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IZA DP No. 15375

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ABSTRACT

Price Expectations and Reference-Dependent Preferences

We experimentally test Kőszegi and Rabin's (2006, 2007) theory of reference-dependent preferences in the context of price expectations. In an incentivised valuation task, participants are endowed with a mug and provide their willingness to accept (WTA) to sell it. We manipulate the sale price in a separate, exogenous forced sale scenario, which is predicted to produce a 'comparison effect', moving WTA in the opposite direction to the forced sale price. Consistent with the theory, we observe a treatment effect of between AUD $0.79 and $2.06 in the hypothesised direction; however, it is statistically insignificant. We also elicit participants' loss aversion to account for heterogeneity in the theorised effect; however, controlling for the interaction between our treatment and loss aversion does not consistently strengthen our result.

JEL Classification: C91, D90

Keywords: reference dependence, price expectations, comparison effect, loss aversion

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1 INTRODUCTION

Although loss aversion has a long theoretical and experimental history, the reference point remains a poorly defined concept. Kahneman and Tversky's (1979) original prospect theory assumes that the reference point against which gains and losses are evaluated is usually the status quo, while noting that in some scenarios it may be a salient benchmark or expectation. While intuitively appealing, the unspecified nature of the reference point affords a lack of falsifiability to prospect theory, such that a cynic might argue that the reference point is whatever it needs to be to explain a particular study's findings.

Kőszegi and Rabin's (2006, 2007) (henceforth KR) model of expectations-based reference-dependent preferences remains the foremost attempt to address this theoretical gap, by pinning down the reference point as an individual's rational expectation given her own planned course of action. The importance of expectations was highlighted by experimental findings clearly violating status quo loss aversion but potentially compatible with expectations-based reference points (List, 2003; Plott and Zeiler, 2005, 2007). Numerous experimental paradigms have been developed to test KR theory, usually by presenting an economic decision that has some chance of being realised and a chance of being overlooked in favour of one or more fixed, exogenous outcomes. Manipulating these fixed outcomes allows experimenters to alter expectations without altering the economic decision or the status quo. Active experimental paradigms testing KR theory include exchange asymmetry (Ericson and Fuster, 2011; Heffetz and List, 2014; Heffetz 2018; Cerulli-Harms, Goette and Sprenger, 2019), real effort tasks (Abeler et al., 2011; Gill and Prowse, 2012; Camerer et al., 2016; Gneezy et al., 2017; Heffetz, 2018) and auctions (Banerji and Gupta, 2014; Rosato and Tymula, 2019). This literature has produced highly mixed results (see O'Donoghue and Sprenger, 2018 for an overview).

This paper contributes to the comparatively sparse experimental literature on KR preferences in the context of price expectations and valuations for a good. The implications of the dependence of individual preferences on expected prices for markets are manifold. First, a literature in industrial organisation shows how firms that interact with reference-dependent and loss averse consumers will utilise more rigid pricing strategies than when consumers have standard preferences (Heidhues and Kőszegi, 2008; Spiegler, 2012). Since facing a higher price than expected is perceived as a loss, firms respond by setting prices that are more similar across different cost levels. Second, Heidhues and Kőszegi (2014) demonstrate how consumer loss aversion can lead a monopolist to employ price distributions that consist of a 'regular' price together with a series of 'sale' prices below that regular price. Finally, Mazar, Kőszegi and Ariely (2014) show how ignoring the dependence of the final purchase price on the distribution of expected prices can lead to biased estimation of demand and welfare.

KR (2006) identify two separate channels through which the expected distribution of prices affects valuations. First, the likelihoods of different prices affect expectations of owning the good. A greater expectation of ownership produces a greater sense of loss if the good is forgone, increasing valuation. KR call this the 'attachment effect'. Second, the prices themselves affect monetary expectations and therefore the sense of monetary gain or loss from a transaction. For a prospective buyer, expecting to pay higher prices makes paying feel like a smaller loss, increasing valuation. For a prospective seller, expecting to receive higher prices makes not selling feel like a greater loss, decreasing valuation. KR dub this the 'comparison effect'.

Ericson and Fuster (2011, Experiment 2) experimentally test the attachment effect by manipulating the background chances of simply keeping or losing the good (a mug) with no monetary transaction. They elicit valuations through a Becker, DeGroot and Marschak (1964) game (BDM) to sell (or else keep) the mug, conditional on the background outcomes not occurring. Consistent with the attachment effect, they find valuations to be USD \$0.38 higher in their treatment with a higher background chance of keeping the mug, but the effect is statistically insignificant ($p = 0.44$), only becoming significant when using log valuations and controlling for valuations of a separate good (a university pen). However, a large-scale replication in Camerer et al. (2016) finds an effect of USD \$0.95 that is highly significant ($p = 0.005$).

We adapt Ericson and Fuster's (2011) design to instead test the comparison effect. We remove the background chances of keeping and losing the mug, replacing them with a fixed, 90% background chance of being forced to sell the mug at an exogenous price. This forced sale price is our manipulation, being AUD \$0.10 in our low treatment and AUD \$6 in our high treatment. The comparison effect predicts that valuations will be lower in our high price treatment. We also separately elicit participants' loss aversion through a monetary gambles task. Since the comparison effect is driven by loss aversion towards money (see Appendix B), this allows us to account for heterogeneity in the predicted size and direction of the effect.

Our experiment makes two contributions. First, to our knowledge, it is the first to isolate the comparison effect while fully controlling for the attachment effect. The only comparable study we are aware of is by Wenner (2015), who studies the impact of manipulating the ex-ante prices a consumer expects to face on their willingness to pay for a good.[1] The main differences between the studies are that Wenner (2015) does not control for the attachment effect since there is no analogue to our forced sales price (making it impossible to disentangle the attachment and comparison effects), and that our paper examines the problem from a seller's (as opposed to a buyer's) perspective. We use the seller frame to retain a tight link to Ericson and Fuster's (2011) study of the attachment effect; in Section 2.2 and Appendix B we show how both their design and ours may be nested within a single integrated framework.

Second, ours is among the few KR experiments to account for heterogeneity in loss aversion. The importance of this was highlighted by Goette et al. (2019), who examine gain-loss attitudes within the KR exchange paradigm and find that 23% of their subjects are loss-seeking, therefore having a theorised effect in the opposite direction. They argue that focusing on an average treatment effect leaves most studies underpowered, potentially accounting for the inconsistent findings in the experimental KR literature. Accounting for the magnitude of loss aversion is important since, as we show in Appendix C, greater loss aversion results in a substantially larger theorised treatment effect in our design.

We find a sizable treatment effect in the hypothesised direction, varying between AUD \$0.79 and \$2.06 (depending on specification),[2] matching effect sizes predicted by our simulations in Appendix C; however, it is not statistically significant. We also observe substantial heterogeneity in loss aversion in our sample. While our average participant is substantially loss-averse ($\lambda = 2$ in terms of standard prospect theory), we find 6% of our sample to be loss-seeking and 8% loss-neutral. Nonetheless, we do not find robust support for an interaction between our treatment and loss aversion, as the sign of the interaction is inconsistent across alternative specifications and measures of loss aversion.

1 Wenner (2015) tests the predictions of KR against a 'good deal model' where consumers are predicted to be disappointed (rejoice) when the realised price is perceived as being worse (better) than the other possible realisation, finding evidence supporting the latter model.

2 Approximately USD \$0.57 to USD \$1.50 at the time of our experiment. All prices are in AUD unless specified otherwise.

2. CONCEPTUAL FRAMEWORK

2.1 Utility Model

Conceptually, KR (2006, 2007) is a simple extension of prospect theory, specifying the reference point through the assumption of rational expectations.

Consider an individual evaluating a lottery X with possible outcomes $(x_1, \dots, x_m)$ occurring with probabilities $(q_1, \dots, q_m)$, respectively. We start with the value of a single outcome, x_j. KR (2006) model this as a combination of consumption utility, $u(x_j)$, as in standard decision theory; and gain-loss utility, $v(x_j|R)$, relative to a stochastic reference point, R, as in prospect theory:

$$V(x_j|R) = u(x_j) + \eta v(x_j|R)$$

where η is the individual's 'gain-loss sensitivity', scaling the relative importance of the two components.

Under KR theory, an individual's reference point is recent beliefs about an outcome. If an individual can commit to lottery X long before outcomes occur, then under rational expectations this becomes her reference point, so we can rewrite the value of x_j as:[3]

$$V(x_j|X) = u(x_j) + \eta v(x_j|X)$$

KR specify $v(x_j|X)$ as a probability weighted, pairwise comparison of x_j to each possible outcome x_k in X:

$$v(x_j|X) = \sum_{x_k \in X} q_k \begin{cases} (x_j - x_k), & x_j \geq x_k \\ \lambda(x_j - x_k), & x_j < x_k \end{cases}$$

The pairwise comparison between outcomes follows a kinked linear function, with λ reflecting the individual's loss aversion. For a loss-neutral individual with $\lambda = 1$, this is a simple linear function, meaning gains and losses are treated equally. For a loss-averse

[3] KR (2006, 2007) draw a distinction between when a decision-maker learns about a choice set and when they commit to their choice. If there is a lag between the former and the latter, the reference point is affected by lagged probabilistic beliefs, while if there is no such lag, then the choice itself is the reference point.

individual ($\lambda > 1$), losses are given greater weight than commensurate gains. For a loss-seeking individual ($\lambda < 1$), losses are given less weight than commensurate gains.

The value of the entire lottery, X, is the probability-weighted sum of the values of each possible outcome:

$$V(X|X) = \sum_{j=1}^{m} q_j \left(u(x_j) + \eta v(x_j|X)\right)$$

Thus, when asked to commit to one of several lotteries, the individual chooses the lottery X such that $V(X|X) > V(X'|X')$ for all other alternatives X', in other words the lottery with the greatest value given that it is expected. KR (2007) call this the 'choice-acclimating personal equilibrium' (CPE).[4]

2.2 Attachment and Comparison Effects

Under KR utility, there are two channels through which the expected distribution of prices affects valuations for a good in equilibrium. Changing the likelihoods of different prices affects expectations of ownership over the good, producing the 'attachment effect'. Changing the prices themselves affects monetary expectations, producing the 'comparison effect'.

KR (2006) demonstrate these effects in a simple framework in which a loss-averse prospective buyer knows that, with probability q_L, a desired good will be discounted to a low price, p_L, at which she is always willing to buy the good. With probability q_H, the good will be unavailable. With constant remaining probability $1 - q_L - q_H$, the good will be available at its regular price. The outcome of interest is the buyer's willingness to pay (WTP) in this third scenario. Figure 1 illustrates this framework.

[4] KR (2006) introduce an alternative equilibrium concept called the 'unacclimating personal equilibrium' (UPE) for contexts where there is a lag between when an individual first contemplates a decision and when the decision can be made. In that case, the reference point is determined by past expectations, and a personal equilibrium (PE) exists when $V(X|X) > V(X'|X)$ for all other alternatives X'. To select between (potentially) multiple personal equilibria, an individual chooses the lottery X that gives the greatest ex-ante expected utility, known as a preferred personal equilibrium (PPE). The effects of changing the expected distribution of prices on valuations are the same under both CPE and UPE, so to simplify the exposition we focus on the CPE.

The attachment effect can be seen by increasing q_L while lowering q_H. This exogenously increases the buyer's overall likelihood of acquiring the good, increasing its prominence in her expectations and therefore the sense of loss if the good is available at the regular price but not purchased. This increases WTP in the regular price scenario. The comparison effect can be seen by increasing p_L. This increases the amount of money the buyer expects to spend (so long as she remains willing to pay p_L). Purchasing at a regular price therefore feels like a smaller monetary loss relative to her expectations, increasing WTP. Building on this framework, Heidhues and Kőszegi (2014) find that the optimal pricing strategy for a monopolist facing a consumer with KR preferences involves a stochastic pattern of discount prices (to induce an attachment effect) and a high regular price (to capture the increased WTP), and note the similarity to observed, real-world pricing strategies.

The attachment and comparison effects are equally applicable to a prospective seller. Assume now that, with probability q_L, the seller is forced to sell the good at a low price, p_L (this must be forced because sale at a low price is undesirable). With probability q_H, the seller is forced to keep the good, with no opportunity for sale. With constant remaining probability $1 - q_L - q_H$, the seller has the option to sell the good for some price higher than p_L (Figure 2). The outcome of interest is WTA in this third scenario. As before, the attachment effect increases valuation for the good as the background expectation of keeping it increases, so WTA increases in q_H. However, the direction of the comparison effect is flipped relative to the buyer case because monetary loss is now felt when not selling the good. Increasing p_L increases the seller's monetary expectations, lowering WTA to sell the good to avoid that loss.

In their Experiment 2, Ericson and Fuster (2011) test the attachment effect within this seller framework by eliciting WTA for a university mug. They fix $p_L = \$0$, making q_L a background chance of simply losing the mug. They set (q_L, q_H) equal to (0.8, 0.1) in their low treatment and (0.1, 0.8) in their high treatment. A BDM is used in the third scenario to measure participants' WTA. Due to the attachment effect, a loss-averse individual is predicted to report a higher WTA in the high treatment than in the low treatment.

In our experiment, we adapt Ericson and Fuster's (2011) design to instead test the comparison effect. We also elicit WTA for a mug, fixing (q_L, q_H) equal to (0.9, 0) throughout and instead varying p_L to be either AUD \$0.10 in our low treatment or AUD \$6 in our high treatment. Due to the comparison effect, a loss-averse individual is predicted to report a higher WTA in the high treatment than in the low treatment.[5]

2.3 Theoretical Predictions

In our experiment, participants face a compound lottery with a q_L chance of being forced to sell their mug for an amount p_L, and a $1 - q_L$ chance of playing a seller BDM with N prices ranging from p_1 to p_N in increments of x. The individual's decision is to choose a WTA, defined as the price at which they are indifferent between selling the mug (having locked in a bid of p_a) and keeping the mug (having locked in a bid of p_{a+1}). Under a choice-acclimating personal equilibrium, the individual chooses p_a, such that $V(p_a \mid p_a) > V(p_{a'} \mid p_{a'})$ for all alternatives $p_{a'}$. Because p_a is chosen in advance of the lottery being realised, the reference point is considered to be the full lottery including their own bid.

Let the individual's consumption utility for the mug (in dollars) be γ. Using dollars as the unit of measurement, the value of selling the mug for p_a, having bid p_a, is given by:

$$\begin{aligned} &V(sell\ for\ p_a | bid\ p_a) \\ &\quad = p_a + q_L \eta (p_a - p_L) + \frac{(1-q_L)(a-1)}{N} \eta (p_a - \lambda\gamma) \\ &\quad - \frac{(1-q_L)}{N} \eta\lambda((p_{a+1} - p_a) + \cdots + (p_N - p_a)) \end{aligned}$$

where the first term is the consumption utility of $\$p_a$. The second term is gain-loss utility compared to the forced sale for p_L that occurs with probability q_L: selling for p_a is a monetary gain of $\$(p_a - p_L)$. Each BDM price occurs with probability $\frac{1-q_L}{N}$. The third term is gain-loss utility compared to lower BDM prices: for all $(a-1)$ lower BDM prices, this is a gain of $\$p_a$ and loss of the mug, which would have given utility γ. The final term is gain-loss utility compared to higher BDM prices: for each price p_{a+1} to p_N, this comparison is a pure monetary loss of that price minus p_a.

The value of keeping the mug, having bid p_{a+1}, is given by:

[5] The attachment effect is driven by loss aversion towards the good, while the comparison effect is driven by loss aversion towards money (see Appendix B). If loss aversion differs across domains, it is possible that an individual may exhibit one effect but not the other.

$$V(keep\ mug|bid\ p_{a+1}) = \gamma + q_L\eta(\gamma - \lambda p_L) + \frac{(1-q_L)(N-a)}{N}\eta\gamma - \frac{(1-q_L)}{N}\eta\lambda(p_{a+1} + \cdots + p_N)$$

where the first term is consumption utility of the mug. The second term is gain-loss utility compared to the forced sale, in this case a gain of the mug and loss of \$$p_L$. At lower BDM prices (which would be rejected), the outcome is identical so there is no gain-loss term. The gain-loss utility compared to higher BDM prices has been split into two terms. The third term is the gain of the mug for all $(N-a)$ of these prices, and the final term is the loss of money compared to each of these prices respectively.

Equating these expressions and solving for p_a gives WTA in Equation 1 (derivation in Appendix A). This WTA is also a CPE because it is an indifference point from which the individual has no incentive to deviate, meaning that it maximises the KR expected utility $V(p_a \mid p_a)$ over all possible prices. For simplicity, WTA is shown as a function of a, however the definition of p_a (Equation 2) pins down a since p_1 and x are fixed BDM parameters.

$$WTA(a) \coloneqq p_a = \frac{\gamma\left(1 + q_L\eta + \frac{(1-q_L)}{N}\eta\big(N - a + \lambda(a-1)\big)\right) - q_L\eta(\lambda-1)p_L}{1 + \eta\left(q_L + \frac{(1-q_L)}{N}(\lambda(N-a) + a - 1)\right)} \tag{1}$$

$$p_a = p_1 + (a-1)x \tag{2}$$

The comparison effect can be seen by differentiating Equation 1 with respect to p_L:

$$\frac{dWTA(a)}{dp_L} = -\frac{q_L\eta(\lambda-1)}{1 + \eta\left(q_L + \frac{(1-q_L)}{N}(\lambda(N-a) + a - 1)\right)} \tag{3}$$

The marginal effect of p_L on $WTA(a)$ is strictly decreasing for loss-averse individuals ($\lambda > 1$), increasing for loss-seeking individuals ($\lambda < 1$) and zero for loss-neutral individuals ($\lambda = 1$). Furthermore, the comparison effect is stronger for larger magnitudes of $\eta(\lambda-1)$, indicating more loss-averse behaviour.[6]

Although we have assumed that gain-loss attitudes are fixed across domains, it is possible that an individual could be differently loss-averse towards money and the mug. If so, the

6 $\eta(\lambda-1)$ is a more meaningful measure of loss aversion in KR theory than λ alone (see O'Donoghue and Sprenger, 2018).

comparison effect is driven solely by gain-loss attitudes towards money (see Appendix B). Therefore, our monetary gambles task should serve to capture heterogeneity in this form of loss aversion.

Our theorised effect is sizable for participants with non-trivial loss aversion. In Appendix C, we simulate effect sizes for hypothetical participants with a range of loss aversion parameters and consumption utilities for the mug. For a moderately loss-averse participant with $\eta(\lambda - 1) = 0.4$ (equivalent to $\lambda = 1.5$ in standard prospect theory), we predict an effect size of approximately \$1.05 to \$1.10. For a highly loss averse participant with $\eta(\lambda - 1) = 0.67$ (equivalent to $\lambda = 2$ in standard prospect theory), we predict an effect size of approximately \$1.75 to \$1.80. The effect size is minimally affected by consumption utility for the mug, because the comparison effect depends only on loss aversion towards money.

Additionally, in Appendix C we simulate effect sizes for Ericson and Fuster's (2011) Experiment 2, showing that both their observed effect size and that of Camerer et al.'s (2016) replication fall within the range of theoretically predicted effects under reasonable parameter assumptions.

Therefore, if there is a comparison effect in our experiment, we expect to be able to detect both a main treatment effect and an interaction between our treatment and loss aversion. We thus present two hypotheses. First, WTA will be lower in our high treatment than in the low treatment. Second, this treatment effect will be stronger for more loss-averse participants.

3. METHOD

3.1 Procedure

Our experimental design and hypotheses were pre-registered at AsPredicted (Bedics, 2018), and our study was approved by the University of Sydney Human Research Ethics Committee (Protocol Number 2021/511).

Due to COVID-19 restrictions the experiment was conducted online in September and October 2021. Our sample consisted of 90 University of Sydney students recruited through the ORSEE online recruitment system (Greiner, 2015).[7] Participants were required to have an

[7] 92 participants were recruited; however, one was excluded due to internet connectivity issues, and another was excluded for failing to complete the task comprehension questions.

Australian postal address (for delivery of a mug) and have (or be willing to create) a PayPal account to receive payment for the study. Experimental sessions were conducted live over Zoom. Participants were provided with individual links during the Zoom call to access the experimental stimuli (created using oTree: Chen, Schonger and Wickens, 2016) on their own computers. Progress through the experiment was controlled by the experimenter, as in a standard laboratory setting. Participants were required to leave their cameras on throughout the session and a second experimenter monitored the cameras to ensure participants' unbroken attention.

The experiment employed a between-subjects design with two treatments. In the low treatment, the forced sale price was AUD \$0.10; in the high treatment, the forced sale price was \$6.00. Treatments were applied at the session level, with three sessions for each treatment. In both conditions, participants completed a valuation task, followed by a loss aversion task and finally a post-experiment questionnaire.

The valuation task began with the virtual 'endowment' of a University of Sydney School of Economics branded reusable coffee mug. Participants were shown multiple pictures of the mug and told that the mug was currently in their possession. Participants were then given the task details: at the end of the experiment, they would have a 90% chance of being forced to sell their mug for the forced sale price (according to treatment). With the remaining 10% chance, they would instead be able to sell their mug in a discrete BDM with prices ranging from AUD \$6.10 to \$30.00 in \$0.10 increments, and with their BDM bid locked in *ex ante*, before the uncertainty was realised. Figure 3 illustrates this task.

Participants were then required to correctly answer eight comprehension questions to demonstrate their understanding of the task. Once all participants had successfully answered the questions, the participants were reminded of the task details and given five minutes to consider their BDM bid before being required to lock it in.

Next, participants completed the loss aversion task, adapted from Gächter, Johnson, and Herrmann (2022). This consisted of accepting or rejecting a series of 50/50 monetary gain/loss gambles, one of which would be chosen at random to be realised at the end of the experiment (if the participant had accepted it). The details of this task are explained below in Section 3.2.2 on 'Measuring Loss Aversion'. No mention was made of the loss aversion task in advance, to ensure that it did not influence expectations in the valuation task.

Finally, participants completed a questionnaire asking their gender, age, whether they were an international student, whether they were a postgraduate student and their degree major, as well as their estimate of the retail value of the mug. Participants also rated how appealing they found the mug, how well they understood the experiment instructions and how much they trusted the experimenter to provide payment as described on four-point Likert scales.

Once all participants had completed the questionnaire, the valuation and loss aversion tasks were realised. Participants were paid a show-up fee of AUD $15, adjusted by the proceeds if their mug had been sold (voluntarily or otherwise) and the realised gain or loss from one randomly chosen gamble if they had accepted it. Payments were made on the evening of the experiment via PayPal. Participants who retained possession of their mug had it posted to them on the following day via Australia Post Express Post, which advertises next business day delivery. (See Appendix F for the full experimental stimuli.)

3.2 Empirical Strategy

3.2.1 Comparison Effect

To test for an overall comparison effect, we test $\delta_1 > 0$ in Equation 4:

$$WTA_i = \delta_0 + \delta_1 d_{H,i} + \boldsymbol{X_i \beta} \tag{4}$$

where d_H is an indicator variable for being in the high treatment and $\boldsymbol{X}$ is our vector of controls. To test whether the effect depends on loss aversion, we perform two analyses. First, we re-estimate Equation 4 for the more loss-averse segment of our sample. Second, we test $\delta_3 > 0$ in Equation 5:

$$WTA_i = \delta_0 + \delta_1 d_{H,i} + \delta_2 LA_i + \delta_3 \left(d_{H,i} * LA_i\right) + \boldsymbol{X_i \beta} \tag{5}$$

where LA is a measure of loss aversion.

3.2.2 Measuring Loss Aversion

The loss aversion task was adapted from Gächter et al. (2022). Participants were presented with thirteen monetary gambles, each with a 50% chance to gain AUD $6.00, and a 50% chance to lose some amount. The potential loss ranged from $1.00 in the lowest loss gamble to \$7.00 in the highest loss gamble in \$0.50 increments. Participants were asked to specify the highest loss gamble they would be willing to accept.

Following Gächter et al. (2022), we treat these gambles as a pure measure of loss aversion. This assumes a kinked linear utility function. We make this assumption for three reasons. Firstly, it is standard in KR theory (see O'Donoghue and Sprenger, 2018). Secondly, Rabin (2000) demonstrates that any curvature detectable in small-stakes monetary gambles has indefensible implications for large-stakes gambles. Thirdly, Gächter et al. (2022) find that loss aversion elicited by this task is highly correlated with loss aversion in the riskless exchange paradigm.

With this assumption of piecewise linearity, the prospect theory measure of loss aversion is simply $\lambda_{PT} = \frac{6}{x}$ where x is the highest potential loss the participant is willing to take. Under KR theory (with commitment), we instead find Equation 6 (see Appendix D):

$$\eta(\lambda - 1) = \frac{12 - 2x}{6 + x} \tag{6}$$

This retains the basic identification property that loss-neutral individuals ($\lambda = 1$) are indifferent to zero-EV gambles, while loss-averse individuals ($\lambda > 1$) reject some positive-EV gambles and loss seekers ($\lambda < 1$) accept some negative-EV gambles. However, the effects of loss aversion are additionally scaled by gain-loss sensitivity, η. This makes $\eta(\lambda - 1)$ the more meaningful measure of loss-averse behaviour in KR theory (O'Donoghue and Sprenger, 2018). Moreover, as this is a monotonic transformation of the prospect theory measure, the ordinal ranking of individuals' loss aversion by either measure (or simply by $-x$) is equivalent. Table 1 shows measures of loss aversion under each model for each response in the monetary gambles task.

We consider four different measures of loss aversion when estimating Equation 5 above. Our primary measures are the $\eta(\lambda - 1)$ obtained under KR theory (which is the most theoretically appropriate), and a dummy dividing the sample into more and less loss-averse halves (which should be the most robust to measurement error or misspecification). Additionally, we consider the λ_{PT} measure under prospect theory, and the simple untransformed switching point, x.

4. RESULTS

Our sample included 90 participants (54 female) with a mean age of 23.0 ($SD = 5.5$). Table 2 shows the means in each treatment for all individual characteristics, as well as participants' estimated retail prices and subjective appeal ratings for the mug. Only gender differs significantly across treatments: there were more females in the high price treatment. Regardless, we control for all of the variables in our analyses, so this imbalance should not influence our results.

4.1 Main Treatment Effect

Table 3 reports regression estimates for our main effect (Equation 4). 20 of our 90 participants (8 in the low treatment, 12 in the high treatment) were willing to sell their mug at any BDM price, censoring their valuations for the mug at the minimum BDM price, \$6.10. Due to this censoring, we also estimate Equation 4 using a Tobit model.

Because our theorised effect size increases with loss aversion, we repeat these analyses using only participants with loss aversion at or above the median (those whose highest acceptable loss was \$3 or less). This subsample includes 56 of our 90 participants (62.2%).[8]

In the full sample, we find an OLS estimate of the effect of the high price treatment of AUD –\$0.79 (USD \$0.57) in the hypothesised direction, however this is not statistically significant ($p = 0.28$). Using a Tobit model, the estimated treatment effect increases to –\$1.19, due to the greater number of left-censored valuations in the high treatment; however, this remains non-significant ($p = 0.19$).

Using only the high loss-aversion subsample, the size of our estimated treatment effect increases further. Our OLS estimate increases to –\$1.60 ($p = 0.18$), though it remains non-significant. Our Tobit estimate increases to –\$2.06 (USD \$1.50), becoming borderline significant ($p = 0.07$). Informally, this appears to indicate that our treatment effect is stronger for the more loss-averse segment of our sample; we will test this formally in the next section.

[8] The remaining participants omitted from this subsample variously exhibit either a lesser degree of loss aversion, loss neutrality, or loss seeking, and are thus predicted to exhibit, respectively, either a smaller treatment effect in the hypothesised direction, a zero effect, or an effect going in the opposite direction.

Our estimates broadly match the simulated effect sizes in Appendix C. Our full sample estimates are comparable to the predicted effect size for a moderately loss averse individual with $\eta(\lambda - 1) = 0.4$ (prospect theory $\lambda_{PT} = 1.5$), although this is smaller than our observed median loss aversion of $\eta(\lambda - 1) = 0.67$ (prospect theory $\lambda_{PT} = 2$). For our high loss aversion subsample, our OLS and Tobit estimates roughly match the predicted effect sizes for highly loss-averse individuals with $\eta(\lambda - 1) = 0.67$ and 0.75, respectively, although once again these measures of loss aversion are smaller than the observed median of $\eta(\lambda - 1) = 1$ (prospect theory $\lambda_{PT} = 3$) in this subsample.

4.2 Effect of Loss Aversion

We observe substantial heterogeneity in loss aversion in our sample. Figure 4 shows the distribution of responses in the loss aversion task. The median and modal participant accepted gambles with losses up to \$3 ($SD = \$1.8$), giving an estimated KR loss aversion of $\eta(\lambda - 1) = 0.67$. In standard prospect theory, the corresponding loss aversion measure is $\lambda_{PT} = 2$ (higher than the median response in Gächter et al., 2022), which would be considered highly loss averse.

Conversely, while not as pronounced as in Goette et al. (2019), we observe some loss-seeking behaviour with 5 participants (5.6%) willing to risk more than \$6 for a gain of \$6 (all chose to accept all gambles up to the maximum loss of \$7). There are 7 participants (7.8%) who reported a maximum acceptable loss of \$6, making them at least loss-neutral (and possibly slightly loss-seeking if their indifference point lies between \$6 and \$6.50). This indicates substantial heterogeneity in our hypothesised effect to account for.

The interaction specification in Equation 5 provides a formal test of our second hypothesis: that our treatment effect is larger (i.e., more negative) for more loss-averse participants. Table 4 reports results for two candidates for the LA measure: the $\eta(1 - \lambda)$ from KR theory (Table 1), which is theoretically the most appropriate measure for our model (see the numerator of Equation 3), and a dummy for being in the more loss-averse segment of the sample (defined as being greater than or equal to the median). As explained previously in Section 3.2.2, this classification is the same whether we rank participants by the KR measure $\eta(1 - \lambda)$, the prospect theory measure λ_{PT} or simply the inverse of their highest acceptable loss.[9] Once again, we report OLS and Tobit estimates for each measure.

Using the KR loss aversion measure (which is the theoretically most appropriate measure), we find an OLS estimate of –\$0.02 ($p = 0.99$) and a Tobit estimate of \$0.43 ($p = 0.87$) for the interaction effect. Not only are these statistically insignificant, they are also inconsistent in direction and, for the OLS estimate, practically insignificant in magnitude.

Using the high loss aversion dummy, we find an OLS estimate of –\$1.41 ($p = 0.57$) and a Tobit estimate of –\$1.15 ($p = 0.67$) for the interaction effect. This suggests an economically meaningful increase in the strength of our treatment effect for the high loss aversion group, consistent with our findings in Table 3. The dummy specification is the most robust to measurement error in eliciting loss aversion or misspecification of the regression. However, these estimates remain statistically insignificant, and moreover we find that even the sign of the interaction effect is not consistently negative across the four measures of loss aversion reported in Table 4 and Appendix E. In light of these inconsistencies and the non-significance of all estimates, we do not interpret our results as supportive of the theoretically predicted interaction effect.

5. DISCUSSION

We observe a sizable main treatment effect in the direction predicted by the comparison effect. For our full sample, the effect is AUD \$0.79 to \$1.19 (depending on specification). Using only the more loss averse segment of our sample (for whom the theorised effect is stronger), the effect is \$1.60 to \$2.06. Despite only being borderline significant in one specification (and insignificant in the others), these effect sizes are practically large, exceeding the USD \$0.38 (AUD \$0.52) effect observed by Ericson and Fuster (2011) and, in the case of our high loss aversion group, exceeding the highly significant ($p = 0.005$) USD \$0.95 (AUD \$1.31) effect observed in Camerer et al.'s (2016) replication. Furthermore, they broadly match the simulated effect sizes in Appendix C (though corresponding to lower levels of loss aversion than observed in our sample). Therefore, while we conclude that our hypotheses were not supported, this is far from a precisely estimated null effect.

9 Appendix E reports specifications using the prospect theory measure of loss aversion λ_{PT} and the highest acceptable loss itself. Neither measure results in a significant interaction effect.

It is common in the experimental KR literature for economically meaningful effects to fail to reach statistical significance owing to large standard errors (see O'Donoghue and Sprenger, 2018 for an overview), with significant findings often requiring very substantial sample sizes (e.g., Banerji and Gupta, 2014; Camerer et al., 2016; Heffetz, 2018; Cerulli-Harms et al., 2019; Goette et al., 2019; Rosato and Tymula, 2019). For our experiment, a *post-hoc* power analysis indicates that we would have required over 1,400 observations to achieve 80% power. This is on the order of the 2,250 observations that Goette et al. (2019) claim would be needed in the KR exchange paradigm to detect an average treatment effect with 80% power.

However, unlike in Goette et al. (2019), our findings do not appear to be driven by heterogeneity in gain-loss attitudes. Despite observing substantial heterogeneity in loss aversion, we did not find the theoretically predicted interaction effect between loss aversion and our treatment.[10] This not only failed to reach statistical significance but was directionally inconsistent across specifications and measures of loss aversion. A potential explanation for this discrepancy is that the KR exchange paradigm used by Goette et al. (2019) relies entirely on loss aversion towards goods, whereas the comparison effect relies entirely on loss aversion towards money. It is possible that heterogeneity in gain-loss attitudes towards goods is more impactful or more pronounced than the equivalent towards money.

An alternative explanation for the mixed findings in the experimental KR literature, highlighted by Heffetz (2018), is that expectations may not have been allowed to adequately sink in before participants were asked to make decisions. Heffetz (2018) finds a significant KR effect in the exchange paradigm with the addition of a 'sink-in manipulation', forcing participants to experience 18 mock probability realisations before making their decision. He contrasts this result with Heffetz and List (2014), whose method was identical apart from the sink-in manipulation and who did not find a significant KR effect.

We do not believe that the non-significance of our treatment effect was caused by insufficient sinking in of expectations. While we did not conduct mock probability realisations, participants were required to correctly answer eight comprehension questions, covering the likelihoods and payoffs of all possible scenarios in the BDM task, as well as having the task instructions read to them both before and after the comprehension questions and considering their choice for an additional five minutes before being permitted to input their decision. We

10 The alternative of simply adding loss aversion as a control variable in our main analysis also does not make the treatment effect significant (see Appendix E).

believe that these measures (which in total took 20-30 minutes) were sufficient to ensure that expectations for the task were fully sunk in.

There is a possible countervailing effect in our experiment if the forced sale price (p_L) acted as an anchor for valuations, or was perceived as a signal of the mug's value or quality. Either effect would cause valuations to *increase* with the forced sale price, which would dilute the comparison effect and bias our estimated treatment effect towards zero. Estimates of the retail price of the mug were indeed \$1.22 higher in the high treatment than in the low treatment, although this difference was not statistically significant ($p = 0.47$, see Table 2) and these estimates were not incentivised. Nevertheless, the difference is sizable (comparable in magnitude to our treatment effect) and possibly indicates that some value signalling did occur.

A further consideration is any possible effects of shifting from the laboratory to online, removing participants' ability to physically interact with their mugs. Perhaps this, combined with the exogenous 90% chance of forced sale, undermined the sense of being endowed with the mug (which O'Donoghue and Sprenger, 2018, argue may be responsible for the null findings of List, 2003, and Plott and Zeiler, 2005, 2007). It is important to note that neither factor should have any effect in KR theory, where the reference point strictly follows rational expectations; however, the sense of ownership does matter in standard prospect theory, and potentially also in alternative expectations-based theories with less stringent assumptions than KR.

Ultimately, we did not find KR's (2006) comparison effect of price expectations on valuations, although our treatment effect is sizable enough to warrant further investigation. Contrary to Goette et al. (2019), accounting for heterogeneity in loss aversion did not enable us to detect this effect, suggesting that, at least for effects driven by loss aversion towards money, heterogeneous gain-loss attitudes are not the missing piece to reconcile the inconsistent findings in the experimental KR literature.

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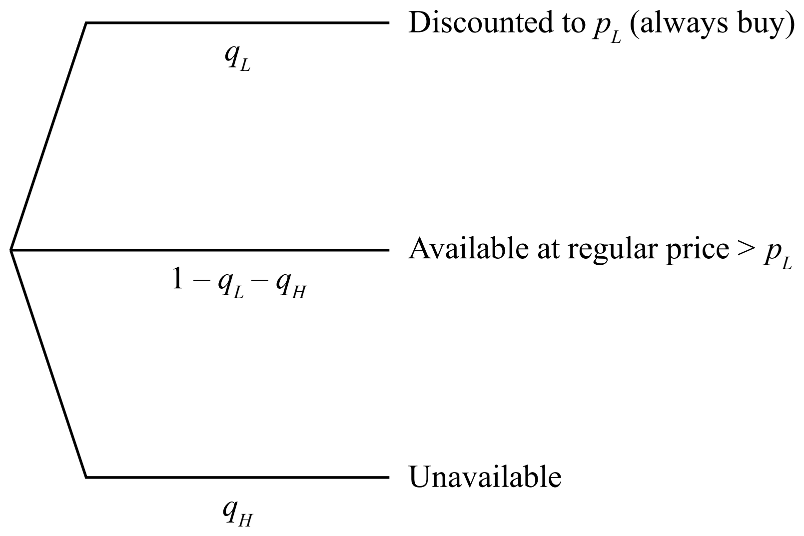
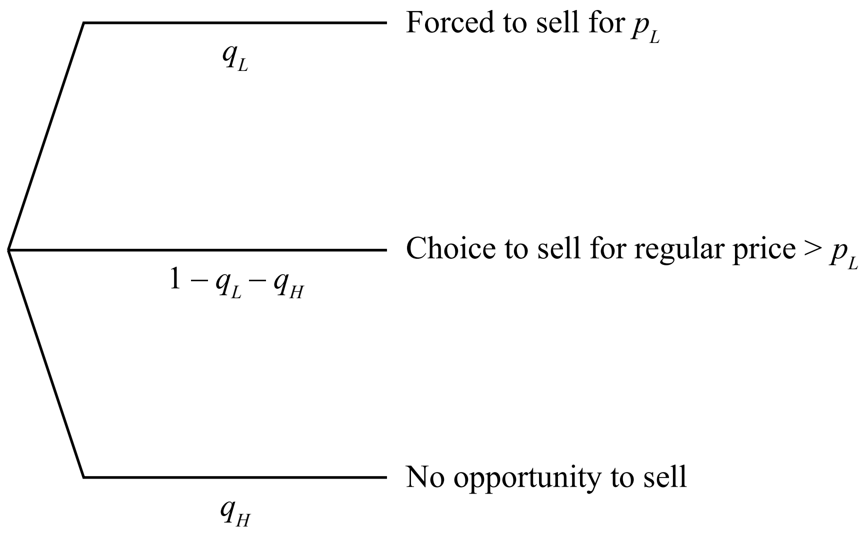
Figure 1. Buyer framework



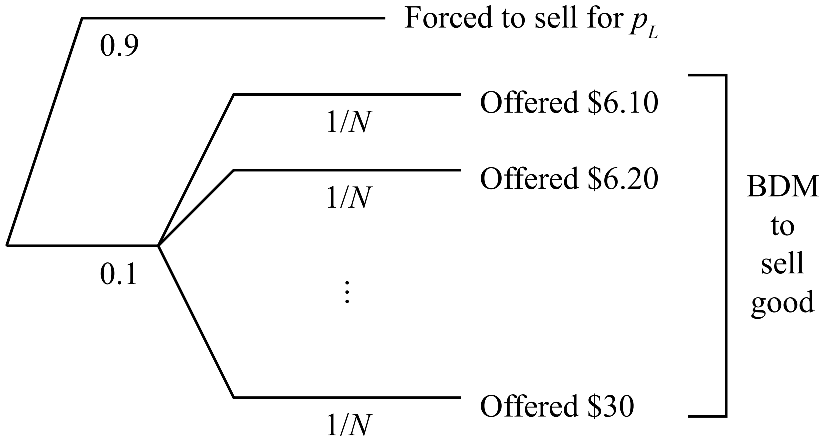
KR’s (2006) simple three-scenario framework to demonstrate the attachment and comparison effects for a loss-averse prospective buyer.

Figure 2. Seller framework



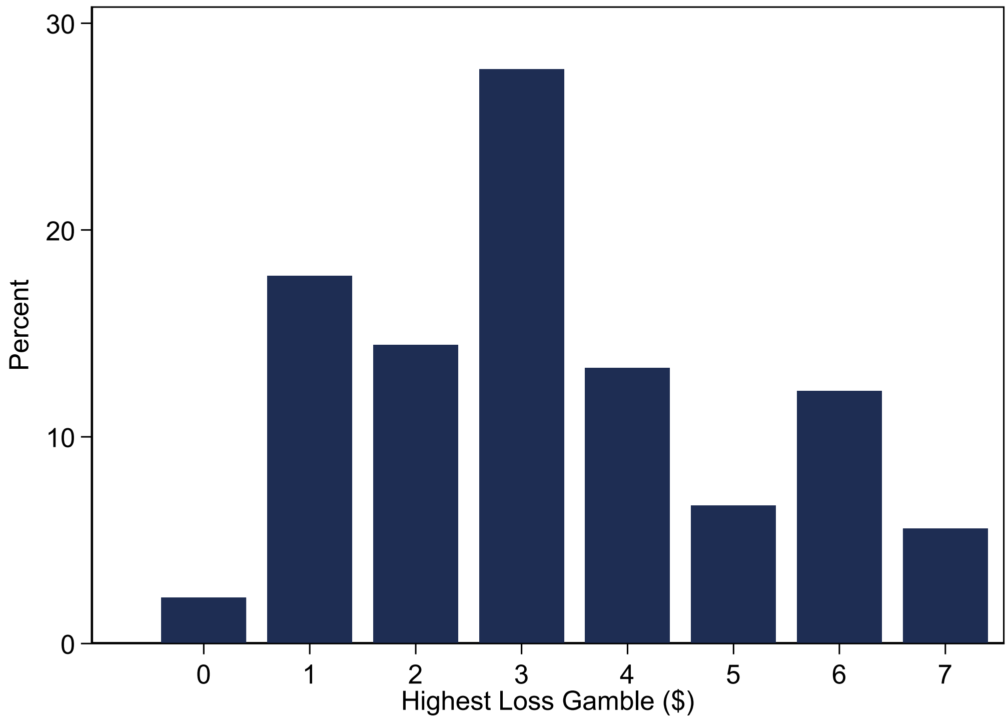
Translation of KR's (2006) buyer framework to demonstrate the attachment and comparison effects for a prospective seller. The seller must be compelled to sell at the low price, p_L, otherwise they would be unwilling to do so.

Figure 3. Valuation task



All possible scenarios in the valuation task. Participants choose a minimum sales price, which determines whether each BDM price would result in a sale or not. Regardless of their decision, there is an exogenous 90% chance that no BDM occurs, and they are forced to sell their mug for $\$p_L$. $N = 240$ is the number of prices in the BDM.

Figure 4. Distribution of responses in loss aversion task



Note. Very few participants chose non-integer responses, so these have been combined with the next integer above. We combine in this way because the integer above could be the indifference point, whereas the integer below cannot be.

Table 1. Estimating loss aversion from 50/50 gambles

Choice	Switching point x	Prospect theory λ_{PT}	KR theory $\eta(\lambda - 1)$
Reject all	< $1.00	> 6.00	> 1.43
Switch at $1.00	$1.00	6.00	1.43
Switch at $1.50	$1.50	4.00	1.20
Switch at $2.00	$2.00	3.00	1.00
Switch at $2.50	$2.50	2.40	0.82
Switch at $3.00	$3.00	2.00	0.67
Switch at $3.50	$3.50	1.71	0.53
Switch at $4.00	$4.00	1.50	0.40
Switch at $4.50	$4.50	1.33	0.29
Switch at $5.00	$5.00	1.20	0.18
Switch at $5.50	$5.50	1.09	0.09
Switch at $6.00	$6.00	1.00	0.00
Switch at $6.50	$6.50	0.92	–0.08
Accept all	≥ $7.00	≤ 0.86	≤ –0.15

Table 2. Sample Balance

	$p_L = \$0.10$	$p_L = \$6$	Difference	p-value
Male	0.522	0.273	–0.249	0.016**
Age	22.870	23.068	0.199	0.867
International	0.370	0.295	–0.074	0.456
Postgraduate	0.261	0.205	–0.056	0.528
Economics major	0.261	0.273	0.012	0.899
Estimated RRP	16.922	18.145	1.223	0.467
Appeal (1–4)	2.674	2.727	0.053	0.766
Observations	46	44		

Note. p-values for dummy variables (Male, International, Postgraduate, Economics major) are for z-tests for equality of proportions. p-values for all other variables are for unequal variance t-tests. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table 3. Regression Results for Main Treatment Effect (outcome variable is BDM bid)

	Full sample		High LA sample $\lambda_{PT} \geq 2$	
	OLS	Tobit	OLS	Tobit
	(1)	(2)	(3)	(4)
High treatment	–0.785	–1.187	–1.601	–2.062*
	(0.677)	(0.900)	(1.082)	(1.120)
Male	1.423	1.891	1.035	1.103
	(1.181)	(1.259)	(1.105)	(1.170)
Age	–0.119	–0.330**	–0.103	–0.220*
	(0.065)	(0.127)	(0.069)	(0.119)
International	1.380	2.043**	0.783	1.296
	(0.854)	(0.998)	(1.133)	(1.142)
Postgraduate	0.977	2.390**	0.379	1.304
	(0.867)	(1.020)	(1.140)	(1.204)
Economics major	1.513*	1.998**	2.367*	3.471**
	(0.650)	(0.795)	(1.085)	(1.560)
Estimated RRP	0.223***	0.245***	0.168**	0.164*
	(0.063)	(0.081)	(0.067)	(0.090)
Appeal	3.304***	4.314***	3.591**	4.643***
	(0.775)	(0.826)	(1.126)	(1.123)
Constant	1.429	1.558	2.458	1.209
	(2.056)	(3.624)	(2.602)	(3.805)
Observations	90	90	56	56

Note. Standard errors are clustered by session. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table 4. Regression Results for Interaction Effect (outcome variable is BDM bid)

	KR measure		Dummy measure $\lambda_{PT} \geq 2$	
	OLS	Tobit	OLS	Tobit
	(1)	(2)	(3)	(4)
High treatment	–0.888	–1.747	–0.016	–0.609
	(1.877)	(2.521)	(1.747)	(2.156)
$\eta(1-\lambda)$	0.813	1.463*		
	(0.673)	(0.813)		
High LA dummy			2.142***	2.717***
			(0.589)	(0.483)
Interaction	–0.015	0.426	–1.410	–1.149
	(2.196)	(2.655)	(2.352)	(2.679)
Male	1.405	1.889	1.540	2.103*
	(1.176)	(1.213)	(1.129)	(1.178)
Age	–0.123	–0.354**	–0.124	–0.343**
	(0.071)	(0.135)	(0.079)	(0.134)
International	1.216	1.728	1.131	1.697
	(0.923)	(1.076)	(0.937)	(1.101)
Postgraduate	0.965	2.435**	0.951	2.344***
	(0.858)	(0.998)	(0.774)	(0.892)
Economics major	1.680**	2.262***	1.500**	1.950**
	(0.592)	(0.630)	(0.613)	(0.771)
Estimated RRP	0.228***	0.257***	0.229***	0.255***
	(0.065)	(0.084)	(0.062)	(0.080)
Appeal	3.378***	4.492***	3.451***	4.538***
	(0.915)	(1.029)	(0.924)	(1.002)
Constant	0.742	0.505	–0.169	–0.484
	(2.116)	(3.396)	(1.932)	(2.952)
Observations	90	90	90	90

Note. Standard errors are clustered by session. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Appendix A

In this Appendix, we show the full derivation of Equation 1. We define WTA for the mug as the BDM bid p_a at which the individual would be indifferent between selling the mug (having bid p_a) and keeping the mug (having bid p_{a+1}). The value of the former outcome is given by:

$$V(sell\ for\ p_a|bid\ p_a)$$
$$= p_a + q_L\eta(p_a - p_L) + \frac{(1-q_L)(a-1)}{N}\eta(p_a - \lambda\gamma)$$
$$- \frac{(1-q_L)}{N}\eta\lambda(p_{a+1} - p_a + \cdots + p_N - p_a)$$

where the first term is the consumption utility of p_a. The second term is gain-loss utility compared to the forced sale for p_L that occurs with probability q_L: selling for p_a is a monetary gain of $\$(p_a - p_L)$. Each BDM price occurs with probability $\frac{1-q_L}{N}$. The third term is gain-loss utility compared to lower BDM prices: for all $(a-1)$ lower BDM prices, this is a gain of $\$p_a$ and a loss of the mug, which would have granted utility γ. The final term is gain-loss utility compared to higher BDM prices. For each price p_{a+1} to p_N, this comparison is a pure monetary loss of that price minus p_a.

The value of keeping the mug is given by:

$$V(keep\ mug|bid\ p_{a+1}) = \gamma + q_L\eta(\gamma - \lambda p_L) + \frac{(1-q_L)(N-a)}{N}\eta\gamma - \frac{(1-q_L)}{N}\eta\lambda(p_{a+1} + \cdots + p_N)$$

where the first term is the consumption utility of the mug. The second term is gain-loss utility compared to the forced sale: in this case a gain of the mug and a loss of $\$p_L$. Compared to lower BDM prices (which would have been rejected), the outcome is identical so there is no gain-loss term. The gain-loss utility compared to higher BDM prices has been split into two terms. The third term is the gain of the mug for all $(N-a)$ of these prices, and the final term is the loss of money compared to each of these prices individually.

To find WTA, we equate these two values and solve for p_a.

$$p_a + q_L\eta(p_a - p_L) + \frac{(1-q_L)(a-1)}{N}\eta(p_a - \lambda\gamma) - \frac{(1-q_L)}{N}\eta\lambda(p_{a+1} - p_a + \cdots + p_N - p_a)$$
$$= \gamma + q_L\eta(\gamma - \lambda p_L) + \frac{(1-q_L)(N-a)}{N}\eta\gamma - \frac{(1-q_L)}{N}\eta\lambda(p_{a+1} + \cdots + p_N)$$

Gathering p_a terms to the left-hand side and all other terms to the right-hand side gives:

$$p_a + q_L\eta p_a + \frac{(1-q_L)(a-1)}{N}\eta p_a + \frac{(1-q_L)(N-a)}{N}\eta\lambda p_a$$
$$= \gamma + q_L\eta\gamma + q_L\eta p_L - q_L\eta\lambda p_L + \frac{(1-q_L)(a-1)}{N}\eta\lambda\gamma + \frac{(1-q_L)(N-a)}{N}\eta\gamma$$
$$+ \frac{(1-q_L)}{N}\eta\lambda(p_{a+1} + \cdots + p_N) - \frac{(1-q_L)}{N}\eta\lambda(p_{a+1} + \cdots + p_N)$$

$$p_a\left(1 + q_L\eta + \frac{(1-q_L)\eta}{N}\big(\lambda(N-a) + (a-1)\big)\right)$$
$$= \gamma(1 + q_L\eta) - (\lambda - 1)q_L\eta p_L + \gamma\eta\frac{(1-q_L)}{N}\big((N-a) + \lambda(a-1)\big)$$

Dividing to isolate p_a:

$$WTA(a) \coloneqq p_a = \frac{\gamma\left(1 + q_L\eta + \frac{(1-q_L)}{N}\eta\big(N - a + \lambda(a-1)\big)\right) - q_L\eta(\lambda-1)p_L}{1 + \eta\left(q_L + \frac{(1-q_L)}{N}(\lambda(N-a) + a - 1)\right)}$$

This is Equation 1.

Appendix B

In this Appendix, we perform a similar derivation to Appendix A but allow loss aversion (λ) and gain-loss sensitivity (η) to differ towards money and the mug (denoted by \$ and c superscripts, respectively). We show that the direction of the attachment effect is solely determined by parameters in the goods domain and the comparison effect is solely determined by parameters in the money domain.

Consider the following seller framework, which nests both our experiment and Ericson and Fuster's (2011) Experiment 2. With probability q_L the mug must be sold for \$$p_L$, with probability q_M the seller BDM is realised, and with probability $1 - q_L - q_M$ the mug cannot be sold. As before, the seller BDM has prices p_1 to p_N in increments of x.

The value of selling at BDM price p_a, having bid p_a, is given by:

$$\begin{aligned} &V(sell\ for\ p_a|bid\ p_a) \\ &\quad = p_a - (1 - q_M - q_L)\eta^c\lambda^c\gamma - \frac{q_M(a-1)}{N}\eta^c\lambda^c\gamma + (1 - q_M - q_L)\eta^\$ p_a \\ &\quad + \frac{q_M(a-1)}{N}\eta^\$ p_a + q_L\eta^\$(p_a - p_L) - \frac{q_M}{N}\eta^\$\lambda^\$(p_{a+1} - p_a + \cdots + p_N - p_a) \end{aligned}$$

and the value of keeping the mug, having bid p_{a+1}, is given by:

$$V(keep\ mug|bid\ p_{a+1}) = \gamma + q_L\eta^c\gamma + \frac{q_M(N-a)}{N}\eta^c\gamma - q_L\eta^\$\lambda^\$ p_L - \frac{q_M}{N}\eta^\$\lambda^\$(p_{a+1} + \cdots + p_N)$$

As before, equating these values and solving for p_a gives WTA. This process is identical to Appendix A, so we skip to the result:

$$WTA(a) \coloneqq p_a = \frac{\gamma\left(1 + (1 - q_M)\eta^c\lambda^c + \frac{q_M}{N}\eta^c\big(N - a + \lambda^c(a-1)\big)\right) - q_L\big(\eta^c(\lambda^c - 1)\gamma + \eta^\$(\lambda^\$ - 1)p_L\big)}{1 + \eta^\$\left(1 - q_M + \frac{q_M}{N}(\lambda^\$(N-a) + a - 1)\right)}$$

Setting $q_M = 0.1$ and $p_L = 0$ gives Ericson and Fuster's (2011) Experiment 2. WTA simplifies to the following, with the term driving the attachment effect highlighted in red:

$$WTA(a) = \frac{\gamma\left(1 + 0.9\eta^c\lambda^c + \frac{0.1}{N}\eta^c\big(N - a + \lambda^c(a-1)\big)\right) - q_L\eta^c(\lambda^c - 1)\gamma}{1 + \eta^\$\left(0.9 + \frac{0.1}{N}(\lambda^\$(N-a) + a - 1)\right)}$$

$$\frac{dWTA(a)}{dq_L} = -\frac{\eta^c(\lambda^c - 1)\gamma}{1 + \eta^\$ \left(0.9 + \frac{0.1}{N}(\lambda^\$(N - a) + a - 1)\right)}$$

The direction of the attachment effect is solely determined by parameters in the mug domain in the numerator. These also largely determine the magnitude, although there is some scaling from parameters in the money domain in the denominator.

Setting $q_L = 0.9$ and $q_M = 0.1$ gives our experiment. WTA simplifies to the following, with the term driving the comparison effect highlighted in red:

$$WTA(a) = \frac{\gamma\left(1 + 0.9\eta^c + \frac{0.1}{N}\eta^c\big(N - a + \lambda^c(a - 1)\big)\right) - q_L\eta^\$\big(\lambda^\$ - 1\big)p_L}{1 + \eta^\$ \left(0.9 + \frac{0.1}{N}(\lambda^\$(N - a) + a - 1)\right)}$$

$$\frac{dWTA(a)}{dp_L} = -\frac{q_L\eta^\$\big(\lambda^\$ - 1\big)}{1 + \eta^\$ \left(0.9 + \frac{0.1}{N}(\lambda^\$(N - a) + a - 1)\right)}$$

The comparison effect depends solely on parameters in the money domain. Therefore, we only consider gain-loss attitudes towards money for our experiment.

Appendix C

In this Appendix, we simulate theoretical effect sizes for both our experiment and Ericson and Fuster's (2011) Experiment 2 and compare the latter to both their observed treatment effect and that of Camerer et al.'s (2016) replication.

In Table C1 we use Equations 1 and 2 to predict WTA in each of our experimental treatments for a range of loss aversions and consumption utilities for the mug (which has a retail value of approximately AUD \$15). We consider four levels of loss aversion: $\eta(\lambda - 1) = 0.18$ describes a slightly loss-averse individual (equivalent to $\lambda_{PT} = 1.2$ in standard prospect theory). $\eta(\lambda - 1) = 0.4$ describes a moderately loss-averse individual (equivalent to $\lambda_{PT} = 1.5$ in standard prospect theory) and matches the median response to Gächter et al.'s (2022) monetary gambles task. $\eta(\lambda - 1) = 0.67$ describes a highly loss-averse individual (equivalent to $\lambda_{PT} = 2$ in standard prospect theory) and matches the median estimate for our sample. Finally, $\eta(\lambda - 1) = 1$ describes an extremely loss-averse individual (equivalent to $\lambda_{PT} = 3$ in standard prospect theory). To recover η and λ from $\eta(\lambda - 1)$, we make the standard assumption that $\eta = 1$ (see O'Donoghue and Sprenger, 2018).

The predicted effect sizes for our experiment are economically significant and increase substantially with participants' loss aversion. Furthermore, they are minimally affected by participants' valuation for the mug, because the comparison effect is driven purely by loss aversion in the money domain (see Appendix B).

Next, we compare predicted effect sizes for Ericson and Fuster's (2011) design to their observed effect sizes and those of Camerer et al.'s (2016) replication. Table C2 shows the predicted WTA for hypothetical participants with differing consumption utilities for the mug (γ) and loss aversion parameters. The left panel ($\eta(\lambda - 1) = 0.4$) describes the moderately loss-averse, median participant in Gächter et al.'s (2022) (equivalent to $\lambda_{PT} = 1.5$ in standard prospect theory). The right panel ($\eta(\lambda - 1) = 0.67$) describes the highly los-averse, median participant we observe in our experiment (equivalent to $\lambda_{PT} = 2$ in standard prospect theory). Included at the bottom are the treatment averages and treatment effect sizes observed by Ericson and Fuster (2011) and Camerer et al. (2016).

Considering both treatment means and the treatment effect, the average result from Ericson and Fuster (2011) broadly matches a hypothetical individual with γ between \$3.50 and 3.75

and $\eta(\lambda - 1)$ slightly below 0.4. The average result from the replication broadly matches an individual with $\gamma = \$3.25$ and $\eta(\lambda - 1)$ slightly above 0.67. We conclude that the observed effect sizes are broadly similar to theoretical predictions of the attachment effect under reasonable parameter assumptions.

Table C1. Simulated Effect Sizes for Our Experiment

	Simulated WTA					
γ	$\eta(\lambda - 1) = 0.18$			$\eta(\lambda - 1) = 0.4$		
	$p_L = \$0.1$	$p_L = \$6$	Difference	$p_L = \$0.1$	$p_L = \$6$	Difference
\$6	5.94	5.47	0.47	5.87	4.82	1.05
\$8	7.94	7.46	0.48	7.85	6.80	1.05
\$10	9.94	9.46	0.48	9.85	8.79	1.06
\$15	14.96	14.48	0.48	14.91	13.83	1.08
\$20	20.03	19.54	0.49	20.05	18.96	1.09
γ	$\eta(\lambda - 1) = 0.67$			$\eta(\lambda - 1) = 1$		
	$p_L = \$0.1$	$p_L = \$6$	Difference	$p_L = \$0.1$	$p_L = \$6$	Difference
\$6	5.78	4.03	1.75	5.67	3.09	2.58
\$8	7.75	5.99	1.76	7.63	5.03	2.60
\$10	9.75	7.98	1.77	9.62	6.99	2.63
\$15	14.84	13.03	1.81	14.76	12.04	2.72
\$20	20.09	18.23	1.86	20.13	17.31	2.82

Table C2. Simulated Effect Sizes for Ericson and Fuster (2011), Experiment 2

	Simulated WTA					
γ	$\eta(\lambda-1)=0.4$			$\eta(\lambda-1)=0.67$		
	$q_L=0.1$	$q_L=0.8$	Difference	$q_L=0.1$	$q_L=0.8$	Difference
\$3	3.04	3.46	0.42	3.06	3.77	0.71
\$3.25	3.30	3.76	0.46	3.33	4.09	0.77
\$3.5	3.55	4.04	0.49	3.59	4.42	0.83
\$3.75	3.81	4.34	0.53	3.85	4.74	0.89
\$4	4.07	4.63	0.56	4.11	5.07	0.95
\$5	5.11	5.82	0.71	5.18	6.38	1.20
	Experimental results (USD)					
				$q_L=0.1$	$q_L=0.8$	Difference
Ericson and Fuster (2011)				3.74	4.12	0.38
Camerer et al. (2016)				3.36	4.31	0.95

Appendix D

In this Appendix, we derive Equation 6, which is used to estimate KR loss aversion from the monetary gambles task. The KR utility of accepting a 50/50 gamble to gain \$6 or lose \$$x$ when expecting to do so is:

$$U(accept|accept) = 0.5(6 - x) + 0.25\eta(6 + x) - 0.25\eta\lambda(6 + x)$$

where the first term is the consumption utility of the gamble (i.e., its expected value), the second term is the gain-loss utility of winning compared to losing, and the third term is the gain-loss utility of losing compared to winning.

The utility of rejecting the gamble when expecting to do so is 0. Thus, the individual would commit to the gamble if:

$$0.5(6 - x) + 0.25\eta(6 + x) - 0.25\eta\lambda(6 + x) \geq 0$$

which rearranges to give:

$$\eta(\lambda - 1) \leq \frac{12 - 2x}{6 + x}$$

For the highest acceptable gamble, this is an equality, giving Equation 6.

Appendix E

In this Appendix, we report additional specifications for both our main analysis and interaction analysis. Table E1 shows the results of the interaction analysis (Equation 5) using two alternative measures of loss aversion. The first is the prospect theory measure λ_{PT}, which is simply $\frac{6}{x}$ where x is the highest loss gamble the participant was willing to play. The second measure is the highest acceptable loss itself as a dollar value. Unlike the other measures, a lower value for the highest acceptable loss indicates greater loss aversion. As before, we report both OLS and Tobit estimates.

Using the prospect theory measure of loss aversion, we estimate an interaction effect of AUD \$0.13 ($p = 0.80$) by OLS and \$0.26 ($p = 0.65$) using the Tobit model. These results are not only insignificant but in the opposite direction to our hypothesis, suggesting that more loss-averse participants experience a weaker treatment effect. Using the highest acceptable gamble loss, we estimate an interaction effect of \$0.01 ($p = 0.99$) by OLS and –\$0.12 ($p = 0.89$) using the Tobit model. Once again, both estimates are insignificant, and furthermore contradict each other in direction. These analyses only add to the inconsistency seen when using the KR loss aversion measure and the high loss aversion dummy in Table 4.

Table E2 reports the results of our main effect analysis (Equation 4) for the full sample when we add a loss aversion measure as a control variable. We consider the KR loss aversion measure and the high loss aversion dummy, as these are the most theoretically sound under KR theory. We report both OLS and Tobit estimates for each specification.

Controlling for the KR measure of loss aversion, we estimate a treatment effect of AUD –\$0.90 ($p = 0.26$) by OLS and –\$1.45 ($p = 0.15$) using the Tobit model. Controlling for the high loss aversion dummy, we estimate a treatment effect of –\$0.89 ($p = 0.20$) by OLS and –\$1.33 ($p = 0.104$) using the Tobit model. Once again, none of these estimates are significant, though they are large and directionally consistent, and the Tobit estimate for the dummy specification is close to 10% significance. Effect sizes are within the range of the estimates reported in Table 3. Overall, these extra analyses accord with the interpretation of our main results.

Table E1. Regression Results for Interaction Effect (alternative LA measures)

	Prospect Theory measure		Highest gamble	
	OLS	Tobit	OLS	Tobit
	(1)	(2)	(3)	(4)
High treatment	–1.162	–2.012	–0.954	–1.074
	(1.616)	(2.136)	(2.003)	(2.259)
λ_{PT}	–0.022	0.124		
	(0.284)	(0.349)		
Highest gamble			–0.236	–0.397*
			(0.188)	(0.220)
Interaction	0.134	0.255	0.013	–0.118
	(0.497)	(0.565)	(0.663)	(0.818)
Male	1.428	1.881	1.414	1.916
	(1.171)	(1.219)	(1.168)	(1.204)
Age	–0.118	–0.347**	–0.122	–0.340***
	(0.068)	(0.146)	(0.069)	(0.125)
International	1.355	1.907*	1.202	1.724
	(0.913)	(1.040)	(0.927)	(1.074)
Postgraduate	0.941	2.368**	0.988	2.407**
	(0.910)	(1.018)	(0.837)	(1.008)
Economics major	1.494**	2.032***	1.704**	2.312***
	(0.594)	(0.627)	(0.559)	(0.606)
Estimated RRP	0.224**	0.253***	0.227**	0.253***
	(0.067)	(0.086)	(0.066)	(0.085)
Appeal	3.317***	4.409***	3.382***	4.481***
	(0.871)	(0.995)	(0.906)	(1.005)
Constant	1.427	1.290	2.042	2.559
	(2.358)	(3.730)	(2.030)	(3.291)
Observations	90	90	90	90

Note. Standard errors are clustered by session. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Table E2. Regression Results for Main Treatment Effect (with LA control)

	Controlling for KR measure		Controlling for Dummy measure	
	OLS	Tobit	OLS	Tobit
	(1)	(2)	(3)	(4)
High treatment	–0.898	–1.448	–0.885	–1.331
	(0.724)	(1.000)	(0.627)	(0.811)
$\eta(1-\lambda)$	0.807	1.656		
	(1.276)	(1.608)		
High LA dummy			1.491	2.199
			(1.346)	(1.542)
Male	1.405	1.874	1.569	2.125*
	(1.189)	(1.244)	(1.122)	(1.182)
Age	–0.123	–0.353***	–0.134*	–0.358***
	(0.071)	(0.132)	(0.068)	(0.109)
International	1.216	1.719	1.185	1.742
	(0.923)	(1.084)	(0.966)	(1.128)
Postgraduate	0.965	2.450**	0.944	2.367**
	(0.850)	(0.971)	(0.773)	(0.942)
Economics major	1.679**	2.300***	1.497**	1.922**
	(0.571)	(0.671)	(0.599)	(0.748)
Estimated RRP	0.228***	0.257***	0.229***	0.256***
	(0.064)	(0.083)	(0.064)	(0.082)
Appeal	3.378***	4.496***	3.447***	4.526***
	(0.910)	(1.045)	(0.948)	(1.050)
Constant	0.746	0.332	0.417	0.154
	(2.508)	(3.630)	(2.387)	(3.372)
Observations	90	90	90	90

Note. Standard errors are clustered by session. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Appendix F

Here we reproduce our experimental stimuli. We add solid lines to indicate the end of a page. For any page without a blue 'Next' button, participants were advanced together by the experimenter.

Results are shown for a hypothetical participant who correctly answers the comprehension questions (which is required to proceed), bids \$10 in the BDM and rejects all monetary gambles.

Welcome

Hello! Thank you for participating in today's study.

During this study, we will ask you to make decisions involving money and goods. We will also ask you some survey questions.

Your base payment for completing the study is $15.00, but the decisions you make may increase or decrease this amount. All payments will be made by PayPal. All goods will be delivered by Express Post to an **Australian** postal address of your choosing.

All of your responses are fully anonymous. This means that once your payment and/or goods have been sent to you, we will de-identify your responses such that we will not be able to tell which ones are yours.

Before we begin, we ask you to respect the following guidelines:

- Please remain in front of your computer throughout the study, even if you have finished the current task.
- Please do not use any other electronic devices during the study.
- Please do not use any other programs on your computer.
- Please close any other windows or tabs in your browser and do not open any during the study.
- Please leave your camera on at all times.
- If you have any issues or questions during the study, you can send a private message to Experimenter B in the Zoom Chat.
- If you disconnect during the study, reopen your link and it will take you back to the page you were on. Your responses won't be lost.
- If your internet stops working, please send a text message to the experimenter at XXXX XXX XXX. The experimenter will also try to ring you to address the issue.

Thank you for your cooperation.

Task Instructions

Your task involves the limited edition School of Economics reusable travel mug shown below. You have been given your own mug just like the one you can see in these pictures:

At the end of the experiment, there is a 9 in 10 chance you will have to sell your mug back to us in return for a bonus payment of $6.00, which will be added to your base payment of $15.00 from the study. I will call this the **Compulsory Sale Scenario**.
With the remaining 1 in 10 chance you will have a choice whether to sell your mug for a bonus payment, or keep your mug and receive no bonus. I will call this the **Choice Scenario**.

The way the Choice Scenario works is as follows: you will tell us in advance the **minimum** price at which you would be willing to sell your mug and receive a bonus payment, which would be added to your base payment of $15.00 from the study. The computer will then **randomly** offer you a price between $6.10 and $30.

- If the computer's offer is ABOVE the minimum price you've told us, you will automatically ACCEPT the offer and SELL your mug for the price offered by the computer.
- If the computer's offer is BELOW the minimum price you've told us, you will automatically REJECT the offer and KEEP your mug. In this case, you would not receive any bonus.

The computer's offer is completely random. Nothing you do will have any effect on the offer you receive. So it's in your best interests to tell us honestly the minimum price at which you would prefer to give up your mug and take the bonus payment instead.

We will ask you to tell us your minimum sales price BEFORE you find out whether you have been assigned to the Compulsory Sale Scenario or the Choice Scenario.

Your response will only affect your bonus payment and whether you sell or keep your mug if you are assigned to the Choice Scenario at the end of the experiment.

Examples

<u>Example 1</u>

Alice chooses a minimum sales price of $19.00. However, at the end of the experiment, she is randomly assigned to the Compulsory Sale Scenario so she is compelled to sell her mug for $6.00. She receives a bonus of $6.00 and loses possession of her mug.

<u>Example 2</u>

Bob chooses a minimum sales price of $9.30. At the end of the experiment, he is randomly assigned to the Choice Scenario so the computer makes him a random offer. This offer turns out to be $19.20. This is above Bob's minimum sales price so Bob **automatically** accepts the offer and sells his mug for the offered price. He receives a bonus payment of $19.20 and loses possession of his mug.

<u>Example 3</u>

Cathy chooses a minimum sales price of $26.70. At the end of the experiment, she is randomly assigned to the Choice Scenario so the computer makes her a random offer. This offer turns out to be $12.60. This is below Cathy's minimum sales price so Cathy **automatically** rejects the offer. She does not receive any bonus payment and keeps possession of her mug.

Please answer the following questions to test your understanding of the task. The experiment will continue once everyone has answered all of the questions correctly.

<u>Question 1</u>

David chooses a minimum sales price of $18.00. At the end of the experiment, he is randomly placed in the Compulsory Sale Scenario.

What bonus payment will David receive? (If he will receive no bonus, enter "0")

[ ] $

Will David keep his mug?

- ○ No
- ○ Yes

<u>Question 2</u>

Emma chooses a minimum sales price of $21.50. At the end of the experiment, she is randomly placed in the Choice Scenario. The computer makes her an offer of $19.30.

What bonus payment will Emma receive? (If she will receive no bonus, enter "0")

[ ] $

Will Emma keep her mug?

- ○ No
- ○ Yes

Question 3

Fred chooses a minimum sales price of $14.50. At the end of the experiment, he is randomly placed in the Choice Scenario. The computer makes him an offer of $18.70.

What bonus payment will Fred receive? (If he will receive no bonus, enter "0")

[ ] $

Will Fred keep his mug?

- ○ No
- ○ Yes

Question 4

What is the chance of being in the Compulsory Sale Scenario at the end of the experiment?

- ○ It's impossible
- ○ 1 in 10
- ○ 2 in 10
- ○ 3 in 10
- ○ 4 in 10
- ○ 5 in 10
- ○ 6 in 10
- ○ 7 in 10
- ○ 8 in 10
- ○ 9 in 10
- ○ It's certain

Question 5

What is the chance of being in the Choice Scenario at the end of the experiment?

- It's impossible
- 1 in 10
- 2 in 10
- 3 in 10
- 4 in 10
- 5 in 10
- 6 in 10
- 7 in 10
- 8 in 10
- 9 in 10
- It's certain

Next

That's correct!

Thank you. We will proceed when all participants have finished.

Task Reminder

This School of Economics reusable travel mug is currently in your possession:

On the next page, you will tell us the minimum price at which you are willing to sell your mug.

There is 1 in 10 chance you will be in the **Choice Scenario** and the computer will offer to buy your mug for a random price anywhere from $6.10 to $30.

- If this price is greater than (or equal to) your minimum sales price, you will automatically accept the offer and give up your mug for a bonus payment of that price.
- If this price is less than your minimum sales price, you will automatically reject the offer. You will keep your mug and will not receive a bonus payment.
- Your answer will be LOCKED IN and you will not be able to change it later.

With the remaining 9 in 10 chance you will be in the **Compulsory Sale Scenario** and you will have to sell your mug for a bonus payment of $6.00 (no matter what your minimum sales price is).

Choose Your Minimum Sales Price

This School of Economics reusable travel mug is currently in your possession:

Task details are repeated at the bottom of the page for your reference.

In the **Choice Scenario**, what is the minimum price at which you would be willing to sell your mug?

Remember the computer's offer will be between $6.10 and $30.
(If you do not wish to sell at any of these prices, please enter "31")

$

Once you press "Next" your minimum sales price will be locked in.

Next

Task Reminder

You will NOW tell us the minimum price at which you are willing to sell your mug.

There is 1 in 10 chance you will be in the **Choice Scenario** and the computer will offer to buy your mug for a random price anywhere from $6.10 to $30.

- If this price is greater than (or equal to) your minimum sales price, you will automatically accept the offer and give up your mug for a bonus payment of that price.

- If this price is less than your minimum sales price, you will automatically reject the offer. You will keep your mug and will not receive a bonus payment.
- Your answer will be LOCKED IN and you will not be able to change it later.

With the remaining 9 in 10 chance you will be in the Compulsory Sale Scenario and you will have to sell your mug for a bonus payment of $6.00 (no matter what your minimum sales price is).

Response recorded

Thank you. Your minimum sales price has been locked in. We will proceed when all participants have finished.

Task 2

At the end of the experiment, one of the monetary gambles in the list below will be randomly offered to you. **This is entirely separate from the previous task** and **everyone** will be offered one of the gambles. It is your choice whether to accept the gamble or not.

Each gamble is a coin flip. If you accept the gamble and the (virtual) coin lands on heads, you would receive a bonus payment of $6. If you accept the gamble and the coin lands on tails, you would lose the amount of money shown.

- This money is on top of your $15.00 base payment and any bonus payment from the Task you just completed. If you lose money in the gamble, this would be subtracted from your base payment.

If you reject the gamble, there will be no change to your payment.

Gamble
#1. If the coin lands heads, you win $6; if the coin lands tails, you lose $1.
#2. If the coin lands heads, you win $6; if the coin lands tails, you lose $1.50.
#3. If the coin lands heads, you win $6; if the coin lands tails, you lose $2.
#4. If the coin lands heads, you win $6; if the coin lands tails, you lose $2.50.
#5. If the coin lands heads, you win $6; if the coin lands tails, you lose $3.
#6. If the coin lands heads, you win $6; if the coin lands tails, you lose $3.50.
#7. If the coin lands heads, you win $6; if the coin lands tails, you lose $4.
#8. If the coin lands heads, you win $6; if the coin lands tails, you lose $4.50.
#9. If the coin lands heads, you win $6; if the coin lands tails, you lose $5.
#10. If the coin lands heads, you win $6; if the coin lands tails, you lose $5.50.
#11. If the coin lands heads, you win $6; if the coin lands tails, you lose $6.
#12. If the coin lands heads, you win $6; if the coin lands tails, you lose $6.50.
#13. If the coin lands heads, you win $6; if the coin lands tails, you lose $7.

I will assume that you would accept any gamble where the possible loss is no more than some cutoff and reject any gamble where the possible loss is higher than that cutoff.

For example, if you tell me that the highest loss you are willing to risk is $4, I will assume that you would accept any gamble with a chance to lose $4 or less (gambles #1 to #7), but refuse to play any gamble with a chance to lose $4.50 or more (gambles #8 to #13).

Remember, you will be offered a 50/50 gamble to win $6 or lose some amount. What is the highest loss you would be willing to risk for the chance to win $6?

- Reject all gambles
- $1
- $1.50
- $2
- $2.50
- $3
- $3.50
- $4
- $4.50
- $5
- $5.50
- $6
- $6.50
- Accept all gambles

Next

Thank you

Thank you. We will proceed when all participants have finished.

Survey

What gender do you identify as?

- ○ Female
- ○ Male
- ○ Other
- ○ Prefer not to say

What is your age?

Are you an international student?

- ○ Yes
- ○ No

Are you studying an undergraduate or postgraduate degree?

- ○ Undergraduate
- ○ Postgraduate

What is your degree major(s)?

How much do you think your mug would cost in a regular store?

$

How appealing did you find the mug?

- ○ Not at all
- ○ Not much
- ○ Somewhat appealing
- ○ Very appealing

Did you understand the instructions in this experiment?

- ○ Not at all

- Mostly not
- Mostly
- Fully

Did you trust the experimenter to provide payment as described?

- Not at all
- Mostly not
- Mostly
- Fully

Next

Thank you

Your responses have been recorded. Once all participants have finished we will show you your results for both Tasks.

Results

Your base payment is $15.00.

You were randomly placed in the Compulsory Sale Scenario. Your mug has been sold for $6.00.

You chose to reject all money gambles so your total payment is unchanged.

You will be paid $15.00 (base) + $6.00 (mug) + $0.00 (gamble) = $21.00 (total).
You will NOT receive a mug.

If you have any questions about your results please message Experimenter B. When you are satisfied with your results, press Next.

Next

Thank you

You will be paid a total of $21.00.

You will NOT receive a mug.

Once all participants are ready, we will ask you to a sign a form to confirm your total payment and whether you will receive a mug.

We will also ask for an email address to send your payment to via PayPal.

Please do NOT submit the form until the Experimenter tells you to or we may be unable to process your payment.
