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A novel experimental test of truthful bidding in second-price auctions with real objects[☆]

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We present experimental evidence on bidding in second-price auctions with real objects. Our novel design, combining a second-price auction with an individual-specific binary-choice task based on the outcome of the auction, allows us to directly identify over- and under-bidding. We analyze bidding in real-object and induced-value auctions, and find significant deviations from truthful bidding in both. Overall, under-bidding is somewhat more prevalent than over-bidding; yet, the latter has a bigger magnitude, especially with induced values. At the individual level, however, we find that participants who over-bid in induced-value auctions are equally likely to over- or under-bid in real-object ones; moreover, there is no association in the size of the deviations from truthful bidding across the two types of auctions. Hence, we conclude that there is no relation between the tendency to deviate from truthful bidding in induced-value vs. real-object auctions.

1. Introduction

From a purely theoretical point of view, the second-price sealed-bid or "Vickrey" auction (Vickrey, 1961) is probably the most famous and easily comprehended auction format. Indeed, it is well-known that in standard private-value models with fully rational bidders, bidding one's own value is a (weakly) dominant strategy. This theoretical prediction holds irrespective of the number of bidders, their risk attitudes, the shape of their values' distribution or whether the values are correlated. Moreover, this prediction continues to hold also under non-standard (risk) preferences such as regret aversion (Filiz-Ozbay & Ozbay, 2007) or ambiguity aversion (Chen et al., 2007), and even under some departures from full rationality; e.g., "level-k" (Crawford & Iriberri, 2007) and "taste projection" (Gagnon-Bartsch et al., 2021).

To actual bidders, however, the rules of the second-price auction might appear counterintuitive, especially in comparison to the more popular first-price auction, where the winner pays a price equal to her bid. Indeed, several experimental studies on second-price auctions have found that participants tend to deviate from the dominant, "truthful" strategy of bidding their values, with over-bidding being somewhat more common than under-bidding (Cooper & Fang, 2008; Flynn et al., 2016; Garratt et al., 2012; Georganas et al., 2017; Harstad, 2000; Kagel et al., 1987; Kagel & Levin, 1993; Rosato & Tymula, 2019).[1] Most of these studies use induced-value auctions where the "goods" being bid on are basically monetary prizes (typically in the form of vouchers redeemable for a specified amount). In this setting, identifying over-/under-bidding is rather simple, as one can just compare the participants' bids with these induced valuations.

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[1] By contrast, experimental evidence from the strategically equivalent ascending English auction shows almost immediate convergence to the dominant strategy; see Harstad (2000). This discrepancy can be rationalized by Li (2017)'s notion of "obvious strategy-proofness". Moreover, differently from the second-price auction, the ascending auction is also a credible mechanism (Akbarpour & Li, 2020).

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In most real-world auctions, however, the prizes are real objects; e.g., consumer goods. While the nature of the prize does not affect the theoretical predictions, identifying over-/under-bidding is less straightforward in real-object auctions, as there are no "objective values" against which to compare bids. Moreover, if the prize is unfamiliar (e.g., a fossil) and bidders are asymmetrically informed, their values can reasonably depend on the information contained in others' bids (List & Shogren, 1999; Rutström, 1998). Furthermore, experimental evidence from Knetsch et al. (2001) and Lusk et al. (2004) suggests that with home-grown values, the endowment effect might complicate the imputation of values from bids in Vickrey auctions. Similarly, Lange and Ratan (2010) show that if bidders are expectations-based loss averse à la Kőszegi and Rabin (2006, 2007), bidding one's own value is no longer a dominant strategy.[2] Other factors that can sway participants away from truthful bidding include mental accounting, framing and reference-price effects, or limited cognitive ability; see Thaler (1985, 1999), Weaver and Frederick (2012) and Lee et al. (2020).[3]

In this paper, we present and test a novel experimental design for identifying deviations from truthful bidding in private-value second-price auctions for real objects. Our design combines a standard second-price auction with a binary-choice task. The key innovation is that the binary-choice task is derived from the auction outcome and is specific to each participant. This enables us to define over-/under-bidding by comparing participants' bids in the auction with their valuations inferred from the binary-choice task.[4]

Consider two bidders competing in a second-price sealed-bid auction for an indivisible item. For $i \in \{1, 2\}$, let v_i and b_i denote bidder i's (private) value and bid, respectively. Bidder i wins the auction if $b_i \geq b_j$, with $j \neq i$ (assume ties are broken randomly), in which case her payoff is $v_i - b_j$; otherwise, the bidder loses the auction, attaining a payoff of 0. The well-known dominant strategy in this auction is to bid $b_i = v_i$. Hence, when following the dominant strategy, i's payoff equals

$$\Delta_i = \begin{cases} b_i - b_j & \text{if } b_i \geq b_j \\ 0 & \text{if } b_i < b_j. \end{cases}$$

Therefore, bidder i should be indifferent between winning the auction and obtaining the item at price b_j, or receiving a monetary payment equal to Δ_i. Moreover, bidder i should strictly prefer the payment if it exceeds Δ_i (and vice versa).

Leveraging this simple yet powerful intuition, our experiment links participants' decisions across two tasks. The first task is a two-bidder second-price auction for a mug. After the auction, without revealing its outcome, participants' bids are used to construct individual-specific lists of binary-choice scenarios for the second task. In this second task, participants make a series of binary choices between buying the same mug at a fixed price p_i or receiving various monetary amounts. The fixed price is chosen such that by electing to buy the mug, a participant would (unknowingly) obtain the same surplus that s/he would obtain in the auction; i.e., $p_i = b_j$ if $b_i > b_j$ and $p_i = b_i$ otherwise. The monetary amounts are chosen from an interval centered on Δ_i.[5] By analyzing participants' switching behavior in the binary-choice task, we can identify whether they over-/under-bid in the auction. For instance, if a participant prefers buying the mug at price p_i over receiving a monetary amount larger than Δ_i, it must be that $v_i > b_i$. On the other hand, if a participant prefers a monetary amount smaller than Δ_i over buying the mug at price p_i, it means that $v_i < b_i$. Furthermore, if participants never (resp. always) choose to buy the mug at price p_i, it suggests that they significantly over-bid (resp. under-bid) in the auction.

Our experimental results show that participants deviate from truthful bidding in real-objects auctions; in particular, 50% of our participants under-bid (by −\$2.21 on average), 37% of them over-bid (by \$2.34 on average), and only 13% bid truthfully.

In addition to the second-price auction and the binary-choice task for a mug, participants in our experiment also bid in a second-price auction with induced values; this allows us to compare the fraction of truthful bidders across the two auctions, and to investigate whether the deviations from truthful bidding have similar sign and magnitude. Though the fraction of truthful bidders in the induced-value auctions is significantly higher (40% vs. 13%), here too we found significant deviations between bids and values; and, perhaps more important, there does not seem to be a meaningful relationship between the deviations across the two types of auction. For instance, subjects who over-bid in the induced-value auctions are equally like to be over- or under-bidders in the auction for the mug; similarly, only a few of the participants who bid truthfully in the induced-value auction did so also in the real-object one. Moreover, the magnitude of the deviations are uncorrelated across the two auctions. These findings suggest that bidders might use different bidding strategies (or heuristics) in induced-value auctions compared to auctions for real goods.

We are not the first to use real goods in experimental auctions, nor the first to compare bids in the Vickrey auction to other methods for eliciting values from experimental participants; see, for instance, Knetsch et al. (2001), List and Shogren (1999), Lusk et al. (2004), Noussair et al. (2004), Rutström (1998) and Frederick (2012). However, our paper differs from these previous contributions in two respects. First, prior studies have compared participants' bids in a Vickrey auction with their bids in an English auction or a BDM. Our paper instead compares the Vickrey auction with a binary-choice task.[6] We chose the binary-choice task over the English auction and BDM because we think the former is cognitively less demanding for participants as the price at which they can acquire the real object is fixed ex-ante. Moreover, we wanted to compare participants' bids in the Vickrey auction with their valuations elicited in a non-strategic and rather simple setting.[7] The second difference is that previous papers employ a between-participant design, whereas our within-participant design, where the binary-choice task varies across participants, allows us to test for deviations from truthful bidding in the Vickrey auction at the individual level.

A more recent paper employing a design similar to ours is Kassas et al. (2018). In their study, participants bid in Vickrey auctions for several real goods and, afterwards, the losing bidders participated in a secondary market where they had the opportunity to purchase any

[2] Rosato and Tymula (2019) provide experimental evidence consistent with this prediction.

[3] Some of these factors also affect other experimental mechanisms commonly used to elicit participants' valuations for real goods, such as the Becker-DeGroot-Marschak (henceforth, BDM) mechanism (Becker et al., 1964); see Banerji and Gupta (2014), Mazar et al. (2014) and Tymula et al. (2016).

[4] Throughout the paper, we maintain the interpretation that valuations inferred from the binary-choice task represent the "true" valuations, and hence interpret inconsistencies between participants' bids in the auction and their behavior in the binary-choice task as evidence of over-/under-bidding. Yet, the opposite interpretation – that the bids in the second-price auction reveal the "true" valuations – is also plausible; this would be the case if, for instance, participants experience an endowment effect in the binary-choice task but not in the auction. We tend to favor the first interpretation since the binary-choice task does not feature any strategic risk and it does not require participants to engage in any form of contingent thinking. We return to this point in the concluding section of the paper.

[5] Notice that some amounts could be negative.

[6] In addition to eliciting valuations for real goods (Andersen et al., 2007; Kahneman et al., 1990), the binary-choice (or multiple price list, MPL) method has been used also to elicit discount rates (Andersen et al., 2008; Coller & Williams, 1999) and risk preferences (Eckel & Grossman, 2008; Holt & Loury, 2002).

[7] While there is no strategic interaction in BDM, participants still have to submit a bid and engage in a form of contingent thinking similar to that of the Vickrey auction; this, in turn, might lead them to erroneously consider the BDM task as a strategic one.

amount of one of the goods for a randomly chosen price. Hence, like in our paper, these authors can use the purchasing behavior in the secondary market to classify subjects as either "consistent" bidders, or under-/over-bidders. Nevertheless, our paper and Kassas et al. (2018) differ for some key design aspects, as well as for the direction of some of the results. With respect to the design, Kassas et al. (2018) had subjects bidding on 8 vegetable products, whereas subjects in our study bid on just one durable good. More importantly, because in our study the prices at which subjects can buy the good are directly linked to their bid in the auction, we can employ a stricter test for over-/under-bidding compared to Kassas et al. (2018). Indeed, whenever subjects in their study accept (resp. decline) to purchase the good at a price lower (resp. higher) than their bid for the same good in the Vickrey auction, they are considered "consistent" bidders. For instance, consider a participant who bid $3 and then accepts to buy the same good for $2. Such a bidder could very well have under-bid in the auction (e.g., if her valuation for the good is $4); yet, she would not be classified as an under-bidder according to Kassas et al. (2018). Similarly, the bidder could have over-bid in the auction (e.g., if her valuation for the good is $2.50), and still be classified as consistent. Hence, their test might underestimate the fraction of over-/under-bidders in their sample. Moreover, Kassas et al. (2018) only considered real-object auctions, whereas by having subjects bid also in induced-value auctions, our study allows us to explore whether there is any relation between the tendency of subjects to deviate from truthful bidding across auction types. In terms of results, Kassas et al. (2018) find that a significant fraction of their subjects overbid, whereas under-bidding is somewhat more prevalent in our study.

Finally, our paper is also related to the literature on "preference reversal". Originally discovered by psychologists (Lichtenstein & Slovic, 1971, 1973), the first economic analysis of this phenomenon is due to Grether and Plott (1979).[8] In preference reversal experiments, subjects are asked to choose between two lotteries. One lottery in a pair typically has a high probability of winning a small amount of money; this is the probability bet or "P bet". The other, riskier lottery in the pair has a smaller chance of winning a larger amount of money; this is the dollar bet or "$ bet". In addition to choosing between the two bets, subjects are also asked to place a monetary value on them. The valuation question has been asked in many different ways, the most common being the BDM mechanism. A preference reversal then occurs if the preference revealed by choice is the reverse of the preference revealed by valuation; i.e., if the chosen bet is given a lower valuation than the unchosen one. In most experiments, observed preference reversals are asymmetric: subjects tend to more frequently choose the P bet and yet assign the higher price to the $ bet. Our finding that participants' bids in real-object auctions differ from their valuations – for the same object – elicited via the binary-choice task can also be seen as a form of preference reversal.[9]

2. Experimental design

The aims of our experiment are to empirically test our novel method for identifying departures from truthful bidding in the second-price auctions for *real goods* and to check whether bids in induced-value auctions predict bidding behavior in real-good auctions. To achieve these goals, we employed a within-subject design.

Each participant in our study completed two tasks: an auction task (consisting of both a real-object auction and an induced-value one) and a binary-choice task, in this order. Upon arrival, participants found $25 on their desks and were told that based on their decisions in the experiment they would be able to earn more money or lose some of this initial endowment. Throughout the paper the symbol $ denotes Australian dollars (AUD); in 2019, when the experiment was carried out, 1 Australian dollar was roughly equal to 0.695 US dollars (USD) and 0.621 euros (EUR). At the beginning of the study, the instructions (see Appendix C) were presented on the screen and read aloud by the experimenter. Moreover, each participant had to answer a series of comprehension questions (see Appendix D). There were five comprehension questions, each with a backup version for those participants who did not answer correctly on the first attempt. After each question, the screen displayed the correct answers along with an explanation. If participants answered a question wrongly, they were provided with an alternative question of the same type.[10]

Each participant bid in two second-price auctions: one for a monetary voucher (induced-value auction) and one for a University of Sydney travel mug featuring university crest, vacuum insulation, and a rubberized paint finish (real-object auction). The order of the two auctions was randomized independently for each participant and, in each auction, participants were randomly paired. Voucher values were drawn randomly and independently for each individual from a uniform distribution between $0 and $20 (in $0.50 increments); they were communicated to the participants before they bid in the auction and were private knowledge, meaning that participants did not know other participants' voucher values. The voucher was redeemable for cash from the experimenter at the end of the experiment. Participants were not informed of the market value of the mug (which sold for $22.95). In both auctions, participants could submit bids from $0 to $25 in $0.50 increments. Figure 5(a) and 5(b) in Appendix A show exemplary screenshots from the auction task.

Departures from truthful bidding in the induced-value auctions can be easily inferred from the auction task. Bids over (under) the nominal value of the monetary voucher are direct evidence of over- (under-) bidding. To elicit participants' valuations for the mug independently of the auction task, and hence to identify instances of over- or under-bidding in real-object auctions, in the second task participants had to make a series of binary choices between buying the mug at a fixed price or receiving various monetary amounts. Figure 5(c) in Appendix A presents an exemplary screenshot of the binary-choice task. The prices and monetary amounts were based on the participants' bids in the auction task. Specifically, in all binary choices the price for the mug was always the same and equal to the price from the real-object auction that a participant bid in. Thus, if participant i was the high bidder in her auction for the mug, then p_i was equal to her opponent's bid; if instead participant i was the low bidder in her auction for the mug, then p_i was equal to her own bid. Finally, if both participants submitted the same bid, then p_i was equal to that bid. In summary, $p_i = \min\{b_i, b_j\}$ for $i \neq j$.[11] The monetary amounts for each participant i were calculated as $b_i - p_i + C_n$, $n \in \{0, 1, \ldots, 10\}$ with $C_0 = -\$2.50$ and $C_{n+1} - C_n = \$0.50$, for a total of 11 choice scenarios. These scenarios were presented one at a time in a randomized order. While such a randomized one-by-one presentation might increase the likelihood of participants switching multiple times between options, we chose it in order to reduce the potential occurrence of the so-called "centrality" effect; i.e., the tendency of participants to often go for the middle option in the multiple price list presentation (Andersen et al., 2006). Moreover, presenting all choices at once in one single list might not be incentive-compatible (Brown & Healy, 2018). Participants whose valuation for the mug is consistent with their bid in the auction should

8 See Slovic and Lichtenstein (1983) for a review of the early literature and Tversky and Thaler (1990) for later references.

9 While most of the studies ask subjects to choose between, and assign monetary values to two monetary lotteries, preference reversal has also been observed with non-monetary options; see Tversky et al. (1988).

10 All participants answered all binary-choice task comprehension questions correctly within two attempts; 66 out of 78 participants answered all auction task comprehension questions correctly within two attempts.

11 In order to maintain incentive compatibility, participants were not told how the price p_i was chosen.

opt for the monetary amount (resp. buy the mug) in all scenarios where $C_n > 0$ (resp. $C_n < 0$). For $C_n = 0$, participants should be indifferent between the two options; hence, selecting either option would be consistent with their bid in the auction.

After completing both tasks, participants answered a short questionnaire (see Appendix E). The last part of the experiment was the payment. Participants' earnings were determined by their performance in either one of the auctions or the binary-choice task; each of these three options had the same chance of being randomly selected for payment. If an auction – either a mug-auction or an induced-value one – was selected for payment and the participant was the winner, the participant would get the prize of this auction and pay for it a price equal to the second-highest bid; the payment was deducted from her initial endowment of $25. If an auction was selected for payment and the participant was the loser, the participant kept the initial endowment. If both participants submitted the same bid, the software randomly selected the winner. If the binary-choice task was selected for payment, the software randomly selected one of the 11 decisions that the participant made in the task and realized it for payment. On average, participants earned $32.85; in addition, 41% of participants also received a mug whose retail price was $22.95 at the time of the experiment.

A total of 78 subjects (36 males; average age: 23) participated in the experiment, which took place at the experimental laboratory of the University of Sydney in 2019. The protocol was approved by the Human Ethics Research Committee at the University of Sydney and all participants gave informed written consent. The study was implemented using z-Tree (Fischbacher, 2007) and participants were recruited via ORSEE (Greiner, 2015).

3. Results

In this section, we report our experimental findings. We begin by separately describing the results for induced-value auctions and real-objects ones, and then discuss the relation between the two.

3.1. Bidding in induced-value auctions

Fig. 1(a) displays participants' bids in the induced-value auctions against the monetary value of their vouchers. The bids ranged from $0 to $25, with an average of $10.54 and a standard deviation of $7.20, whereas the average value of the voucher was $10.26 with a standard deviation of $6.12. To investigate bidding behavior in induced-value auctions, we begin by regressing each participant's bid on the value of their voucher plus a constant; i.e., $b\hat{i}d = \hat{b}_0 + \hat{b}_1 IV$.[12] Hence, estimates of $\hat{b}_1 = 1$ and $\hat{b}_0 = 0$ would indicate that, on average, participants' bids were equal to their values. Our results are consistent with this value-bidding prediction, as we estimate that $\hat{b}_1 = 0.95$ (not significantly different from 1) and $\hat{b}_0 = 0.80$ (not significantly different from 0).

However, while the data seem to support value-bidding in the aggregate, at the individual level the picture is less positive. Indeed, we find that only 31 out of 78 participants (40%) bid their voucher's value, while 27 (35%) under-bid (by an average of $2.69), and 20 (25%) over-bid (by an average of $4.73); see also Fig. 1(b).[13] The observed fraction of value-bidding participants is in line with previous experimental findings, but we find under-bidding to be somewhat more prevalent than over-bidding. For instance, Kagel and Levin (1993) found 27% of value-bidding, 5.7% of under-bidding and 67.2% of over-bidding. In Cooper and Fang (2008), Garratt et al. (2012) and Rosato and Tymula (2019) the same figures were: 44%, 16% and 40%, 21.2%, 41.3% and 37.5%, and 40%, 38% and 22%, respectively.

The observed departures from value-bidding at the individual level can hardly be explained by the participants feeling cash constrained (an item in the post-experimental questionnaire) or misunderstanding the task. Indeed, as shown in Table 3 in Appendix B, neither the difference between the bids and the voucher's value nor the absolute value of this difference are significantly related to poor task comprehension or cash constraints.

3.2. Bidding in real-object auctions

Fig. 2(a) illustrates bids in the auction for the mug. These bids ranged from $0 to $25, with an average of $8.81 and a standard deviation of $7.78. To assess whether participants bid truthfully, we compare the bids in the auction task with the valuations obtained from the binary-choice task. In the latter, participants made a series of choices between buying the mug at a fixed price or receiving a monetary amount that changed from trial to trial.

To infer a participant's valuation for the mug from the binary-choice task, we arrange the 11 choice scenarios in increasing order according to the amounts C_n. Rational participants would choose to buy the mug at the fixed price when $C_n < 0$ and then would switch to preferring the monetary amount for $C_n \geq 0$; denote this "switching" scenario by $\hat{n}$. For each participant i, we can then infer that, for the last scenario in which they selected the mug, it must hold that $v_i - p_i \geq b_i - p_i + C_{\hat{n}-1}$; similarly, for the first scenario in which they selected the monetary amount, it must hold that $v_i - p_i \leq b_i - p_i + C_{\hat{n}}$. Thus, the participant's valuation for the mug must lie in the interval $[b_i + C_{\hat{n}-1}, b_i + C_{\hat{n}}]$. In order to estimate the participant's valuation for the mug, we take the midpoint of this interval; i.e., $v_i = b_i + (C_{\hat{n}} + C_{\hat{n}-1})/2$.[14] With this formula, from the binary-choice task we can recover the valuations of the 37 participants who switched only once between buying the mug and receiving the monetary amount. For the 32 participants who never switched, while we cannot pin down their valuation for the mug, we can identify whether they under- or over-bid. For instance, if they never chose the mug in the binary-choice task, it means that they over-bid in the auction; by contrast, if they always chose the mug, it means that they under-bid. Moreover, we can obtain upper and lower bounds on the mug valuations of these participants by using their auction bid + $3 (resp. −$3) if they always (resp. never) selected the mug.[15]

Valuations (respectively lower or upper bounds for those who never switched) for the mug inferred from the binary choice task for participants who switched once or never are displayed in Fig. 2(b). On average, these participants' valuations are equal to $8.53 (with a standard deviation of $7.75), which is not statistically different from their auction bids ($8.23 average with a standard deviation of $7.75) in a two-sided t-test. Notice also that two participants bid $0 in the auction for the mug and then never chose to buy the mug in the binary-choice task if the monetary option was weakly positive; hence, their inferred valuations for the mug are negative (−$0.25 and −$3, respectively).[16]

Nevertheless, Fig. 3 shows that, as for the induced-value auctions, many participants depart from truthful bidding in real-object auctions

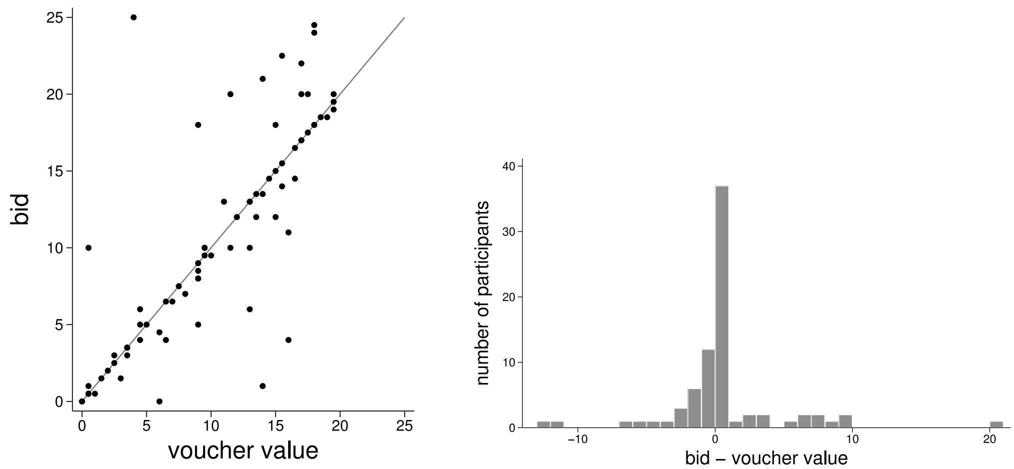
[12] This approach is quite common in the experimental literature on auctions; see, for instance, Cherry et al. (2004), Shogren et al. (2001) and Jacquemet et al. (2013).

[13] There are 3 participants whose bids depart from the voucher value by more than $11; when we remove these outliers, we observe that 19 participants over-bid (on average by $3.87) and 25 under-bid (on average by −$1.83).

[14] For other methods that address the issue of interval responses, see Andersen et al. (2006).

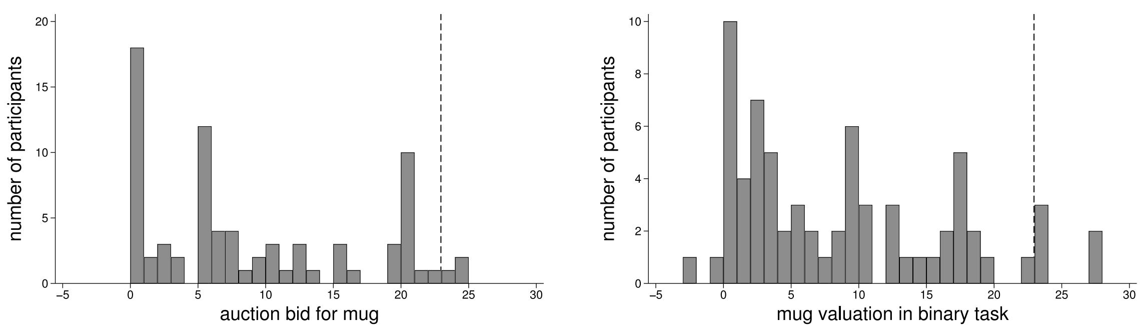
[15] 9 participants out of 78 (11.5%) switched more than once; hence, they are excluded from the analysis that follows. As argued by Charness et al. (2013), multiple switch points are not unusual in binary-choice experiments and various methods have been proposed to address them; see, for instance, Andersen et al. (2006), Engel and Kirchkamp (2019) and Yu et al. (2021).

[16] If we restrict attention to participants who switched exactly once in the binary-choice task, we find that their mug valuations are slightly higher than their auction bids ($5.59 vs. $5.19, two-sided p = 0.07).



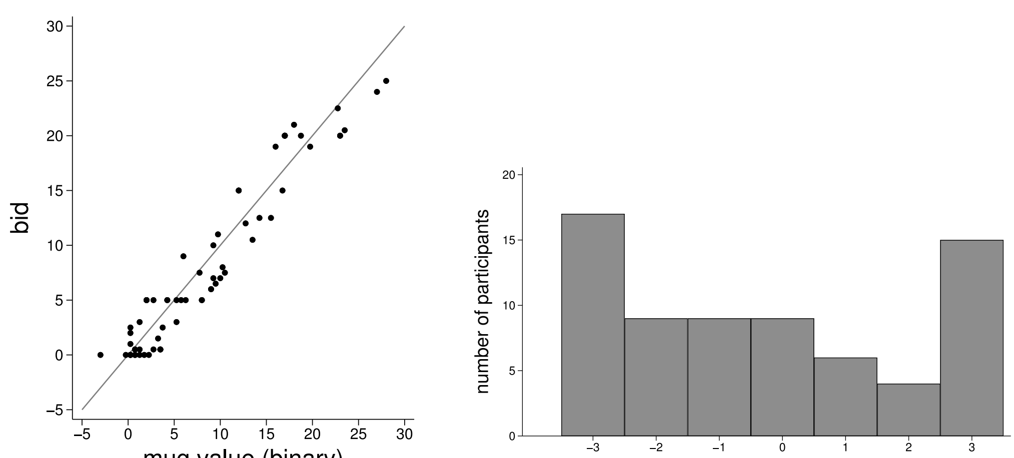
(a) bids for money voucher (b) bid deviations from voucher value

Fig. 1. Bids for money voucher.



(a) auction bids (b) binary task valuations

Fig. 2. Distributions of bids and valuations for the mug. The dashed vertical line indicates the price of the mug at the time of the experiment ($22.95).



(a) mug bids and valuations (b) mug bid deviations

Fig. 3. Relationship between bids and valuations for the mug.

Table 1
Over-, under-, and rational bidders by whether their price is equal to their bid.

	price≠bid	price=bid	
Overbid	14	11	25
Rational	3	6	9
Underbid	15	20	35
Total	32	37	69

Table 2
Relationship between overbidding for money (in columns) and mug (in rows) for all participants who switched once or never.

		Money			
		Overbid	Rational	Underbid	Total
Mug	Overbid	7	11	7	25
	Rational	2	4	3	9
	Underbid	7	16	12	35
Total		16	31	22	69

as well. Because the monetary options in the binary choice task increased in \$0.50 increments, whenever the gap between the inferred values and the auction bids is within \$0.25, we interpret it as evidence of participants' behavior being consistent across the two tasks. Overall, 25 participants over-bid for the mug (on average by \$2.34), 35 under-bid (on average by −\$2.21), and 9 bid rationality (that is within +/−\$0.25 from their valuation inferred from the binary choice task).[17] Hence, as for the induced-value auctions, we find under-bidding to be more common than over-bidding. Finally, comparing Fig. 3(a) with Fig. 1(a) might give the impression that deviations from value-bidding are more pronounced in induced-value auctions than in real-object ones. However, recall that for participants who switched only once in the binary-choice task, their value for the mug is estimated at $v_i = b_i + (C_{\hat{n}} + C_{\hat{n}-1})/2$; similarly, the value of participants who never switched is censored at $v_i = b_i \pm 3$. Therefore, our measure of deviations from truthful bidding in real-object auctions is quite conservative, which might explain why bidding for real objects appears "tighter".

3.2.1. Winners vs. Losers

In the binary-choice task, some participants saw their own auction bid as the fixed price for the mug. This group consists of those participants who either lost or tied with their opponent in the auction for the mug. For these participants, $b_i - p_i = 0$ and their monetary amounts always range from −\$2.50 to \$2.50. Overall, 52.56% of the participants are in this category (53.62% when dropping participants who switched more than once in the binary-choice task). One might therefore wonder whether seeing their own previous bid as the price in the binary-choice task could have affected the decision process of these participants. Yet, as Table 1 shows, deviations between the two tasks were similar (χ^2's $p = 0.423$) for "losers" (who faced a fixed price equal to their bid) and "winners" (who faced a fixed price lower than their bid).

3.3. Induced-value vs. Real-object auctions

As we have shown in the previous sections, in our study participants deviated from truthful bidding in both real-object and induced-value auctions. Moreover, in each auction type, under-bidding is somewhat more common than over-bidding. In this section, we investigate whether participants' bidding behavior is correlated across the two types of auction.

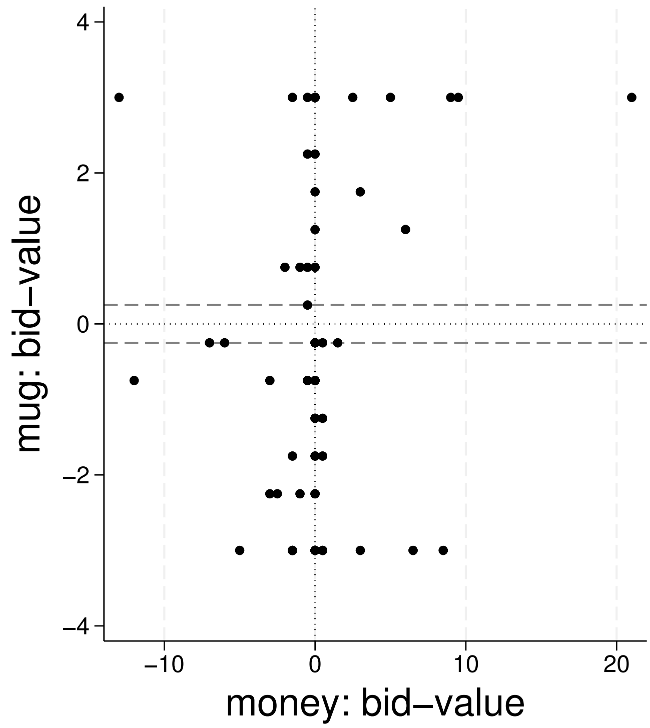


Fig. 4. Relationship between mis-bidding for money and mugs. The vertical dotted line and the area between horizontal dashed lines indicate truthful bidding.

Table 2 reports how many participants over-bid, bid truthfully, and under-bid for the mug (rows) and the money voucher (columns).[18] There is no significant association between these categories across auction type (Fisher's exact $p = 0.970$; χ^2's $p = 0.963$). For example, of the 16 participants who over-bid with induced values, only 7 over-bid for the mug as well, which is the same number of participants who under-bid for it.

Next, we compare the size of the deviations from truthful bidding across the two types of auction. If participants' bidding behavior is similar across auctions, we would expect that those who over-bid more for the money voucher also over-bid more for the mug. Fig. 4 suggests that there is no such positive correlation. We confirm this observation by regressing the amount of mis-bidding (either over- or under-bidding) in the real-object auctions on the amount of mis-bidding in the induced-value one using a Tobit model; see Table 4 in Appendix B. We find no association in the tendency to mis-bid across different auction types despite the data in both auctions coming from the same individuals and the same experimental session.[19] Hence, we conclude that there is no significant relationship between how participants bid in induced-value auctions versus real-object ones.

Could the lack of any meaningful relation between the two types of auction be due to the fact that their environments are somewhat different? After all, real-object auctions entail a loss of control in the sense that bidders' values are home-grown rather than randomly assigned. For instance, the support and distribution of values are commonly known in induced-value auctions. Moreover, participants might be uncertain about their value for the mug, especially if they are not familiar with it; or, their values could be correlated. Yet, we do not think that these potential concerns would undermine the implications

[17] If we exclude the participants who never switched, 10 participants over-bid (by \$1.35 on average), 18 participants under-bid (by −\$1.47 on average), and 9 participants bid rationally.

[18] The 9 participants with multiples switching points in the binary-choice task are excluded from this table.

[19] The relationship remains insignificant even when censoring deviations from truthful bidding in the induced-value auctions at ±\$3.

of our study. Indeed, as long as values are private, truthful bidding remains a (weakly) dominant strategy in the Vickrey auction even if the values are correlated and if their supports are asymmetric (or unknown). Therefore, we think that our results hint at the possibility that bidders might be using different bidding strategies (or heuristics) in induced-value auctions compared to auctions for real goods.

4. Discussion and conclusion

We presented results from a laboratory experiment with a novel design aimed at testing for deviations from truthful bidding in second-price auctions with real objects. Our design, combining a standard second-price auction with an individual-specific binary-choice task, allows to directly identify over- and under-bidding. Moreover, we also compared participants' bidding behavior in real-object auctions vs. induced-value ones. We found significant deviations from truthful bidding in both types of auctions, with under-bidding being more common than over-bidding. Yet, we found no significant relationship between deviations from truthful bidding across the two types of auction, suggesting that people might bid differently in real-object auctions than in induced-value ones.

Most of the literature in experimental economics has been dominated by the use of induced values. Such a design feature allows researchers to control for otherwise unobservable confounds when studying the properties of different games and market institutions. Yet, the use of real goods in economic experiments is becoming more common; e.g., food, stationary products and, especially, mugs. In these experiments, therefore, researchers are faced with the additional task of eliciting participants' home-grown values. Elicitation methods commonly employed include the second-price (or Vickrey) auction, the ascending (or English) auction, the BDM mechanism and the binary-choice format. All these methods are equivalent in principle as, under standard assumptions, they are all incentive compatible. However, there are some procedural differences which can cause the elicited values to differ across these methods. First, as participants compete against each other in Vickrey and English auctions, these two methods feature a strategic element which is absent in BDM and binary choice. Furthermore, even though strategic interaction is absent in BDM, participants might perceive it as being similar to an auction since they still have to submit bids and are exposed to some risk with respect to the item's price. For these reasons, we think that the binary-choice format is cognitively less demanding for participants and hence more apt to elicit their "intrinsic" values. Indeed, this is what we have implicitly assumed in our analysis of over-/under-bidding in real-object auctions. Under the alternative hypothesis that bids in the second-price auctions are truthful, then our results should be interpreted as evidence against the binary-choice method.[20] In either case, our study shows that these two methods deliver different and somewhat inconsistent estimates for participants' home-grown values.

Throughout the paper, we have been deliberately agnostic about which theoretical mechanisms might explain the deviations from truthful bidding that we observe in real-object auctions. We now conclude by discussing some alternatives.

One possibility is the "joy of winning" hypothesis, which has already been put forward to explain deviations from truthful bidding in second-price auctions with induced values (see Cooper and Fang (2008)). Insofar as participants experience a boost in utility only when getting the mug in the auction but not in the binary-choice task, this hypothesis can rationalize deviations from truthful bidding in second-price auctions. Yet, one would expect such utility boost to lead to over-bidding whereas we find that more participants in our study under-bid.

As we mentioned in the introduction, our finding that participants' bids in the auction for the mug differ from their valuations elicited via the binary-choice task can also be interpreted as a form of preference reversal. Common explanations for preference reversals include nontransitive choice models (Loomes & Sugden, 1983) and risk preferences that violate the independence axiom of expected utility theory (Holt, 1986; Karni & Safra, 1987; Segal, 1988). None of these models, however, can explain deviations from truthful bidding in second-price auctions with induced values. A third option, advocated by Tversky et al. (1990), is a particular failure of procedural invariance, called "scale compatibility", whereby people focus their attention on the attributes that are most compatible with the response mode. In the context of the typical preference reversal experiment, scale compatibility implies that subjects attend to the monetary payoffs more when pricing the bets than when choosing between them. Hence, in the context of our study, this would imply that participants would assign a bigger monetary value to the mug in the auction task than in the binary-choice task. Indeed, we found that the average bid for the mug is slightly higher than the average valuation from the binary-choice task ($8.81 vs. $8.53), although the difference was not statistically significant.

Finally, another possibility, in light also of the differences that we observe in bidding behavior between real-object auctions and induced-value ones, is provided by models where an individual assigns different utility weights to consumption and money; e.g., reference dependence, narrow bracketing, or mental accounting. For instance, according to the expectations-based model of reference-dependent preferences of Kőszegi and Rabin (2006), when buying a new pair of shoes a shopper experiences simultaneously a gain in shoe consumption and a loss in money. Since gains and losses are assessed relative to the expectations about the shoes' price and availability, the willingness to pay is endogenous and thus can vary depending on the elicitation mechanism; i.e., SPA vs. binary-choice task. We think that a thorough investigation of these hypotheses represents a promising avenue for future research.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.socec.2024.102221.

[20] Because of the order of the two tasks, this could apply if participants experience an endowment effect (which would increase their willingness to pay) in the binary-choice task but not in the auction.

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