loss aversion in their subject pool of old people (age > 70

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

TABLE II

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%

Models (4) to (6) replicate the analysis for our risky choice task using ordered probit estimation. We regress the lottery choice categories (see Table I) 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.

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

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.

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

significantly correlated and that the socio-demographic variables affect both measures qualitatively very similarly corroborate 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 is not representative for the population at large (although it is quite varied according to many socio-demographic dimensions). 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, Falk, Huffman, Sunde, Schupp and Wagner [2005] for an investigation of risk attitudes and Booij and Van de Kuilen [2006] for an investigation of prospect theory).

IV. Discussion and Conclusions

In this paper we investigated loss aversion in riskless and risky choices and showed that loss aversion underlies both the riskless and the 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 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 recent research 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, Kahneman, Munro, Starmer and Sugden [2005]) or for experienced traders (e.g., List [2003]).

Furthermore, recent neuro-scientific evidence (Tom, Fox, Trepel and Poldrack [2007]), evidence from non-human primates (Chen, Lakshminarayanan and Santos [2006]) and from young children (Harbaugh, Krause and Vesterlund [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. The fact that higher education reduces loss aversion is consistent with this argument. Johnson, Haeubl and Keinan [in press] propose a cognitive account for loss aversion, and provide experiments which explore some proposed boundary conditions.

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.

A final comment about these results is that it suggests that certain groups may be more affected by loss aversion. One observation is that most laboratory studies of loss aversion use young, well educated student subjects who, according to our results, tend to be less loss averse. Field data particularly gathered with participants with less education or increased age may well show larger effects of loss aversion. Another observation is that the characterization of groups who are ‘at risk’ to loss aversion is not what we might think: While older people, blue collar workers, and the unemployed do seem to be more loss averse, income and wealth tend to be positively correlated with loss aversion, a somewhat surprising result.

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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