Lagged Beliefs and Reference-Dependent Utility

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November 24, 2018

Abstract

Models of expectation-based reference-dependent preferences propose that the reference point to which consumption outcomes are compared is endogenously determined as a function of lagged, probabilistic beliefs. This paper presents an experiment designed to test some predictions of expectation-based reference dependence models. The design induces a stochastic reference point via a lottery and then measures valuations for a commodity. The experimental results find no effect of the first stage lottery on commodity valuation.

Keywords: expectations, beliefs, reference-dependent preferences, endowment effect, prospect theory, experiment

JEL Classification: D11, D12, D84, D91

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1 Introduction

Prospect theory (Kahneman and Tversky 1979) and related models of reference-dependent preferences assume that choices result from the evaluation of gains and losses relative to a reference point. The models typically incorporate loss aversion: in evaluating outcomes, losses are given greater weight than equally sized gains. A fundamental issue in reference dependent models is the specification of the reference point. Kahneman and Tversky (1979) suggest that in most cases the reference point is the status quo, but also they add that "there are situations in which gains and losses are coded relative to an expectation or aspiration level that differs from the status quo." This indeterminacy regarding the reference point has left reference-dependent preference models open to criticism that the reference point is a free parameter to be determined by the researcher (*e.g.* Pesendorfer 2006).

One response is to model the reference point as a function of beliefs.[1] Kőszegi and Rabin (2006, henceforth KR) develop a model of reference-dependent preferences where the reference point is an individual's probabilistic beliefs about consumption outcomes.[2] KR also propose a solution concept, personal equilibrium, where the reference point is endogenous. The personal equilibrium concept is closely related to the psychological Nash equilibrium of Geanakoplos et al. (1989), and may be interpreted as a (one-person) psychological game in the extended framework of Battigalli and Dufwenberg (2009).[3] KR suggest that the reference point does not update immediately, even when beliefs change. Rather, they propose that the "reference point is fully determined by the expectations a person held in the recent past" (Kőszegi and Rabin 2006, page 1141). KR demonstrate that their model can explain a range of empirical observations such as the target income hypothesis (Camerer et al. 1997) and the fact that experienced traders do not exhibit an endowment effect (List 2003, 2004).

This paper describes the first experiment to test Kőszegi and Rabin's suggestion that lagged, probabilistic beliefs are the reference point to which gains and losses are compared in commodity valuation.[4] The experiment was designed to induce a stochastic reference point by endowing subjects with a lottery, and to then test for an effect of this induced reference point on valuation. In the experiment, subjects were endowed with a lottery that determined their chance of winning a commodity prize (a water bottle). They were assigned to either a high (70%) or a low (10%) probability of winning. To focus attention on the probability of winning the prize, the lottery was implemented using marbles that subjects were asked to count. Then, subjects drew marbles to resolve the lottery, and prizes were awarded. Finally, values were elicited using the Becker, deGroot and Marschak (1964) (BDM) mechanism to test for treatment differences resulting from endowment with different lotteries in the first stage. Winners were given a seller version of the BDM mechanism while those who did not win were given a buyer version. To avoid confounding the treatment with subjects'

[1] See *e.g.* Bell (1985), Loomes and Sugden (1986), Shalev (2000), Sugden (2003), Munro and Sugden (2003), Schmidt et al. (2008).

[2] See also Kőszegi and Rabin (2007, 2009).

[3] Section 6.3 of Battigalli and Dufwenberg (2009) discusses the extension of their framework to allow for utility to depend on a decision maker's own plan.

[4] The experiment and results were first reported in a earlier version of this paper, Smith (2008). Another early work, Abeler et al. (2011) examines expectations-based reference dependence in effort provision. Subsequent experiments studying stochastic reference dependence and valuation including Ericson and Fuster (2011) and Heffetz et al. (2014) are discussed below.

beliefs about the value elicitation stage, subjects were not told in advance about the BDM procedure.

The analysis tests for an effect of lagged beliefs by comparing the reported values of participants who were assigned to high and low probabilities of winning the prize. If the initial lottery endowment influenced the reference point, then subjects who were assigned to the high-probability treatment should value the item more than subjects assigned to the low probability treatment, consistent with the *attachment effect* predicted by Kőszegi and Rabin (2006). The design also allows a comparison of the relative magnitudes of the effects of lagged beliefs versus current endowments on valuations. Because valuations were measured after the realization of the first-stage lottery, some participants were endowed with the commodity at the time valuations were measured, and some were not. Both KR's model and models of loss aversion in riskless choice (such as Tversky and Kahneman 1991) predict an *endowment effect*: an increase in valuation due to ownership.[5] When applied to the experiment setup with reasonable assumptions about parameter values, KR's model predicts that the size of the endowment effect will be modestly larger than the attachment effect.

The results provide at best weak support for the influence of lagged beliefs on choice behavior. Assignment to a high probability of winning the prize does result in a small but statistically insignificant increase in valuation. In comparison, possession of the commodity prize results in a large and statistically significant increase in valuation, consistent with prior experimental results on the endowment effect Kahneman et al. (such as 1990). Because these effects are predicted to have comparable magnitude by KR's model, it is unlikely that failure to find an effect of lagged beliefs on choice is due to a lack of power. The experiments are informative regarding the speed of updating of the reference point and the magnitude of the effect on values for commodities of lagged beliefs relative to the effect of current endowments. The results suggest that possession has a powerful effect on valuation, but that the effect of lagged expectations is small.

The interpretation of the results depends upon the assumption that the reference point is the first stage lottery.[6] Under other timing structures the results of the experiment might be different. Although KR argue that reference points are based upon lagged expectations (see Footnote 9 of their paper), KR do not provide explicit theoretical guidance regarding the speed of reference point adjustment in response to new information. The timing by which new information is incorporated into the reference point is still not well understood, and this experiment can be viewed as a contribution to the study of reference point updating.[7]

Related experiments studying exchange and valuation also yield mixed results. Two studies closely related to this paper are Ericson and Fuster (2011) and Heffetz et al. (2014). These authors also conduct experiments that endow subjects with a lottery and then test for effects of changing the composition of the lottery. Ericson and Fuster (2011) find evidence to support the notion that people are loss averse relative to expected outcomes in both an

[5]The term "endowment effect" is due to Thaler (1980); see also Tversky and Kahneman (1991) for a model of loss aversion in riskless choice, and Ericson and Fuster (2014) for a review of the literature. The endowment effect contradicts classical predictions that the difference between willingness-to-pay (WTP) and willingness-to-accept (WTA) should be negligible if income effects are small, or if the commodity has many substitutes (Willig 1976, Hanemann 1991).

[6]Thanks to two anonymous referees for encouraging the emphasis of this point.

[7]Related works include Arkes et al. (2008, 2010) and Baucells et al. (2011).

exchange and a valuation experiment. In contrast, Heffetz et al. (2014) fail to find evidence for expectation-based reference points in two separate exchange experiments. In other decision-making experiments involving commodity valuation or lottery choices, Knetsch and Wong (2009), Sprenger (2015), and Song (2016) report results that support the notion of expectation-based reference points, while Goette et al. (2014) and Chapman et al. (2017) present evidence that is inconsistent with stochastic reference dependence.

Another group of experiments studies expectations based reference points in the context of labor supply. Abeler et al. (2011) find that when expected incomes are high, subjects work longer and earn more than when they are low, a result consistent with KR's prediction of income targeting around expected incomes.[8] Gill and Prowse (2012) use a structural estimation approach to model the behavior of subjects who are loss averse relative to a reference point given by endogenous expectations that adjust to both the subject's own effort choice and that of her rival, finding that reference points update dynamically and rapidly to the choice-acclimating personal equilibrium of Kőszegi and Rabin (2007). However, Gneezy et al. (2017) modify the design of Abeler et al. (2011) by making the fixed payment a lottery and document behavior that is inconsistent with expectations-based reference points. Overall, labor supply experiments involving real effort choices are also equivocal regarding the role of expectations as reference points.

In subsequent work, Kőszegi and Rabin (2009) develop a dynamic version of their model that generates preferences over the temporal resolution of uncertainty or "news utility." A few papers study the predictions of dynamic stochastic reference dependence in the laboratory. Pagel and Zeppenfeld (2013) test standard consumption and portfolio choice predictions against those of expectations-based reference-dependent and hyperbolic-discounting preferences and find that subjects behavior more closely conforms to the standard model. Zimmermann (2015) finds little support for the hypothesis that decision-makers should prefer clumped over piecewise information as a result of loss aversion over rationally expected changes in beliefs about fu- ture consumption. However, Falk and Zimmermann (2017) do find evidence that laboratory dislike fluctuations in their beliefs, supporting the assumptions and implications of the model by Kőszegi and Rabin (2009). As with the literature apply the static model, the experiments literature finds mixed support for dynamic reference dependence and news utility.

In applied work, a few papers explicitly connect to KR. Mas (2006) finds that police performance declines when pay arbitration outcomes are worse than expected. Crawford and Meng (2011) find evidence that taxi-drivers are loss-averse relative to daily income expectations. Card and Dahl (2011) find that domestic violence increases after unexpected losses of NFL teams. Olafsson and Pagel (2018) document that households reduce consumption and increase savings around retirement, in contrast to the predictions of traditional life-cycle models and consistent with Pagel (2017). These authors all interpret their results as being consistent with expectations-based reference points.

The growing body of research that applies reference dependent preference models to field data highlights the importance of laboratory work on the determinants of reference points. Controlled laboratory experiments can isolate the factors that determine reference points without relying on structural assumptions, and a better understanding of how reference

[8]See KR, Section V.

points are determined in the lab can improve our understanding of the assumptions necessary for identification of structural parameters in applications to field data. While the lack of support for KR's model in this paper does not invalidate the estimation results in these empirical studies, the results in this paper suggest that the door is not closed to alternative interpretations of these results. We return to these issues in the conclusion.

2 Theoretical Background

KR modify and extend prospect theory (Kahneman and Tversky 1979, Tversky and Kahneman 1991). In their model decision-makers (DMs) derive utility from consumption and from gains and losses over multiple dimensions. KR first define a utility function over deterministic outcomes and reference points, analogous to Bernoulli utility, and then allow for both stochastic consumption and stochastic reference points. They propose that lagged beliefs about consumption are the reference point, and provide a model of reference point determination, personal equilibrium, in which the reference point is determined from the DM's beliefs about the choice sets he will face and the choices he will make from each set in the support of his beliefs. Finally, KR assume that DM's evaluate uncertain options according to their expected utility, in contrast with prospect theory where DMs are assumed to transform probabilities with a nonlinear weighting function.

In this section I provide a brief overview of the model of Kőszegi and Rabin (2006) and its application to consumer behavior. For more details see their paper.

2.1 KR's model

Formally, given a consumption level $c \in \mathbb{R}^n$ and a reference level $r \in \mathbb{R}^n$, KR's utility function $u : \mathbb{R}^n \times \mathbb{R}^n \to \mathbb{R}$ is defined as

$$u(c|r) = \sum_{k=1}^{n} m_k(c_k) + \sum_{k=1}^{n} \mu(m_k(c_k) - m_k(r_k))$$

Consumption utility is $m(c) = \sum_k m_k(c_k)$, where for each $k \in \{1, \ldots, n\}$, $m_k(\cdot)$ is a strictly increasing and differentiable function. Gain-loss utility in each consumption dimension is $\mu(m_k(c_k) - m_k(r_k))$, where $\mu(\cdot)$ has the properties of Kahneman and Tversky's (1979) value function.

The reference level r is determined by the probability measure G over $\mathbb{R}^n$, which captures recent expectations about consumption. Given G, the overall utility from a deterministic consumption level c is calculated by comparing the consumption utility from c to the DM's beliefs about the reference level of consumption:

$$U(c|G) = \int u(c|G) dG(r)$$

If the consumption level is given by the probability measure F over $\mathbb{R}^n$, then utility is

$$U(F|G) = \int \int u(c|r) dG(r) dF(c)$$

In addition to specifying a utility function which allows for both the objects of choice and the reference point to be stochastic, KR propose a model of reference point determination, personal equilibrium (PE).

In a PE, the DM has exogenously given beliefs about the possible choice sets he will face. For example, he might have beliefs about his future income or about the prices he might face. The reference point is determined endogenously as a result of the DM's planned choices for each possible choice set. A PE is a form of rational expectations in which the DM both correctly predicts his choice sets and his behavior when facing those choice sets, and does not want to deviate from his plan when actually faced with any given choice set. Although KR do not specify the timing aspects of their model, they do state that the appropriate reference point is "recent expectations" and that the specification of beliefs about choice sets should correspond to "expectations formed after the decision-maker started focusing on the decision."

2.2 Consumer Behavior

Consider a DM who derives utility from a consumption bundle $(c_1, c_2) \in \mathbb{R}^2$, with c_1 representing ownership of a commodity and c_2 is the DM's dollar wealth.[9] The DM's endowment is $(0, w)$. The DM has Kőszegi-Rabin utility with $m_1(1) - m_1(0) = v$ and $m_2(c_2) = c_2$, so consumption utility is linear in wealth. Assume the gain-loss function is piecewise linear, so that

$$\mu(x) = \begin{cases} \eta x & \text{if } x > 0, \\ \eta\lambda x & \text{if } x \leq 0 \end{cases}$$

Here $\eta > 0$ is the weight the DM attaches to gain-loss utility, and $\lambda > 1$ measures the DM's loss-aversion.

The DM's problem is to determine the prices at which he would be willing to buy or sell one unit of the commodity. Assume the DM evaluates his gain-loss utility with respect to the reference point $\mathcal{L}$, a binary lottery in which the decision-maker receives one unit of the commodity with probability q, and receives nothing with probability $1 - q$. This reference point can be interpreted as exogenously given or alternatively one can consider the personal equilibrium in which the DM expects to face the lottery $\mathcal{L}$ with probability $(1-\alpha)$ and some other choice set $\mathcal{D}$ with probability α. Letting α approach 0, the contribution of outcomes from $\mathcal{D}$ to gain-loss utility will be minimal, and so for very small α the DM will evaluate choices from $\mathcal{D}$ as if $\mathcal{L}$ is the reference point.

The DM will compare the utility from buying at some price p with $\mathcal{L}$ as the reference point, to the utility from not buying again with $\mathcal{L}$ as the reference point. The DM's maximum willingness to pay (WTP) will be the price at which he is indifferent between buying and not buying:

$$U(\text{not buy at } p|\mathcal{L}) = U(\text{buy at } p|\mathcal{L})$$

[9] See KR, Section IV.

that is, if

$$\begin{aligned} m_1(0) + w + q\eta\lambda(-v) &= m_1(1) + (w-p) + (1-q)\eta v + \eta\lambda(-p) \\ p &= \frac{1+\eta+q\eta(\lambda-1)}{1+\eta\lambda} v = WTP \end{aligned} \tag{1}$$

Alternatively, leaving the reference point fixed at $\mathcal{L}$, but changing the endowment level to $(c_1, c_2) = (1, w)$ the DM's minimum willingness-to-accept (WTA) will be the price at which he is indifferent between selling the item and keeping it:

$$U(\text{sell at } p|\mathcal{L}) = U(\text{keep}|\mathcal{L})$$

$$\begin{aligned} m_1(0) + (w+p) - q\eta\lambda v + \eta p &= m_1(1) + w + (1-q)\eta v \\ p(1+\eta) &= v + (1-q)\eta v + q\eta\lambda v \\ p &= \frac{1+\eta+q\eta(\lambda-1)}{1+\eta} v = WTA \end{aligned} \tag{2}$$

The right-hand side of Equations 1 and 2 is increasing in q, the probability of receiving the commodity for free. As q increases, so does the DM's valuation (WTP or WTA) for the item. This is KR's attachment effect.

The numerator in the expressions for WTP and WTA is the same, but the denominator is larger for WTP. This difference between WTP from Equation 1 and WTA from Equation 2 results from the fact that the price paid p by the buyer is evaluated as a loss for the buyer but as a gain for the seller. This result leads to an endowment effect: seller's valuation is predicted to be greater than buyers. In this case the result is derived from loss aversion over wealth.

3 Experiment Design and Hypotheses

Given the specification of the reference point as lagged beliefs, an experimental design studying how behavior varies with a belief-dependent reference point might either elicit beliefs (*e.g.* with a scoring method) or induce beliefs by endowing subjects with a lottery (Hurley and Shogren 2005). Because scoring might influence subject's reference point, the design employed belief induction. Stage 1 of the design was a binary lottery intended to induce a reference point in subjects. In Stage 2, subjects participated in a value-elicitation procedure in order to measure the effect of varying the Stage 1 lottery.

After taking their seats subjects were given a packet of instructions (see the supplementary materials in the online Appendix) and a bag containing 10 marbles, some of which were blue and some of which were white; an example is shown in Figure 1. The instructions stated that the experiment would have two parts, and that the first part was a drawing for a prize. Participants were asked to count the number of marbles of each color, and were informed that if they drew a blue marble, they would win the prize. Before the drawing subjects were given an opportunity to examine the prize.

The treatment variable in the experiment was the probability of winning the water bottle in the first stage lottery, specifically the number of blue marbles and white marbles assigned

to each subject. In Treatment L, subjects were assigned 1 blue marble and 9 white marbles, and so had a 10% chance of winning the prize. In treatment H, subjects were assigned 7 blue marbles and 3 white marbles, and so had a 70% chance of winning. The marble procedure was intended to make the computation of probabilities as simple and intuitive as possible, to increase the likelihood that the marble drawing procedure would induce a stochastic reference point.

Figure 1: Sample packet of marbles provided to subject."51" was a subject identification number.

The prize was a 32-ounce polycarbonate water bottle, manufactured by NALGENE Outdoor; an example is shown in Figure 2. The bottle had the University of Arizona logo on it and was virtually identical to bottles which retail in the university bookstore for $13.95 plus tax[10] Subjects were not told the retail price, though several subjects did ask about it. This particular prize was chosen because students on campus were frequently seen carrying similar products and it seemed likely that most subjects would be willing to pay some positive amount for the bottle.

After the subjects had an opportunity to examine the marbles and the water bottle, the experimenters walked around the room with a small bag. Participants were asked to put the marbles they had been assigned in the bag and to then draw a marble. The bag was made of dark cloth and was small enough so that subjects could not see into it when they reached in to draw a marble. After each subject drew marbles, the container was emptied and the

[10]The bottles were custom ordered and had a slightly different logo design than those sold in the bookstore.

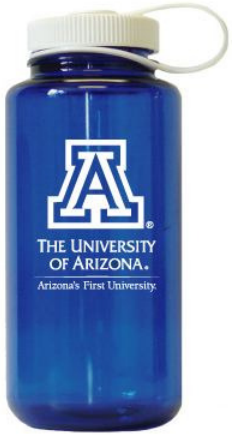

Figure 2: A sample of the water bottle used as a prize.

next subject was asked to repeat the procedure, until all the subjects drew marbles. After all subjects had a chance to draw, prizes (the water bottles) were given to subjects who had drawn a blue marble, and subjects were asked to wait for the next part of the experiment.

After the prizes were awarded, instructions for Stage 2 were handed out. In Stage 2 the Becker et al. (1964) mechanism was implemented to elicit subject's values for the water bottle. The instructions were titled either "Seller Information Sheet" and "Buyer Information Sheet" depending on the results of the Stage 1 drawing. See the supplementary materials in the online Appendix for copies of the instructions.

After the instructions were handed out subjects were shown ping-pong balls with prices ranging from \$0.00 to \$21.00, in increments of \$0.30. The balls were then placed in a bingo cage while subjects filled out their record sheets. Participants were asked to check all prices up to their maximum buying price, for buyers, and all prices above their minimum selling price, for sellers. It was clearly stated that "if you have indicated that you will buy (sell) at the price that is drawn from the bingo cage, then you buy (sell) at that price." As in the marble drawing procedure, the bingo cage was used to make the experimental procedures simple and transparent and to avoid complicating the instructions with discussions of random numbers and probabilities.

Next, the various seller and buyer information sheets were collected. Then a ball was drawn from the cage in full view of the subjects and the resulting price was written on the whiteboard at the front of the lab. Afterwards subjects were called individually, by their identification number, to another room in the laboratory to privately settle trades and conclude the experiment.

Table 1 describes the treatment assignment process in the experiment. The experiment was designed such that there are four data points: Measures of willingness-to-pay for subjects who were initially assigned to either the low or high-probability lotteries (WTP-L and WTP-H) and measures of willingness-to-accept for subjects assigned to each lottery treatment (WTA-L and WTA-H). Because the first stage lottery generates an imbalance in the number of buyers and sellers, the experiment was designed to balance the the number of buyers in each

treatment, at the expense of limiting observations of sellers assigned to the low-probability lottery (WTA-L). Participants were randomly assigned to treatments via independent draws of a Bernoulli random variable with the propensity of assignment to treatment H equal to 0.75. Because the probability of obtaining the prize is 0.1 in treatment L and 0.7 in treatment H, treatments were approximately balanced in terms of total observations on WTP and WTA (since $P(\text{Treatment L}) \times P(\text{not win}|L) = .25 \times .9 = .75 \times .3 = P(\text{Treatment H}) \times (P(\text{not win}|H)$ and in terms of observations on WTP-L and WTP-H, but there are many more observations of WTA-H than of WTA-L. While stopping short of a full 2×2 design due to the unbalanced assignment, the design does generate a comparison of WTP in both treatments H and L, as well as of WTA with WTP in treatment H. Therefore, the only effect that can't be tested for is an interaction between treatment assignment and the realization of the lottery. WTP was selected for balancing because it matches the "Shopping" example in Kőszegi and Rabin (2006).

Table 1: Treatment Assignment

Treatment	P(win)	Propensity	P(win) × Propensity	(1-P(Win))× Propensity
H	0.7	0.75	0.525	0.225
L	0.1	0.25	0.025	0.225

The first hypothesis about the experimental results from the attachment effect:

Hypothesis 1. ***Attachment Effect.***

WTP-H > WTP-L

Willingness-to-pay among buyers will be higher in Treatment H than in Treatment L.

The intuition for Hypothesis 1 is that if subject's reference point is the first stage lottery then subjects will evaluate gains and losses relative to that reference point. The calculations in Section 2.2 show that the loss experienced from not winning the item is increasing in the probability of winning. The incentive to avoid these losses results in a higher predicted WTP for the object in Treatment H than in Treatment L. A similar prediction holds for willingness-to-accept, namely that willingness-to-accept among sellers will be higher in Treatment H than in Treatment L. However, as discussed above, WTP was selected for balancing and thus the design does not generate sufficient observations of WTA-L to test this hypothesis with adequate power.

KR also predict an endowment effect. The endowment effect results from loss-aversion: DMs are biased towards the status quo because losses count more than gains in evaluating potential actions. For those who did not win the prize, buying is always a loss in the money dimension, while for those who did win selling is always a gain. Because of loss aversion, gains count less than losses, and sellers require a higher price to compensate them for the loss of the item than buyers are willing to pay to obtain the item.

Hypothesis 2. ***Endowment Effect.***

WTP-H < WTA-H

Buyers' willingness-to-pay in Treatment H will be less than seller's willingness-to-accept.

A similar prediction holds for the relationship between willingness-to-pay and willingness-to-accept in treatment L, though the experiment was not designed to test that hypothesis.

Laboratory studies commonly find that for ordinary private goods, the ratio WTA/WTP is somewhere between 2 and 3.[11] In the context of KR's model this ratio can be calculated from equations 1 and 2. Normalizing the weight placed on gain-loss utility (η) to 1, a loss aversion (λ) parameter value of 3 implies a WTA/WTP ratio of 2, and this ratio is increasing in λ.[12] After substituting the high and low probabilities of winning the water bottle into Equation 1, these same parameter values imply that the ratio WTP-H/WTP-L (the attachment effect) should be about 1.55. Thus, under typical assumptions we might expect to observe an attachment effect that is a little over half the size of the endowment effect.

To control as much as possible for endogenous reference point formation, no details about the Stage 2 task were provided in advance, so that subjects did not anticipate the BDM mechanism in Stage 2. After the marble drawing, while prizes were awarded subjects were simply asked to wait for the second part of the experiment. If subjects had been told in advance that they would be given the opportunity to buy or sell, then their reference point might include that information, diminishing the effect of the Stage 1 lottery on elicited values.

Because surprise was an important feature of the design, care was taken to avoid deception in the experiment. The scenario in this experiment is a little bit different from KR's model in that the lottery which induces the reference point is resolved before valuations are elicited, unlike in KR where surprise results when a DM expects one choice set and faces another. While implementing the BDM mechanism immediately after endowing subjects with the lottery (and not drawing marbles) would more closely resemble KR's model, such a design would clearly involve deception, the use of which is prohibited at the Economic Science Laboratory. The important issue is that KR specify the reference point as lagged beliefs. Given this specification, the hypothesis that the first stage lottery should affect values elicited in the BDM mechanism is a reasonable interpretation of their model.

4 Results

6 experiment sessions were conducted June 7-15, 2007. All sessions took place at the Economic Science Laboratory (ESL) at the University of Arizona. Subjects were given a showup fee of $10 upon arrival.[13] After the subjects arrived they were seated in the lab. Participants were undergraduates who had signed up to be recruited by the ESL's email-based recruiting software. The maximum number of subjects per session was 14, and the minimum was 6.

[11] See Kahneman et al. (1990) and the review of WTA/WTP studies by Horowitz and McConnell (2002).

[12] Kőszegi and Rabin (2007) and Heffetz et al. (2014) also use these parameter values as examples.

[13] In Sessions 5 and 6 subjects were given the showup fee after the marble drawing.Including or excluding these sessions does not meaningfully affect the results, so they are included in all analyses.

The data is contained in Table 2. The mean of WTP-L was 4.12 and the mean of WTP-H was 4.22. The mean WTA-L was 6.8 (though here there are few observations), and mean WTA-H was 7.30.

Table 2: Individual Data and Summary Statistics

Session	Treatment L		Treatment H	
	WTP-L	WTA-L	WTP-H	WTA-H
1	0.9, 1.5, 1.8, 1.8, 3.0, 3.0, 4.5, 9.0		-	0.3, 8.1, 9.0, 12.0
2	7.5, 9.0	10.2	1.5, 6.3	1.2, 5.1, 5.1, 5.1, 7.2, 10.2, 12.0, 12.0
3	3.0	-	0.9, 0.9, 1.5, 1.8, 15	1.2, 3.0, 3.0, 5.1, 7.5, 10.8, 11.1, 15.0
4	-	7.2	1.5, 1.8, 2.1, 3.9	3.0, 4.2, 5.1, 5.1, 6.0, 12.0
5	3.0, 3.9, 7.5	-	3.0, 9.0, 9.9	9.0, 10.2, 10.2
6	2.4	3.0	-	3.0, 5.1, 10.2, 13.8
Mean	4.12	6.80	4.22	7.30
Std. Dev.	2.76	3.62	4.28	3.95
n	15	3	14	33

The results do not support the hypothesis of an attachment effect. A Mann-Whitney/Wilcoxon test for equality of distributions of WTP-L and WTP-H fails to reject the null hypothesis that the distributions are equal (p-value .43). A Mann-Whitney/Wilcoxon test for equality of distributions of WTA-L and WTA-H fails to reject the null hypothesis that the distributions are equal (p-value .77). While the comparison of WTA-L and WTA-H suffers from the low number of observations of WTA-L, taken together the results suggest that the first stage lottery does not have an effect on behavior in the BDM mechanism.

The data do support the hypothesis of an endowment effect. A Mann-Whitney/Wilcoxon rank sum test for equality of distributions of WTP-H and WTA-H rejects the hypothesis that the two distributions are equal ($p = 0.02$). Although the number of observations for WTA-L is low by design, we can pool treatments H and L to check for an overall WTP/WTA gap. After pooling Treatment H and Treatment L, a Mann-Whitney/Wilcoxon test for equality of distributions of WTP and WTA rejects the hypothesis that the two distributions are equal ($p < 0.001$).

Regression results give a similar conclusion. Table 3 shows results regressions of reported values on treatments and on whether subjects won the prize in the second stage. Column 1 reports coefficients and standard errors from a simple linear regression of reported valuation on treatment; the coefficient estimate for "Treatment H" is the additional value in dollars that the subjects in the high-probability treatment placed on the water bottle. Column 2 reports results from a simple regression of reported value on whether subjects were buyers or sellers the coefficient estimates for "Won prize" is the additional value that subjects who reported selling prices placed on the water bottle relative to subjects who reported buying

prices. Column 3 reports results from a multiple regression that includes both treatment assignment and whether subjects won the prize, and Column 4 adds session fixed effects.

Table 3: Determinants of Valuation for the Water Bottle

	(1)	(2)	(3)	(4)
Treatment H	1.82	-	0.21	0.24
	(1.10)	-	(1.19)	(1.32)
Won prize	-	3.08***	3.00***	3.22***
	-	(0.93)	(1.07)	(1.12)
Constant	4.57***	4.16***	4.07***	3.92***
	(0.93)	(0.69)	(0.90)	(0.98)
Session Controls	No	No	No	Yes
Observations	65	65	65	65
Adjusted R^2	0.03	0.14	0.12	0.06

Notes. Dependent variable is reported valuation: WTA for sellers, WTP for buyers. ***$p < 0.01$. Standard errors in parentheses.

Positive and statistically significant estimates for the coefficient on "Treatment H" would provide support for the idea that lagged beliefs affect valuation. None of the regression specifications in Table 3 report significant estimates of the coefficient on Treatment H. In contrast, in each specification that includes "Won prize" as a predictor, the reported coefficient is both statistically and economically significant. Sellers demand approximately $3 more than buyers in the BDM mechanism. This difference is consistent with both KR's model, with most other models of reference-dependent preferences, and with much of the literature on the endowment effect and WTA-WTP gap.

Columns 3 and 4 provide a comparison of the effect size of lagged beliefs versus current endowment. In these models, the coefficient estimate for "Treatment H" is less than 10% the magnitude of the coefficient for "Won Prize," a ratio much smaller than predicted when applying KR's model to the experiment under reasonable assumptions about parameter values. A comparison of the coefficient estimates for "Won Prize" with the values for the constant in these regressions shows that possession of the water bottle results in an endowment effect on the order of 65 and 85%. The conclusion from these analyses is that in this design lagged beliefs do not have a significant effect upon valuation. Log-transforming the dependent variable, as in Ericson and Fuster (2011), does not result in noteworthy changes in the results.

5 Discussion and Conclusion

It is not surprising that an endowment effect was observed in the experiment. An endowment effect is predicted by KR's model and by many other reference dependent models. The endowment effect would be expected if the stage 1 lottery was eliminated from the design.

Why then, was no attachment effect observed in the experimental data, as predicted by expectation-based reference dependence?

One explanation that is consistent with KR's model is that DMs may require more time to incorporate a lottery into their reference point than was provided in the experiment. Strahilevitz and Loewenstein (1998) varied the time of endowment with various (deterministic) prizes and showed that increased time of ownership led to a larger endowment effect. It is possible that the attachment effect works in a similar way.

Alternatively, it may be that DMs update their reference points very quickly, and that as soon as subjects in the experiment were awarded prizes, they updated their reference points to reflect their current endowments. For deterministic events, it is well known that DMs do update their reference points almost immediately. Kahneman et al. (1990) refer to the "instant endowment effect" where endowment with an item immediately changes the reference point. Instant reference point updating together with the endowment effect is consistent with status quo bias models such as Masatlioglu and Ok (2005), and with a literature showing that physical proximity to or possession of an item, rather than ownership, is the driving force behind the endowment effect (Reb and Connolly 2007, Wolf et al. 2008, Bushong et al. 2010). The results suggest that reference point updating in this experiment is fast enough to obscure any influence of lagged beliefs when uncertainty is resolved and when decision-makers have limited ability to make choices that influence the reference point. However, in KR's framework, if real-world updating is very fast, consumers who have beliefs about prices are unlikely to exhibit loss aversion, since they will update their beliefs to the deterministic price once it is observed, and in KR's model loss aversion does not play a role in deterministic choice.

Plott and Zeiler (2005) suggest that the WTP-WTA gap is not due to loss aversion but rather to misunderstanding of the experiment instructions. KR argue that one interpretation of the Plott & Zeiler results is that in their experiments they have successfully decoupled exxpectations from ownership status. In either case, the principal measure of interest in this experiment was the differences between WTP in Treatments L and H. Presumably any distortion of values would be the same in each treatment, since treatment assignment was random. Thus the main issue with using the BDM mechanism in the design is that variation in elicited values resulting from subject misunderstanding might obscure the attachment effect.[14]

A potentially important difference between the experiments of Ericson and Fuster (2011) and Heffetz et al. (2014) and the one described in this paper is that these studies rely upon the strategy method: that is, they elicit behavior that is conditional upon an as-yet unrealized event. Both Ericson and Fuster (2011) and Heffetz et al. (2014) endow participants with a lottery, then ask how they will behave conditional upon the lottery realization unlike in this paper where the lottery is realized before valuations are elicited.[15] That both of these experiments employ the strategy method and come to different conclusions suggests that this aspect of the design is not driving the results.

Novemsky and Kahneman (2005) claim that the important contribution of KR is that

[14]See also Isoni et al. (2011) and Plott and Zeiler (2011) for an extended discussion of the results in Plott and Zeiler (2005).

[15]See Brandts and Charness (2011) for a review of experiments that compare conditional choices elicited using the strategy method with direct responses that are made after outcomes are realized.

intentions matter in the determination of the reference point.[16] For intentions to matter, a DM must make plans that are contingent upon the choice sets in the support of his beliefs. In both the example given at the beginning of section 2, and in the experiment, the reference point is purely dependent on beliefs about outcomes, and in neither case is there an opportunity for intentions to influence the reference point. When the reference point is endogenously determined (as in the labor supply experiments of Abeler et al. (2011) and Gill and Prowse (2012)), rather than exogenously imposed as in this experiment, expectations appear to have a stronger influence on choice.[17]

Modeling the reference point as a function of beliefs is an intuitive and appealing way to formalize reference-dependent preferences using mathematical objects familiar to economists and decision theorists, namely, probability distributions over consumption outcomes. This paper describes an experiment that studies whether lagged probabilistic beliefs influence valuation for a simple commodity in a design that is motivated by Kőszegi and Rabin (2006). The results do not support the idea that lagged beliefs, in the absence of other factors, have a significant effect on valuation. In contrast with laboratory work studying deterministic reference points in the context of the endowment effect, the conditions under which stochastic reference effects may be robustly observed in the laboratory have yet to be identified. Furthermore, the mechanism by which expectations - lagged or current - are incorporated into the reference point is still not well understood. The evidence suggests that additional psychological factors such as possession or proximity and goals may also play a role in driving reference points and choice. KR say that "psychological and economic judgment" is needed in applying their model. One way to develop this judgment is to conduct more experiments.

[16] In addition, Heath et al. (1999) propose that goals serve as reference points, emphasizing the role of "psychological salience" (p. 106) over expectations in reference point formation.

[17] However, see the experiments of Gneezy et al. (2017) who document behavior inconsistent with expectations-based reference points in a modified version of Abeler et al. (2011).

A Supplementary materials

The supplementary materials include the experiment instructions and record sheets.

Instructions

Thank you for participating in this session. The purpose of this experiment is to study consumer behavior.

Please do not speak to other participants during the session. In addition, please refrain from reacting verbally to events that occur during the experiment.

You have been assigned:

1. Instructions
2. Marbles

These items will be used in the experiment. The record sheet and instructions are your private information. Do not share them with anyone.

The experiment will have two parts. The first part of the experiment is a drawing for a 32-ounce bottle, produced by Nalgene, which is similar to those sold in the university bookstore. The second part of the experiment is a decision task. You will receive instructions for the second part after the drawing.

Please turn to the page titled "Drawing Instructions"

Drawing Instructions

Take a look at the marbles you have been given. Count the number of white and blue marbles.

Record the number of white marbles here: _____

Record the number of blue marbles here: _____

The experimenter will walk around with an empty container and ask you to place the marbles you have been assigned in the container. Then you will draw a marble. **If you draw a blue marble you win the Nalgene bottle.**

Results

Did you win the item?
___ Yes ___ No

After you have drawn, please wait for the next part of the experiment.

Buyer Information

You will now have the opportunity to buy the Nalgene bottle by paying money for it.

First, please indicate on the attached sheet the prices at which you would buy the item, if it were for sale at that price.

If you indicate that you would buy at a given price, you must also indicate that you would buy at lower prices. So, please check all prices less than or equal to the highest price at which you would buy the item.

When you are done the experimenters will collect the sheets.

Next, the experimenters will randomly draw a price from those listed on the record sheet. The price will be drawn from a bingo cage containing one ball for each of the prices on the list.

Finally, if you have indicated that you would buy at the price that is drawn from the bingo cage, then you buy the item at that price.

Because the price is randomly chosen, neither you nor the experimenters can have an effect on the price.

Please indicate your choices in the table on the next page.

Seller Information

You now own a Nalgene bottle. You have the opportunity to sell the item for cash compensation.

First, please indicate on the attached sheet the prices at which you would sell the item.

If you indicate that you would sell at a given price, you must also indicate that you would sell at higher prices. So, please check all prices greater than or equal to the lowest price at which you sell buy the item.

When you are done the experimenters will collect the sheets.

Next, the experimenters will randomly draw a price from those listed on the record sheet. The price will be drawn from a bingo cage containing one ball for each of the prices on the list.

Finally, if you have indicated that you would sell at the price that is drawn from the bingo cage, then you sell the item at that price.

Because the price is randomly chosen, neither you nor the experimenters can have an effect on the price.

Please indicate your choices in the table on the next page.

Spoken Instructions:

To read aloud after handing out data sheet and before drawing price:

"After the price is drawn from the bingo cage we will examine your record sheet. If one of the prices you have checked matches the price drawn from the bingo cage, then you trade at the price that is drawn from the bingo cage. If none of the prices you have checked matches the price drawn from the bingo cage, then you do not trade."

"Are there any questions about the procedure?"

Buyer Record Sheet

Please indicate if you are willing to buy the Nalgene bottle at a price by checking the box next to the price.

		I will buy			I will buy
If the price is	$0.00	☐	If the price is	$10.80	☐
If the price is	$0.30	☐	If the price is	$11.10	☐
If the price is	$0.60	☐	If the price is	$11.40	☐
If the price is	$0.90	☐	If the price is	$11.70	☐
If the price is	$1.20	☐	If the price is	$12.00	☐
If the price is	$1.50	☐	If the price is	$12.30	☐
If the price is	$1.80	☐	If the price is	$12.60	☐
If the price is	$2.10	☐	If the price is	$12.90	☐
If the price is	$2.40	☐	If the price is	$13.20	☐
If the price is	$2.70	☐	If the price is	$13.50	☐
If the price is	$3.00	☐	If the price is	$13.80	☐
If the price is	$3.30	☐	If the price is	$14.10	☐
If the price is	$3.60	☐	If the price is	$14.40	☐
If the price is	$3.90	☐	If the price is	$14.70	☐
If the price is	$4.20	☐	If the price is	$15.00	☐
If the price is	$4.50	☐	If the price is	$15.30	☐
If the price is	$4.80	☐	If the price is	$15.60	☐
If the price is	$5.10	☐	If the price is	$15.90	☐
If the price is	$5.40	☐	If the price is	$16.20	☐
If the price is	$5.70	☐	If the price is	$16.50	☐
If the price is	$6.00	☐	If the price is	$16.80	☐
If the price is	$6.30	☐	If the price is	$17.10	☐
If the price is	$6.60	☐	If the price is	$17.40	☐
If the price is	$6.90	☐	If the price is	$17.70	☐
If the price is	$7.20	☐	If the price is	$18.00	☐
If the price is	$7.50	☐	If the price is	$18.30	☐
If the price is	$7.80	☐	If the price is	$18.60	☐
If the price is	$8.10	☐	If the price is	$18.90	☐
If the price is	$8.40	☐	If the price is	$19.20	☐
If the price is	$8.70	☐	If the price is	$19.50	☐
If the price is	$9.00	☐	If the price is	$19.80	☐
If the price is	$9.30	☐	If the price is	$20.10	☐
If the price is	$9.60	☐	If the price is	$20.40	☐
If the price is	$9.90	☐	If the price is	$20.70	☐
If the price is	$10.20	☐	If the price is	$21.00	☐
If the price is	$10.50	☐			

Seller Record Sheet

Please indicate if you are willing to sell the Nalgene bottle at a price by checking the box next to the price.

		I will sell			I will sell
If the price is	$0.00	☐	If the price is	$10.80	☐
If the price is	$0.30	☐	If the price is	$11.10	☐
If the price is	$0.60	☐	If the price is	$11.40	☐
If the price is	$0.90	☐	If the price is	$11.70	☐
If the price is	$1.20	☐	If the price is	$12.00	☐
If the price is	$1.50	☐	If the price is	$12.30	☐
If the price is	$1.80	☐	If the price is	$12.60	☐
If the price is	$2.10	☐	If the price is	$12.90	☐
If the price is	$2.40	☐	If the price is	$13.20	☐
If the price is	$2.70	☐	If the price is	$13.50	☐
If the price is	$3.00	☐	If the price is	$13.80	☐
If the price is	$3.30	☐	If the price is	$14.10	☐
If the price is	$3.60	☐	If the price is	$14.40	☐
If the price is	$3.90	☐	If the price is	$14.70	☐
If the price is	$4.20	☐	If the price is	$15.00	☐
If the price is	$4.50	☐	If the price is	$15.30	☐
If the price is	$4.80	☐	If the price is	$15.60	☐
If the price is	$5.10	☐	If the price is	$15.90	☐
If the price is	$5.40	☐	If the price is	$16.20	☐
If the price is	$5.70	☐	If the price is	$16.50	☐
If the price is	$6.00	☐	If the price is	$16.80	☐
If the price is	$6.30	☐	If the price is	$17.10	☐
If the price is	$6.60	☐	If the price is	$17.40	☐
If the price is	$6.90	☐	If the price is	$17.70	☐
If the price is	$7.20	☐	If the price is	$18.00	☐
If the price is	$7.50	☐	If the price is	$18.30	☐
If the price is	$7.80	☐	If the price is	$18.60	☐
If the price is	$8.10	☐	If the price is	$18.90	☐
If the price is	$8.40	☐	If the price is	$19.20	☐
If the price is	$8.70	☐	If the price is	$19.50	☐
If the price is	$9.00	☐	If the price is	$19.80	☐
If the price is	$9.30	☐	If the price is	$20.10	☐
If the price is	$9.60	☐	If the price is	$20.40	☐
If the price is	$9.90	☐	If the price is	$20.70	☐
If the price is	$10.20	☐	If the price is	$21.00	☐
If the price is	$10.50	☐			

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