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Is there a valuation gap? The case of interval valuations

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Abstract

We extend the literature on the willingness-to-pay/willingness-to-accept (WTP/WTA) disparity by testing two hypotheses, distilled from the literature. We also introduce a modified mechanism for eliciting the subjective valuation range if the individual cannot articulate the subjective value as a precise amount confidently. We elicited valuations for four goods: three ordinary market goods and a lottery ticket. Under the conventional setting in which subjects are asked to state a single precise amount, we observed a significant disparity for the lottery ticket. On the other hand, our key finding is that the disparity disappears under the intervals treatment, suggesting that response format is important, given that earlier experimental studies invariably uses point values (i.e. open ended questions about WTP/WTA). Moreover, for the risky prospect we observe that from their admissible range the buyers state the lower bound as their WTP whereas sellers state the upper bound as their WTA. We conclude that this type of behavior can to some extent explain the observed disparity at least for the risky prospects.

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1. Introduction

The "valuation gap" refers to the empirically found disparity between WTP and WTA. It remains one of the most prominent anomalies in standard economic theory, because we expect that WTP and WTA should be similar if the goods in question have close substitutes and if the income effects are small (Hanemann, 1991). The gap was first documented by mathematical psychologists Coombs et al. (1967) and by Hammack and Brown (1974) in an early contingent valuation study. Knetsch and Sinden (1984) brought the issue into the laboratory using real monetary incentives and found a significant difference between WTP and WTA. Since then, the disparity has been found in an array of studies, including contingent valuation surveys and in field and laboratory experiments for a wide range of goods: e.g. mugs, pens, movie tickets, hunting permits, nuclear waste repositories, foul-tasting liquids, and pathogen-contaminated sandwiches (Horowitz and McConnell, 2002).

The gap has many implications for the application of economic theory, but also for theory proper. For example, if a cost-benefit analysis is conducted on a proposed policy that generates both winners and losers, estimated net benefits will then depend on whether WTA or WTP was used in the assessment. At a more fundamental level, the gap raises questions about the power of standard preference models to explain economic behavior (Braga and Starmer, 2005).

Explanations of what may drive the disparity include the endowment effect which suggests that preferences are reference dependent and losses loom larger than gains. Thus sellers perceive giving away the good as a loss and ask for more as a compensation for their loss (Thaler, 1980). Theorists have also developed alternative models of economic behavior that address the disparity and several other anomalies[1].

Yet, emerging evidence suggests that, under certain types of procedures and settings, the WTP-WTA disparity is smaller than previously observed. Shogren et al. (1994) find that the size of the gap depends on the type of good that is used in the experiments (e.g., mugs, candies, lottery tickets, and tokens). Other researchers find that the disparity declines with trading experience (List 2003; List 2004; Shogren et al. 2001; Loomes et al., 2003). Sayman and Onculer (2005) conducted a meta-analysis of 39 studies and found that studies that employ iterative bidding exhibit smaller disparities. These findings suggest that experimental design features are critically important. Indeed, in the most recent meta-study, Tuncel and Hammit (2014) find that studies that were published after the first meta-study (Horowitz and McConnell (2002)), exhibit lower WTP-WTA ratios and interpret this as the improvements in study design characteristics. This begs the question of what an "improvement" entails. We suggest two criteria that can be used to assess an experiment:

i. the experimental instructions and procedures should be clear to the subject,
ii. the response format should be close to the "natural way" that people think about their valuations.

The first item has been covered by Plott and Zeiler (2005), who conducted experiments to control for subject misconceptions about the experimental mechanisms, such as the Becker–DeGroot–Marschak mechanism (BDM). Their design employs numerical examples, paid and

[1] Briefly, Prospect Theory (Kahneman and Tversky 1979), Cumulative Prospect Theory (Tversky and Kahneman, 1992), Third Generation Prospect Theory (Schmidt et al., 2008), Rank Dependent Utility Theory (Quiggin, 1982), and Regret Theory (Bell, 1982; Loomes and Sugden, 1982).

unpaid training rounds, anonymity of the subjects' identities, and verbal explanations of how to obtain the optimal response. The disparity is not observed for ordinary market goods when procedures to eliminate subjects' misunderstandings about the experimental mechanism are employed: Their result weakened the loss aversion explanation of the disparity. However, Isoni et al. (2011) pointed out that the disparity persists when using lottery tickets, so the issue extends beyond subject misconceptions.

Our second criterion has not yet been sufficiently explored in valuation gap studies in an experimental setting. In the contingent valuation literature, a substantial number of papers have been published on the subject of elicitation mechanisms. One strand of this literature compares open-ended and dichotomous choice formats (Reaves et al., 1999; Loomis et al., 1997). In the open-ended format, subjects are simply asked how much they are willing to pay, whereas in the latter, subjects are asked to accept or reject a series of pre-selected prices. More recent elicitation mechanism allows for respondent uncertainty in various ways; see Mahieu et al. (2014) for a recent survey. In short, experimental studies that find a disparity, invariably uses an open-ended valuation question. This format is not currently much used in contingent valuation, the most important reason being that the response rates are typically low.

The contingent valuation literature rather converged on finding a response format that is allegedly closer to the way that individuals think about their valuations (Brown et al., 1996). For most individuals, valuation (of the maximum/minimum buying/selling price) is not a routine task. Therefore, asking individuals for precise estimates of their subjective valuations can be cognitively challenging (Mitchell and Carson, 1989), especially for complex and unfamiliar goods (Gregory et al., 1995; Ready et al., 1995). We also know from the psychology literature that when individuals are faced with difficult tasks, they have a tendency to employ heuristics to facilitate them (Shah and Oppenheimer, 2008). For example, McCollum and Miller (1994) found that 44% of the respondents reported $0 due to their inability to provide a precise WTP even when they indicated a positive attitude towards the good.

If the same behavioral pattern is also present in experiments on disparity, then it might, for example, cause buyers to understate their subjective valuations and cause the observed disparity. A particularly useful alternative mechanism caters for imprecision, without compromising the possibility to state a precise amount. In this variation, individuals are asked to state interval valuations, in case they are unable to come up with a point[2].

In a related literature which focuses on imprecise preferences, subjects are assumed to have an admissible range of subjective valuations from which they cannot state a precise amount confidently (See Cohen et al. 1987; Butler and Loomes 1988, 2007, 2011; and Morrison). Butler and Loomes (2011) claims that preference imprecision could explain anomalies within Expected Utility Theory. For example, Butler and Loomes (2007)[3] explore imprecision as a way to understand preference reversals. They argue that many individuals' choices and valuations

[2] Some researchers in the contingent valuation related literature have suggested the use of self-selected intervals in surveys. The basic idea behind self-selected intervals dates to at least Morgan and Small (1992), who suggested them as a way of overcoming "overconfidence" in surveys and to address the anchoring problem. There is also a connection to symbolic data analysis (Billard and Diday, 2007), in which intervals play an important role. Detailed statistical theory for handling this unusual kind of interval censoring has been developed by Belyaev & Kriström (2015).

[3] See Gal (2006) and Neilson (2008) for a theoretical approach to imprecision and empirical studies that can be classified similarly but that used non-incentivized elicitation methods for strength of preference (Dubourg et. al, 1994; Loomes et al., 1997).

involve a degree of uncertainty or imprecision, and their findings suggest that imprecision explains a significant portion of the preference reversal phenomenon[4].

Interval valuation as a response format is yet to be tested thoroughly in an experimental setting. Banerjee & Shogren (2014) explore the bidding behavior in second price auctions using an induced value experiment in which subjects are given point or interval values and are asked to state point or interval bids. In their *point value/interval bid* treatment, they find that even though the value of the object is given exogenously as points, most of the subjects tend to state their values in terms of intervals. It appears that subjects form these intervals in a way that the expected value of the interval equals the point value. This observation is important because it is natural to expect imprecision to be case for uncertain and/or unfamiliar goods; yet their subjects prefer to state their bids in intervals although the goods has an exogenously given point value.

As a simple remedy for the problem observed by McCollum and Miller (1994), we frame the response format as intervals of which the bounds are determined by subjects: if they cannot provide a precise estimate, they are allowed to state an interval for their WTP and WTA, and we test whether the disparity survives under this framing. If individuals are stating some amount lower than they would pay for the good merely because they cannot provide a precise amount, but the experimental design asks them to do so, framing the response format as intervals can decrease the cognitive burden and make subjects think more carefully about their valuations (*Response Format Framing Hypothesis;* RFFH). This is called *framing* here, because only the buyer's upper bound and the seller's lower bound are incentivized; the trade is determined by comparing only the incentivized bound with the randomly selected market price. Consider a buyer who states a range: the subject buys the good, if the market price is within or below the stated range. For the seller role, trade occurs if the market price is within or above the stated range. We do not observe a disparity when we use interval framing, whereas we observe a significant disparity for the lottery ticket, when we asked subjects to state single points (See Section 3 for details).

Gregory et al. (1995) found that individuals display a surprisingly large WTP range, and when they are asked to state a single amount, they are likely to state an amount closer to the middle of their range. As sellers, subjects tend state a point close to the upper bound of their admissible range. This behavioral pattern might produce the observed disparity and gives rise to a hypothesis we call the *Preference Cloud Hypothesis* (PCH). The Preference Cloud Hypothesis posits that individuals cannot intrinsically determine precise single points, but able to identify a range of values for their personal valuation of the good. If the experiment forces them to state a point, they employ a heuristic: buyers state the lower bound while sellers state the upper bound in their admissible range[5].

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[4] They asked the subjects to state their preferences in a series of binary choices in which one option (A) was held constant and the other (B) was adjusted upwards or downwards by $1, depending on the starting point. (In one treatment, they started from $1 and increased, whereas in another treatment they started from a positive payoff of the first lottery and gradually decreased.) In each binary choice problem, the subjects stated which option they chose and selected one of the following phrases that reflected the strength of their decision: definitely prefer A, prefer A but not sure, prefer B but not sure, and definitely prefer B. However, "preference strength elicitation" is not incentivized under their design.

[5] Providing a theoretical discussion of the issue is beyond the scope of this paper, see Bayrak and Hey (2015) for a recent theory which asserts that individuals end-up having a range of expected utilities due to their vague understanding of the numerical objective probabilities, and when they are asked to state a single amount as their valuation, they withdraw a single amount from the range depending on their pessimism level. The values withdrawn depends on the role that they are assigned such as buyer and seller, because they determine which bound is worst and best case in a reference dependent way. Therefore in a buying task the worst case is the lower bound of their admissible EU range whereas for a seller the upper bound is the worst case. Since the worst thing that can happen to a buyer is the good that is bought have a low utility, whereas for a seller the converse is true.

To test this hypothesis we first have to focus on the good which we observe a significant disparity under the conventional setting as our baseline, in our case it was only for the lottery ticket that we observed a gap. For comparison we use the bounds of the intervals elicited in another treatment (Buyer-Seller Uncertainty, BSint hereafter) in which subjects are allowed to state intervals, not knowing in advance whether they are buyers or sellers (the role is determined randomly after they stated their offers). Statistical tests confirm our hypothesis that WTP in baseline treatment and lower bound of the offers in the intervals treatment comes from identical distributions, whereas WTA in the baseline treatment and upper bound of the interval treatment comes from the identical distributions (See Section 3 for details).We now turn to empirical analysis and begin by explaining the experimental design.

2. Experimental Design

We conducted a between-subjects experiment with two treatments: *Points* and *Intervals* (See Table 1 for an outline of the experimental design). The only difference between the two treatments is that in the *Intervals* treatment subjects were allowed to state their valuations in terms of ranges. Subjects are allowed to state single amounts if they prefer. In *Points* only single amounts are allowed, there were the usual two groups: Buyers and Sellers denoted B_p and S_p, respectively. In *Intervals*, we use three groups: Buyers, Sellers, and *Buyer-Seller Uncertainty* (B_{int}, S_{int}, and BS_{int}, respectively).

In the *Points* treatment: subjects state their offers, and then a market price is determined randomly. If the market price equals or is below the stated offer, a buyer pays the market price and buys the good. For sellers, if the market price equals or is above the stated offer, the seller gets the amount of money equal to the market price and gives away the good. As noted, B_{int} and S_{int} groups of *Intervals* treatment is a new type of framing, because only the buyer's upper bound and the seller's lower bound are incentivized; the trade is determined by comparing the incentivized bounds with the randomly selected market price. For the buyer only the upper bound of the stated range is binding. For the seller, trade occurs if the market price is within or above the stated range. Therefore only the lower bound of the range is binding. The only difference between *Points* and *Intervals* is the response format; thus, any difference in the results is due to this feature. We compare the values elicited by B_p, S_p, B_{int}, S_{int} to test the RFFH, (WTP_p, WTA_p, WTP_{int}, WTA_{int}; respectively). If we observe a statistically significant difference between WTP_p and WTA_p but not between WTP_{int} and WTA_{int}, RFFH is supported.

Testing PCH is not straightforward; we need to compare the point offers with ranges that are elicited in an incentive compatible way. Remember that PCH claims that buyers state the lower bound, whereas sellers state the upper bound of their admissible range (this is the underlying reason for observing the disparity). We elicit the usual point offers in B_p and S_p however we cannot use the ranges elicited in B_{int} and S_{int} because only one bound of those ranges are incentivized. They are only appropriate to test RFFH which is a hypothesis focusing on the framing of the response format.

To accomplish this we developed BS_{int} which is a modified version of BDM in which both the lower and upper bounds were incentivized (See the appendix for details): At the end of the experiment, roles were determined randomly; the probability of being a buyer is ½ (likewise, the probability of being a seller is ½). If subjects overstate their valuations, there is a 50% chance of being a buyer and a risk of paying an undesirably high amount. If they understate their values, they might be a seller and would have to sell the good for an undesirably low amount.

Table 1: Summary of the Experimental Design

1.Anonymity	Assigning subjects an ID number randomly
2.Instructions	Also read aloud Numerical examples to explain optimal response Hypothetical Training Round
3.Goods	Four goods with real incentives
Good 1	Premium bitter chocolate
Good 2	Created their own package of three cans, from five different flavours of a beverage brand
Good 3	Select one of the ten different flavours of a chocolate brand
Good 4	Lottery ticket: winning 30 SEK with a probability of 0.5, zero otherwise
4.Incentives	Show-up fee of 100 SEK≈$12 One of the four goods and a market price selected randomly Only in BS_{int} group, subject role (buyer, seller) is also selected randomly after value elicitation

The roles were determined after the four tasks were completed using the following procedure: The experimenter wrote "*buyer*" and "*seller*" on two separate pieces of paper, placed them in two separate envelopes, one of them is picked from an opaque bag. In addition, the procedure was explained to the subjects in detail when the instructions were provided.

We recruited the subjects by announcement (flyers and posters) from Umeå University and the Swedish University of Agricultural Sciences (SLU)[6]. In total, 38 subjects participated in points, and 54 subjects participated in intervals, most of whom were master's degree students from various fields of study. The sessions lasted approximately 40 minutes, and the average earnings were 108 SEK[7] (including a 100 SEK show-up fee). Each subject chose an envelope marked with an ID number upon entering the room. We told the subjects to keep these ID cards and to use them to retrieve their earnings after the experiment. The instructions were read aloud, and the participants were instructed not to communicate with each other or react verbally to any events that occurred during the experiment.

In both experiments, following Plott and Zeiler (2005), certain training procedures were employed to minimize or prevent subject misconceptions, i.e., anonymity was ensured and numerical examples were used to explain the mechanism[8] together with examples to show the subjects why stating their true value is the dominant strategy. In addition, the participants were provided with an unpaid training round in which the good was a candy. As indicated in Plott and Zeiler (2005), the provision of paid practice rounds is not an essential procedure: No disparity is however found between bids submitted in the paid and unpaid practice rounds.

After the training round, the subjects were encouraged to ask questions. They wrote their questions on pieces of paper and raised their hands; the experimenter silently read the questions and answered them by writing on the same piece of paper.

[6] These two universities are very close to each other and can considered the same campus area. Umeå University has over 20,000 students, whereas SLU is a much smaller university.

[7] 1 SEK is approximately 0.15 US Dollars.

[8] The numbers that are used in the examples are completely unrelated to the possible range of prices in the experiment to avoid any anchoring effects (e.g., 1000–1020 SEK, whereas the experiment market price can be between 1 and 30 SEK). The numerical examples were part of the written instructions provided, and they were explained on a board.

The practice round was followed by four tasks (goods), and the subjects were told that these four tasks had an equal chance of being selected and the payoffs will be determined according to the randomly selected task.

In task 1, the good was a premium bitter chocolate. In task 2, the subjects were given a list of five different flavors (regular, light, zero, vanilla, and cherry) of a nonalcoholic beverage brand. They were asked to create any package of three cans; thus, they were allowed to mix and match among the five types. Then, they stated offers for their created package. The good in task 3 was similar: In that case, 10 different flavors of the same brand of chocolate were provided, and we asked the subjects to select one of the flavors.

Goods 2 and 3 are homogenous for all subjects, since prices in local shop do not vary with the flavors and these two goods can be considered as vouchers providing the right to choose a favorite flavor. We included these to contribute the literature by re-examining the disparity with a new type of goods. Also, the endowment effect might be stronger for these goods since the subjects picked their favorite flavors; thus, they might have felt more attached to these goods.

The participants were not provided with any information about market prices during the experiment. The prices of the goods in tasks 1, 2, and 3 were 19 SEK, 24 SEK, and 22 SEK, respectively, at a local shop.

Finally, the fourth good was a lottery ticket with the following prospects: winning 30 SEK with a probability of 0.5 and winning nothing with a probability of 0.5. The lottery outcome was determined by using one hundred ping-pong balls that were numbered from 1 to 100 and placed in an opaque bag. At the end of the experiment, a ball was selected from the bag. If the number on the ball was 50 or below, the lottery paid 30 SEK; otherwise zero.

After a task had been completed, the response sheets for that task were collected, and the next response sheet was handed out to prevent cheating. The subjects were given the goods and told to examine them before recording their offers. The sellers were told that they owned the good; the buyers were told that they could inspect the good but did not own it.

When all four tasks were completed, one task was chosen as "real," and the market price was drawn for that task. In all of the tasks, including the unpaid training round, the subjects were told that the market price would be randomly selected from a range of 1 to 30 SEK using the ping-pong balls. The market price was determined by picking one ball out of 30, each with a single price written on it. To avoid any bias that might result from the potential market price range, we used the 1–30 SEK range as a potential market price range for all of the tasks (see Bohm et al. (1997) for a comprehensive discussion of this issue).

At the end of the experiments, the subjects were given both a questionnaire requesting demographic information and test of their understanding of the instructions. Only the subjects who answered all quiz questions correctly were included in the analysis.

3. Results

Summary statistics are reported in Table 2. The second column indicates the percentage of subjects that preferred to state intervals. Except for the BS_{int} group for good 3, a majority preferred intervals.

Table 2: Summary Statistics

	Treatment	Mean $_L$	Mean $_U$	Median $_L$	Median $_U$	σ $_L$	σ $_U$
Good 1							
(Premium bitter chocolate)	B_{int} (71%)	17.3	20.2	18.0	22.0	6.6	5.4
	S_{int} (83%)	18.9	21.8	20.0	22.0	4.5	4.7
	BS_{int} (62%)	14.9	17.8	15.0	17.8	3.2	3.9
	B_p	14.3		15.0		6.3	
	S_p	13.5		14.0		5.1	
Good 2							
(3 cans of Coke)	B_{int} (65%)	15.0	18.4	15.0	18.0	9.4	9.5
	S_{int} (56%)	18.6	20.5	17.5	20.0	7.2	7.9
	BS_{int} (62%)	14.6	17.5	15.0	18.0	6.7	6.6
	B_p	13.9		15.0		8.0	
	S_p	19.1		18.0		6.8	
Good 3							
(Chocolate)	B_{int} (75%)	13.3	16.6	13.5	15.0	5.6	4.5
	S_{int} (50%)	19.0	20.7	17.0	20.5	6.5	5.7
	BS_{int} (46%)	14.3	16.2	15.0	16.0	5.3	5.7
	B_p	16.4		15.0		6.4	
	S_p	19.3		19.5		6.8	
Good 4							
(Lottery ticket)	B_{int} (59%)	11.8	14.5	10.0	15.0	8.7	9.3
	S_{int} (61%)	14.3	17.2	15.5	18.0	6.9	7.4
	BS_{int} (54%)	12.5	18.2	14.0	15.0	6.2	6.7
	B_p	12.5		11.0		5.6	
	S_p	20.2		20.0		7.2	

Notes: The subscripts *L* and *U* denote the *lower* and *upper* bound, respectively. σ denotes the standard deviation. The values within the squares are the incentivized ones. In the treatment column, the percentages in parentheses denote the portion of subjects stating a range of values for the specific task. Sample size for each treatment: B_{int}=17, S_{int}=18, BS_{int}=13, B_P=19, S_P=14.

Overall, statistical tests confirm both PCH and RFFH. To test the PCH, we should look at the first and second set of results (Table 3): For good 2, a ratio of 1.20 is significant with a p-value of 0.0449; the W statistic is 86.0 according to the Wilcoxon-Mann-Whitney rank sum test. For good 4, the ratio is 1.82, which is significant with a p-value of 0.0014 and a W statistic of 51.0.

Since the significance of the gap for Good 2 is on the edge (p-value=0.0449), we focus on good 4 (p-value=0.0014) and compare the point bids with the bounds that were elicited in the BS_{int}. The second set of results presents these comparisons, showing that the Wilcoxon-Mann-Whitney tests support our hypothesis: We cannot reject the hypothesis that the mean WTP in *points* and the mean lower bound of BS bids were drawn from the same distributions as the mean WTA in *points* and the upper bound of BS bids.

To examine the support for RFF, we look for the existence of the WTA-WTP disparity in *points* and its absence for *intervals*. For the *Points,* we observed a significant disparity for good 2 (p=0.0449) and good 4 (p=0.0014) (beverage and lottery ticket respectively). For the *intervals,* test results comparing the incentivized bounds ($3.S_{int}^{L}/B_{int}^{U}$) suggests that although the ratio of WTA to WTP is not exactly one, the difference in *Intervals* is not statistically significant.

Table 3: Statistical Test Results

	Ratio[a]	Wilcoxon-Mann-Whitney rank sum test (Null hypothesis: identical distributions) W	*p*-value	Conclusion (α = .05)
1. S_p / B_p				
Good 1	0.93	141.5	0.6299	Cannot reject null
Good 2	1.20	86.0	0.0449	Reject null
Good 3	1.30	97.5	0.1005	Cannot reject null
Good 4	1.82	51.0	0.0014	Reject null
2. Good 4[b]				
B_p / BS_{int}^{L}	0,79	115.5	0.7699	Cannot reject null
B_p / BS_{int}^{U}	0,73	64.0	0.0211	Reject null
S_p / BS_{int}^{L}	1,43	145.0	0.0087	Reject null
S_p / BS_{int}^{U}	1,33	111.5	0.3233	Cannot reject null
3. $S_{int}^{L} / B_{int}^{U}$				
Good 1	0.91	176.5	0.7871	Cannot reject null
Good 2	0.97	168.0	0.6959	Cannot reject null
Good 3	1.13	122.5	0.1594	Cannot reject null
Good 4	1.03	148.0	0.4407	Cannot reject null

[a] Median ratios. [b] Two sided

In order to explore the power of our statistical tests we used the method of Plott and Zeiler (2005).We test the null hypothesis of WTA=2·WTP for the results obtained in the *intervals* treatment (See Table 4). The reason for multiplication by two is the same that Plott and Zeiler (2005) suggested. In the previous literature several authors claim that WTA is twice the WTP (e.g. Dubourg et al., 1994 and Knetsch et al., 2001). A t-test assuming unequal variances led to a rejection of the null in favor of the alternative, WTA < 2·WTP for all goods (See Table 4 first two columns). A two-sample Wilcoxon-Mann-Whitney rank-sum test gives the same result (See Table 4 last two columns).

Table 4: Power of the Tests

Goods	T-test (Unequal Variances)		Wilcoxon-Mann-Whitney rank-sum test	
	T	p-value	z	p-value
1	-7.5642	0.0000	4.810	0.0000
2	-3.6934	0.0007	3.255	0.0011
3	-5.4225	0.0000	4.437	0.0000
4	-3.0386	0.0032	2.267	0.0234

4. Concluding Remarks

Allowing subjects to state their sentiments using any interval on the line (of which a point is a special case) essentially has an effect on the observability of the disparity: When we use the conventional point response format, in line with Plott and Zeiler's (2005) findings, we observe disparity for the risky prospect, but not for the ordinary market goods[9]. Moreover, when we allow subjects to state intervals i.e. framing the response format as intervals, the gap disappears for all goods we used in our experiment.

As pointed out by Plott and Zeiler (2005), experimental procedures minimizing the subject misconceptions and misunderstandings are crucial. We have added the response format; taken together, this raises doubts about interpreting the disparity as an evidence for an endowment effect. In short, the endowment effect may not be the only explanation of the disparity, when we consider the total effect of selected experimental procedures.

In contrast to our results, Morrison (1998) observed a large gap between the two ranges; lower bound of WTA being more than one and a half times the upper bound of WTP. However, he did not use any procedures to minimize the subject misconceptions. In short, our results suggests that preference imprecision should not be discarded as a potential explanation of the observed anomalies. In the instructions, Plott and Zeiler (2005) included a guideline which explains subjects how to find their optimal offers: For example for buyers they suggest them to start thinking about a low amount such as 1 SEK, and ask themselves whether they are willing to pay 1 SEK for the good or not. If the answer is no, record 1 SEK as WTP. If the answer is "YES", they are suggested to think about a higher amount such as 2 SEK, repeat the process until they reach an amount which they would not pay for the good and record that amount as WTP. This sequential process is similar to the "iterative bidding" scheme, but without an interviewer, in other words subjects interview with themselves silently. Similarly, Sayman and Onculer (2005) found that the disparity is lower in an iterative setting; the sequential process helps subjects to discover their optimal responses. Our results suggest that together with Plott and Zeiler procedures, allowing subjects to state intervals lead them think about each value more carefully like a sequential process, decrease tendency of biases and heuristics.

Consequently, many questions are left to be explored in more detail. For example, why do we observe a disparity for lottery tickets but not for ordinary market goods, when we ask for single amounts? How do individuals form admissible ranges? Why do buyers/sellers state different bounds? Thus, the area is fertile ground for development of new theory and additional testing. This could lead to an improved understanding of a long-standing controversy regarding the WTA-WTP disparity and potentially to the development of novel designs of survey instruments. Because the bulk of empirical research in e.g. social science is based on surveys, we do believe that there are good reasons to further explore the elicitation mechanisms studied in this paper.

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[9] Except "three cans of coke" for which we observe a disparity significant on the edge (p=0.0449).

APPENDIX

The treatment used for the BS_{int} group in *intervals* is a modified BDM, and we call it as *Buyer-Seller Uncertainty* mechanism, in which the lower and upper bounds were incentivized since the subjects learned whether they were buyers or sellers after stating their offers. The roles were determined after the four tasks were completed by using the following procedure: The experimenter wrote "*buyer*" and "*seller*" on two separate pieces of paper, placed them in two separate envelopes, and one of them was picked from an opaque bag. The probability of being designated as a buyer is ½ (likewise, the probability of being a seller is ½). In addition, the procedure was explained to the subjects in detail when the instructions were provided.

To analyze the incentives under this scheme, the first assumption we make is that there are three possible cases or groups of people [A1]:

i. Individuals who have a precise estimate of their WTA and WTP and they exhibit no endowment effect therefore behave according to the Standard Economic Theory: The optimal response for them is obviously to state the precise estimate as a single point and they are allowed to do so in BS. Note that for this type WTP equals WTA.

ii. Individuals who have a precise estimate of WTA and WTP but exhibit loss aversion, therefore their WTA is higher than their WTP:

$$u\left(y_0 + WTA - \lambda X\right) - u\left(y_0\right) = 0 \qquad (1)$$

$$u\left(y_0 - WTP + X\right) - u\left(y_0\right) = 0 \qquad (2)$$

where y_0 is the wealth, X is the good in question and λ lambda is the loss aversion parameter. Obviously when $\lambda > 0$, we have WTA>WTP, individual exhibits a WTA WTP disparity. So far is standard in studies which explain endowment effect (WTA-WTP disparity) with loss aversion concept. However, under BS mechanism, individual does not know whether his or her role is buyer or seller in advance (both is equally likely, determined by a random mechanism). Optimal offer $u(offer^*)$ under this setting is given by:

$$u\left(offer^*\right) = \tfrac{1}{2}u\left(WTA\right) + \tfrac{1}{2}u\left(WTP\right) \qquad (3)$$

Note that for type ii individuals, an optimal offer does not guarantee a positive payoff in all cases: Consider an individual who has a WTA of 10 and WTP of 5, thus states 7.5. Now suppose the randomly selected market price is 8 and the individual is designated as seller, randomly. Thus, trade occurs: the individual sells the good for 8 which is lower than 10 (WTA). However stating the mid-point is still optimal: optimal does not mean that the payoff will be positive in all states of the world; it means it is the best strategy among the possible ones. If the subject stated a bid equal to 10 which is the WTA, then there is a ½ probability that the subject would be a buyer: Subject would buy the good for 8, although WTP is 5, thus ending up having a loss of 3. Stating an interval is not optimal for this group, because in the buyer role the trade occurs if the market price is inside or below the stated range and in the seller role the trade occurs if the market price is inside or above the stated range. Obviously, the bounds which are valid for payoff determination is lower bound for selling and upper bound for buying. This rule ensures that the subject cannot state a selling price higher than the buying price, the best he or she can do is to minimize the expected loss and state the weighted average of his or her WTA and WTP, where the weights are probability of being a buyer and seller (in our case 1/2 for each).

iii. Now consider the case in which individual cannot come up with a precise estimate of his or her subjective value but a range from which cannot confidently state a single amount. For this case, we make another assumption [A2] that individuals with imprecise preferences have "equivalence intervals" rather than having precise points of indifference between alternatives (MacCrimmon and Smith, 1986). This suggests that individuals assign interval values to the goods instead of precise points and individual is indifferent between the good and the values inside this range. For example consider an individual comes up with a range of values between 5 and 10 dollars but cannot state one of them confidently. This implies that individual is indifferent between \$5 and the good, \$6 and the good, and so on. For a theoretical discussion of the issue see Luce (1956) which discusses the notion of *just noticeable difference* and *semiordering*. To understand the intuition, suppose you are given several cups of tea which have different amount of sugar in it, and the difference between the cups are very small amounts such as 1 mg. You start tasting the cups of tea starting from the one which has the lowest amount of sugar to the highest one. You might not be able to distinguish the difference between them, therefore not be able to state your preference between cups, confidently. However, you would be able to state your preference between two cups confidently if the difference was large enough, which is called the *just noticeable difference*.

We develop a much simpler understanding of the imprecision range to demonstrate the incentives under *Buyer-Seller Uncertainty* mechanism. Denote the equivalence interval as $[L,H]$, where $L \le H$ corresponds to the lower bound and upper bound of the range, respectively. For any good X, an individual stating $[L,H]$ as his or her subjective valuation for the good implies:

$$X \sim L \sim \ldots \sim H \tag{4}$$

Which means that, individual is indifferent between the good and the sure amount of monetary amounts between L and H.

Denote the surplus from the trade as $S(X,p) = u^{-1}(X) - p$ for buying task, and $S(X,p) = p - u^{-1}(X)$ for the selling task, where $p \in [a,c]$ is the randomly determined market price. For our experiment, a is 0 SEK and c is 30 SEK. Thus, the expected surpluses for buyer and seller role are[10]:

$$E[S(p,X)] = \int_0^b \left(u^{-1}(X) - p\right) f(p) \partial p \tag{5}$$

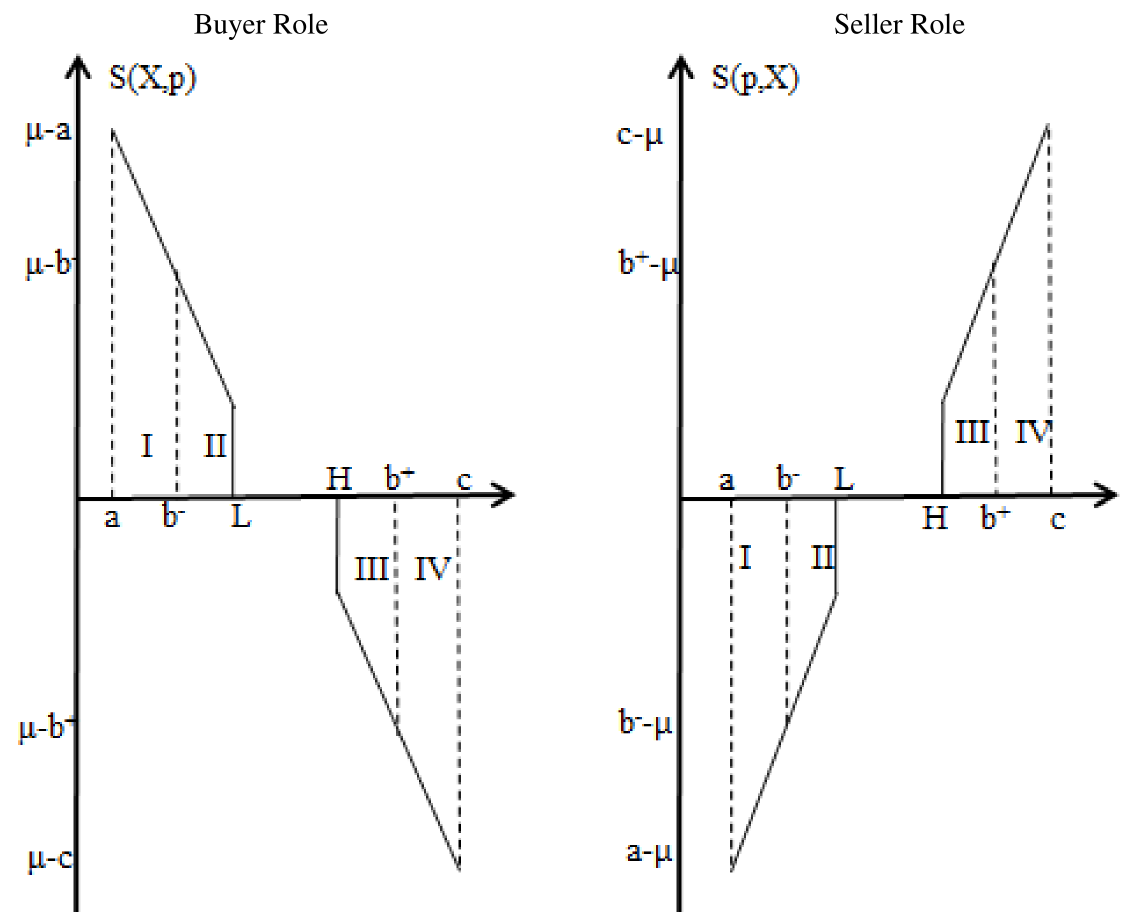
$$E[S(X,p)] = \int_0^b \left(p - u^{-1}(X)\right) f(p) \partial p \tag{6}$$

where b is the stated bid of the individual and $f(p)$ denote density function of the market price. Note that in our experiment we employed uniform distribution, and market price can be

[10] The similar approach of analyzing the incentive compatibility of a mechanism can be found in Kaas and Ruprecht (2006). They analyzed BDM and Vickrey auction and we adapted their approach to *Buyer-Seller Uncertainty* mechanism.

any value from the range of [0 SEK, 30 SEK]. Figure A1 shows the surplus for each market price, separately in the case of buyer and seller roles. When the market price equals the values in the equivalence interval, surplus is 0, which follows from A2. To calculate the surplus outside the imprecision range, we need to make further assumption [A3]: we assume that individual takes the mean of the range as the benchmark for the good X, denoted by μ. This may seem problematic when we look at the issue from the standard view of "well behaved" preferences; however one should note that we are in the realm of preference imprecision which indeed implies that preferences are not "well-behaved" objects[11].

Figure A1: Trade Surplus for individuals with imprecise preferences



In Figure A1, left panel shows the surplus of buyer and the right panel shows the surplus of seller. Note that in *Buyer-Seller Uncertainty* mechanism, both roles have equal likelihood. After stating the bids, if the individual is assigned to the role of being buyer the payoffs are calculated according to left panel; whereas if the selected role is being seller the right panel is applicable. Remember that individual is allowed to state either as a point or interval, if individual stated a

[11] Note that the theoretical aspect of the issue is not central to our study, but one way to connect the nonstandard terminology with the imprecise preferences or equivalence intervals can be the following: Denote the *just noticeable difference* as $\eta = L - \mu = h - \mu$, therefore, if we see μ as the true subjective value, the equivalence interval is constructed around it by adding and subtracting η.

point and assigned to be a buyer; transaction takes place when the bid is higher than the randomly market price. This part is identical to the standard BDM mechanism. On the other hand if individual stated an interval, he or she buys the good when the randomly selected market price is inside or below the stated range. For the seller role, if individual states a point, selling transaction occurs when the market price is higher than the bid. Finally, if individual states a range, he or she sells the good when the market price is inside or above the stated range.

[L,H] is the privately known true interval, we see that it is weakly dominant strategy for individual to state either the true range, [L,H], or any single point from this interval. The expected surplus will be the areas I and II if the assigned role is being buyer, and III and IV if the role is being seller. Since we employed uniform distribution, we can suppress the probability part for simplicity.

Stating narrower intervals or points from the true range: However, if an individual with imprecise preferences, states a point from the true range or a narrower interval but keeping it inside the true range, still obtains I and II as surplus in the case of buying and III and IV in selling but he or she decreases the chances to buy or sell the good at a desirable price. Suppose the individual has a true range of 5 and 10 dollars but he or she overstates the lower bound such as a range between 7 and 10 dollars; if the individual is randomly assigned as being a seller at the end of the experiment, the individual loses the chance to sell the good for prices between 5 and 7 dollars. Now consider the case of understating the upper bound: Suppose the individual states a range between 5 and 8 dollars; if the individual is assigned as a buyer at the end of the experiment and the market price is between 8 and 10 dollars, individual misses the chance to buy the good for these prices which are inside the individual's acceptable range.

Misstatement outside the true range: If individual understates the true value either as a range or point such as b^-, the surplus shrinks to area I for the buyer role and for the seller role it becomes III+IV-II which is lower than III+IV. If individual overstates such as b^+, the surplus from buying is I+II-III which is lower than I+II and the selling surplus shrinks to III from III+IV.

To summarize, individuals belong to either group i or ii, prefer to state precise points. Additionally some of the subjects who have imprecise preferences (group iii) might also prefer to state points. Because of this we conduct the test of PCH by eliminating the point responses too, but the results still confirm PCH. Looking at the analysis above, subjects who stated an interval definitely belongs to group iii, thus having imprecise preferences. Looking at table 2, the ratios in parenthesis in second column, we can say that more than half of the subjects have imprecise preferences except for good 3 for which the ratio is 46%. Considering the possibility of some subjects stating a point from their range although they have imprecise preferences, we can speculate that the ratio of subjects having preference imprecision can be even higher than the observed ratios.

Existing studies rely on the subject's self-reporting which is certainly not incentivized. Typically subjects are asked to fill a response table as in Table A1, where the first column includes sure amounts increasing incrementally. For each amount subject states his or her preference by choosing one of the three phrases which are in the remaining columns.

Table A1: Example Response Table

Certain Amounts	I definitely prefer the good	Not sure	I definitely prefer the certain amount
0	✓		
1	✓		
2	✓		
3		✓	
4		✓	
5			✓
6			✓

As an example, in Table A1, we see that for sure amounts equal and below 2, good is definitely preferred over the sure amounts for an imaginary individual. However, for the sure amounts, 3 and 4, the individual exhibits imprecision by stating "not sure" about his or her preferences. Finally, for the sure amounts 5 and 6, the individual definitely prefers the certain amount. Looking at this example response table, we say that the imprecision range corresponds to the value between 3 and 4. After the subject fills the response tables, usually a random mechanism draws a single amount from the imprecision range to determine the payoffs. Another procedure that can be used under this scheme is to let the subject determine the single amount chosen from the imprecision range. However, the disadvantage of this method is that subjects do not have a monetary incentive to reveal the true bounds of their imprecision range, if it exists. The reason is that the payoffs are determined by looking at a single amount either chosen randomly or by the subject from the imprecision range, and the information about the bounds of the imprecision range relies on the subjects' self-reporting.

We do not claim that *Buyer-Seller Uncertainty* mechanism is the perfect method for eliciting the imprecision range, but considering the hypothetical nature of the existing methods reviewed before, *Buyer-Seller Uncertainty* mechanism is superior in terms of incentive compatibility. We hope it finds the fruitful applications in the literature will be developed more in the future studies.

The following numerical examples are provided to help the reader to understand the incentives under this mechanism intuitively:

a. Overstating the lower bound: Suppose the individual states a range between 7 and 10 dollars; if the individual is randomly assigned as being a seller at the end of the experiment, the individual loses the chance to sell the good for prices between 5 and 7 dollars and remember that these are inside the true subjective valuation range (5-10 dollars).

b. Understating the lower bound: Suppose the individual states a range between 3 and 10 dollars. If the individual is randomly assigned as being a seller at the end of the experiment and the market price is randomly determined as some amount between 3 and 5 dollars, then the individual sells the good for an undesirably low price. Note that the true range is between 5 and 10 dollars.

c. Overstating the upper bound: Suppose the individual states a range between 5 and 12 dollars; if the individual is assigned as a buyer at the end of the experiment and the market price is between 10 and 12 dollars, individual has to buy the good for an undesirably high price.

d. Understating the upper bound: Suppose the individual states a range between 5 and 8 dollars; if the individual is assigned as a buyer at the end of the experiment and the market price is between 8 and 10 dollars, individual misses the chance to buy the good for these prices which are inside the individual’s acceptable range.

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