How Robust is Cason-Plott's Theory of Game Form Misconception? *

Charles Bull† Pascal Courty‡ Maurice Doyon§ Daniel Rondeau¶

January 30, 2016

Abstract

This paper explores the robustness of the theory of game form misconception (GFM) developed by Cason and Plott (2014) to explain bidding mistakes in the Becker-DeGroot-Marschak valuation revelation method. New evidence is broadly consistent with the existence of two types of bidders and with the presence of bidding noise. However, bidders' responses to an increase in competition does not accord with GFM. Moreover, we find that misconception increases when subjects perform simultaneously the misconceived task and the task it is misconceived for.

Keywords: Game form recognition, subject misconception, mistake, Becker-DeGroot-Marschak, preference elicitation.

JEL Classification: C8, C9.

*This research was sponsored by the Ministre des Ressources Naturelles du Quèbec. The analysis and opinions presented are exclusively those of the authors and errors remain our sole responsibility.

†University of Victoria; clbull@uvic.ca.
‡University of Victoria and CEPR; pcourty@uvic.ca.
§University of Laval; Maurice.Doyon@eac.ulaval.ca.
¶University of Victoria; rondeau@uvic.ca.

1 Introduction

Cason and Plott (2014; hereafter CP) argue that experimental subjects sometimes confuse the game they are playing for some other game. They call this type of misconception, game form misconception (GFM), and argue that it can explain the systematic bidding mistakes found in the valuation revelation method proposed by Becker-DeGroot-Marschak (Becker et al., 1964; hereafter BDM).[1] The purpose of this paper is to test the robustness of the CP theory of GFM.

CP use a reverse BDM where induced-value cards worth $2 are given to untrained subjects. The subjects are instructed to make an "offer price" that, if less than a hidden "posted price" on the back of the card, would enable them to sell the card for the posted price. If the offer price turns out to be more than the posted price, the card is redeemed for its value, $2. Consistent with the GFM hypothesis, CP report that some subjects mistakenly believe they are participating in a first price procurement auction when they are, in fact, participating in a reverse BDM (which is the same as a second price or Vickrey auction), and conclude: "The subjects consist of at least two groups. One group understands the game form as a a second-price auction and behaves substantially as game theory predicts. Another group has a misconception of the game form as a first-price auction and under that model behaves substantially as game theory predicts." (p. 1263)

According to CP, misconceived subjects misconceive BDM for a first price auction (FP). Is it correct, however, to assume (as CP do) that misconceived subjects behave like game theory optimizers in a FP auction? Even more relevant, how do misconceived subjects behave when they have to complete both the misconceived task (BDM) and the task it is misconceived for (FP)? Arguably, one could draw on the large body of experimental evidence on FP auctions (Kagel and Levin, 1993) to offer speculative answers to these questions. However, CP have warned us that game procedure and context influence game outcomes. This makes cross-game comparisons problematic. More to the point, evidence from FP auctions alone cannot answer the question of how misconception changes when subjects are presented simultaneously with the misconceived game and the game it is misconceived for.

To test the robustness of the CP theory, we run four distinct experimental treatments: one replicates the CP's experiment and the other three modify it to investigate new implications of the theory. To start, we compare the data gathered in our replication of CP's experiment to an experimental first price benchmark rather than a theoretical optimum. Next, we investigate whether first price misconceivers respond to an increase in competition as theory predicts. In that treatment, subjects compete against two posted prices instead of one. Finally, the last treatment explores how bidding behavior changes when subjects are asked to perform both the misconceived task (BDM) and the task it is misconceived for (first price) simultaneously.

Our results show support for CP's theory of subject misconception general premise that subjects are composed of two groups that behave significantly differently. However, we show

[1] Understanding the nature of such mistake is important to interpret revealed preferences in the BDM valuation method: ''It is a failure of the decision maker to recognize the proper connections between the acts available for choice and the consequences of choice, which, by necessity, are associated with the method of measuring preferences. If the individual fails to understand the connection between acts and outcomes, the choice of acts can be misleading about the preferences over outcomes." (p. 1237)

that the group of first price misconceives does not respond to an increase in competition in a BDM payment mechanism as optimizing behavior under game theory predicts. We also find that presenting simultaneously the misconceived task and the task it is misconceived for surprisingly increases, rather than decreases, misconception.

Section 2 reviews CP's theory of GFM. Section 3 describes the experimental design and goes over the procedures used during the experiment. Section 4 provides an overview of the data gathered, replicates CP results and presents evidence that some subjects misconceive the payment method used to compute payoffs. Although some of the treatments include a second 'repeat' round, we discuss the evidence on the second round only in the replication of CP analysis. Section 5 presents the main results of this paper and Section 6 summarizes the main findings. The Appendix, presents further analysis and details on the experimental design.

2 CP's Theory of GFM: The BDM Case

The BDM is an incentive–compatible procedure for measuring a subject's WTA or WTP.[2] Standard economic theory implies that for a given object, a subject's WTP should be equal to their WTA (i.e., the most one is willing to pay for an object is equal to the lowest price one is willing to sell the same object for). Several experiments using the BDM, however, have found that many subjects state a greater WTA than WTP and have attributed this difference to a behavioral bias (the literature refers to the notions of 'endowment effect', framing, reference point and loss aversion).[3] Plott and Zeiler (2005) dispute this popular conclusion and instead argue for the possibility that subjects have misconceptions.[4] In their overview of the literature on WTA-WTP gaps, they note that "experimenters are careful to control for subject misconceptions, [but] there is no consensus about the fundamental properties of misconceptions or how to avoid them. Instead, by implementing different types of experimental controls, experimenters have revealed notions of how misconceptions arise" (p. 530).[5]

CP focus on a specific type of misconception in an induced-value experiment, thus eliminating unobserved preferences. Subjects are given a card and are told that they can sell it for $2. According to CP "all theories agree that the preference value the subjects place on the card is $2." Since induced-value cards are used instead of goods, the only matter to

[2]Karni and Safra (1987) showed that this does not follow if the good in question is a lottery and Horowitz (2006) shows that this result need not be true for non-expected utility maximizers.

[3]See Plott and Zeiler (2005) Table 1 for an overview of experimental papers on WTA-WTP gaps.

[4]They report "while many experimenters have observed a WTP-WTA gap, others have failed to observe it. This variation in experimental results seriously undermines the claim that the gap is a fundamental feature of human preferences" (p. 531).

[5]Procedures used to control for subject misconception include using an incentive-compatible elicitation device, subject training, paid practice rounds, and the provision of anonymity for subjects. Plott and Zeiler (2005) first replicate a prominent experiment in the literature cited as evidence for the endowment effect, Experiment 5 in Kahneman et al. (1990), and then proceed to implement all possible controls for subject misconception found in the literature. WTA-WTP gaps were noted in the former but not the latter, providing evidence that the particular experimental procedures, not the endowment effect, are responsible for the noted gaps. However, Bartling, Engl, and Weber (2014) show that framing effects, such as the endowment effect, can persist in trained subjects that show correct game form recognition.

study is why, in the absence of training or explanation of the BDM rules, some subject bid different amounts than $2.

CP argue that the reason some subjects make systematic mistakes is because they do not understand the game they are playing. They question the implicit assumption made in many experimental studies that there necessarily exist "a solid connection between the game form and an individuals understanding of the game form." They acknowledge that there may be many forms of misconception, but they argue that a significant fraction of mistakes in a BDM game can be attributed as subjects misconceiving the BDM auction as a first price (FP) auction, a mistake they call Game Form Misconception (GFM): "The mistakes are not simply random departures from a correct understanding of the experimental task, but rather arise from a misconception of the rules of the BDM." They take the next step and argue that an experimenter who knows the game that is misconceived as the game being played can make prediction on how the subject should respond to changes in game parameters: "In order to make a case that the choices reflect a systematic, fundamental mistake, the mistake itself is described and stated in a form that yields testable predictions that are comparable to the predictions of other possible models." To summarize, CP's application of GFM theory to interpret bidding outcomes in a BDM is based on the following three premises:

Premiss 1. *Subject heterogeneity: some subjects are BDM optimizers and others have GFM.*

CP write, "The data are better and more completely explained by a mixture of some subjects who understand the BDM mechanism and submit optimal offers and others who have a specific type of game form misconception."

Premiss 2. *GFM applies to BDM but not to FP.*

According to CP, "The choices of many of these untrained subjects appear to be based on a misconception of the task. They think that it is a first-price auction rather than a second price auction." (p. 1262). Thus, subjects with GFM behave in BDM as if they were in a FP auction. This establishes testable predictions on how misconceived subjects should respond when the parameters of the BDM game changes. They should respond as if the game rules were FP because a misconceived subject "has a misconception of the game form as a first-price auction and under that model behaves substantially as game theory predicts." CP also argue that subjects make random decision errors.

Premiss 3. *Subjects bid distribution is best explained with random decision noise.*

CP consider models of optimal decision with noise because: "Mistakes, decision error, and noise can complicate inferences about fundamental economic primitives, and these complications call for stochastic and heterogeneous models."

Using these three premises, CP explain experimental data on variations of the BDM using induced-value cards. This paper first replicates most of their results and subsequently moves on to develop new variations of the BDM to further test CP theory of GFM.

3 Experimental Design

The experiment performed in this study consists of four similar, though distinct, treatments. In all of the treatments, subjects were given two cards worth $2 each and were informed of a rule by which they could sell them back to the experimenter. In the first three treatments, subjects are given two cards sequentially. In the last treatment, subjects are given 2 cards simultaneously.

3.1 BDM and First Price Treatments

Subjects performed two rounds of these treatments, though the second was unannounced. Each subject was handed a large envelope that contained detailed instructions on how to perform the experiment; an experiment card; a consent form; and a smaller envelope. After the subjects completed the experiment card, the instructions prompted them to open the smaller envelope. Inside the smaller envelope was a second experiment card that used the same sale mechanism. Subjects were instructed to complete this card and put all the material, except for a tag with an ID number on it, back in the large envelope. This tag was their ticket for payment. Payments to subjects were made in subsequent lab sections and lectures.

3.1.1 CP Replication (BDM1)

The BDM1 treatment uses a reverse BDM sale mechanism. The subject is instructed to read the card over and write down an offer price. On the back side of the experiment card is a covered posted price randomly drawn from the distribution U(0,5); subjects are instructed to uncover the posted price only after writing down an offer price. If their offer price is less than or equal to the posted price, the subject sells their experiment card at the posted price. If their offer price is greater than the posted price, the subject sells their card for $2.The theoretically optimal offer for an expected utility maximizer only concerned with monetary payoffs is $2.

BDM1 more or less replicates the experiment performed in CP. As in CP, this treatment consists of two rounds. The wording on the card was slightly edited for clarity. An important distinction with CP is that subjects are told that all posted prices would be drawn from a uniform distribution with support $[0, 5]$—a fact made known to subjects in plain English (see Appendix for an example experiment card). Moreover, we use a single price distribution for all groups while CP use different distributions of posted prices with different groups.

3.1.2 First Price (FP)

The FP treatment uses a first price sale mechanism. The subject is instructed to read the card over and write down an offer price. On the back side of the experiment card is a covered posted price randomly drawn from a uniform distribution with support $[0, 5]$; subjects are instructed to uncover the posted price only after writing down an offer price. Subjects are informed in plain English about the distribution the posted prices are drawn from. If their offer price is less than or equal to the posted price, the subject sells their experiment card at their offer price. If their offer price is greater than the posted price, the subject sells their card for $2.

The optimal offer price for a risk neutral subject is $3.50 in this treatment (given that the random price is uniform with support $[0, 5]$). The first round of FP is referred to as FP1, and the second round is referred to as FP-2.

Our main critique of CP's analysis is that the modeling technique they employed compares experimental behavior in the BDM to theoretical optimizing BDM and first price behavior. Our motivation for including the FP treatment is to provide a behavioral first price benchmark to compare with our replication of CP's experiment (BDM1), as subjects participating in first price auctions tend not to act according to what game theory predicts (Harrison, 1990).

3.1.3 Increased Competition (BDM2)

The BDM2 treatment differs from BDM1 in one way: two posted prices are drawn, not one. The subjects are instructed that if their offer price is less than both posted prices, or equal to the lowest posted price, they sell their experiment card at the posted price. If their offer price is greater than one or both of the posted prices, they sell their experiment card for $2. The subject is informed in plain English that both posted prices are randomly drawn from the distribution U(0,5). An offer price of $2 is again optimal. The first round of BDM2 is referred to as BDM2-1, and the second round is referred to as BDM2-2.

Our motivation for including this treatment in the experiment is to observe the behavior of CP's so-called first price misconceivers. As optimal first price behavior changes with the number of bidders, a good test of CP's theory would be to vary the number of posted prices. If a group of first price misconceivers is indeed present, and of any meaningful size, the offer distribution of BDM2 should differ from that of BDM1 in key areas. Most notably, the offer distribution should be shifted to the left relative to that of BDM1's. It should also contain a statistically greater amount of offers around $3.00 (the optimal offer for BDM2 under the first price misconception model).

3.2 Simultaneous Task Completion (Within Subject — WS)

The WS (within–subject) treatment presents the subject with two experiment cards from the outset. One of the cards uses the mechanism found in BDM1, and the other uses the mechanism found in FP. The subjects are notified by the instructions that the sale mechanisms are different, though the subjects must discern the difference themselves. The card using the BDM sale mechanism is referred to as WS-BDM, while the card using the first price sale mechanism is referred to as WS-FP.

We include this treatment in our experiment to observe the behavior of subjects when confronted with a BDM and a FP mechanism simultaneously. By explicitly telling subjects that the two cards implement different payment mechanisms, we expect a greater proportion of them to correctly recognize the games they are playing and thus move the bid distributions towards their respective optima.

Copies and examples of all material used during the experiment (instructions, consent forms, experiment cards) can be found in the Appendix.

3.3 Procedures

Experimental sessions lasted approximately twenty-five minutes and were run in first–year undergraduate classes at the University of Victoria. Subjects were not trained and were told that the purpose of the research project was to understand how participants take advantage of simple trading opportunities in different forms.

All experimental material was prepackaged in envelopes and handed out in an alternating pattern, ensuring that each treatment's envelopes was homogeneously distributed across the entire classroom (a fact made known to the subjects). For every envelope of FP handed out, two envelopes of BDM1, BDM2, and WS were each handed out. Subjects were instructed not to talk to one another until the experiment was completed. Very few instances of talking were noted by proctors. All data were gathered in arena-style classrooms: 235 participated in the first session, 309 in the second, and 36 in the third. A total of 579 subjects participated: 164 in BDM1, 159 in BDM2, 171 in WS, and 85 in FP. In the first two sessions the subject to proctor ratio was roughly 30:1; in the third it was 18:1. The data were collected over the period September 22-23, 2015. The experiment was run using Canadian dollars.

Of the 164 subjects that participated in BDM1, 163 completed both experiment cards; 158 of the 159 subjects that participated in BDM2 completed both experiment cards; 170 of the 171 subjects that participated in WS completed both experiment cards; and 83 out of 85 of the subjects that participated in FP completed both experiment cards. It is unknown why five subjects only completed one of the two cards presented to them; however, the data they provided is used when appropriate.

Subjects were informed they could earn up to \$10. The average payout was \$4.91, the minimum was \$2, and the maximum was \$9.75. Table 9 in the Appendix breaks down payout results by treatment.

For convenience of both the experimenters and the subjects, payouts were rounded up to the nearest quarter dollar. Subjects were not aware of the rounding up at the time of the experiment. Cards handed back without being filled out were considered given back and not sold; consequently payment was not made on them.

4 Data, CP Replication, and Revealed Misconceptions

Table 1 presents summary descriptive statistics for all four treatments. We refer to that table throughout the rest of this paper. Each treatment is broken down into two sub-treatments, which correspond to a repetition of the task for the first three treatments and to the two distinct tasks done simultaneously in the last treatment. Table 1 first presents simple statistics on the distribution of bids and then computes the fraction of offers measured at key points in the distribution that correspond to the optimal offers under three auction rules (\$2 for all BDM, \$3.5 for FP with one random bid and \$3 for FP with two random bids). The table also reports the fraction of outliers bids (offers below \$.10 and above \$5). The bottom part of the table reproduces results on misconception regarding the rule used to compute payoffs as defined in CP, and discussed in section 4.2.

4.1 CP Replication

CP provide five main results in Section V of their paper. Our data allows to test four of these results (Results 1, 2, 3, and 5).[6] We compare our baseline findings in BDM1 with these four results. When relevant, we also discuss results from BDM2 keeping in mind that this treatment differs from CP treatments in that subjects compete against two random bids instead of one. Detailed information can be found in the Appendix.

CP 1. *With simple instructions and no training or feedback, the BDM does not provide reliable measures of preferences for the induced-value object.*

In BDM1-1, 7.9% of subjects offer within 5 cents of $2 while in BDM2-1, 8.8% of subjects offer with 5 cents of $2. The corresponding number in CP is higher 16.7%.

CP 2. *A second round of decisions (including subjects rereading the instructions and after receiving feedback) nearly doubles the number of subjects stating the correct valuation.*

The fraction of subjects offering amounts within 5 cents of $2 increases to 13.5% in BDM1-2 and 13.3% in BDM2-2. Fisher's exact test gives p-values of 11.1% and 21.5%, respectively, indicating that this is not a statistically significant shift in either treatment. However, the difference in statistical significance may be explained by the fact that we test this hypothesis using BDM1 and BDM2 samples (about 160 subjects each) while CP use their entire sample pooling different sub-treatments (244 subjects). In fact, when we pool BDM1 and BDM2 treatments (which is similar to CP pooling data from sub-treatments with different supports for the random price), the increase across rounds in the fraction of offers within 5 cents of $2, is significant (the Fishers exact test gives a p-value of 0.0432).

CP 3. *Subjects that chose the theoretically optimal offer price (near $2) on the first card also usually choose the theoretically optimal offer price on the second card. Subjects who did not choose optimally on the first card tend to choose a different offer price on the second card.*

Take BDM1 where 163 subjects completed both cards. Out of these subjects, 13 offered a bid within 5 cents of $2 in BDM1-1. Of these 13 subjects, 76.9% offered the same amount in BDM1-2. Of the 150 subjects who did not offer within 5 cents of $2, 79.3% offered a different amount in BDM1-2. As put in CP "The hypothesis that the stability of choice is the same for those who chose optimally and those who did not choose optimally on the first card is strongly rejected" (p. 1248) (Fisher's exact test p-value < 0.001). These results extend when we compare stability of choice across BDM2-1 and BDM2-2 (Fisher's exact test p-value < 0.002).

CP 5. *Subjects who were "exposed" to their mistake (in the sense that a different offer amount would have increased their payoff) were more likely to choose a correct offer in round 2.*

[6]We cannot investigate Result 4 because we have used a single upper-bound ($5) for the support of the random price in our treatments.

In BDM1, exposed subjects are more likely to move toward the optimum (bid within 5 cents of $2) than non-exposed ones. They are also less likely to move away from the optimum. Both these results are statistically significant. However, exposed subjects are not more likely to move onto the optimum. For BDM2, exposed subjects are more likely to move toward the optimum. See explanations and Tables 6 and 7 in the Appendix for a complete breakdowns of these results.

To sum up, we conclude that our results largely agree with CP's main findings:

Result 1. *Results 1-3 and 5 from CP are replicated with similar quantitative effects and statistical significance.*

This validation of CP's findings establishes a solid ground for the interpretation of the new treatments that follow.

4.2 Revealed Misconception

Folllowing CP, we say that a subject has *first price misconception* (FPM) in a given BDM sub-treatment (BDM1-1, BDM1-2, BDM2-1, BDM2-2, and WS-BDM) if she wins and requests to be paid her offer price instead of the posted price. By symmetry, we say that a subject has *second price misconception* (SPM) in a FP sub-treatment (FP and WS-FP) if she wins and asks to be paid the posted price instead of her offer price. Revealed misconceptions are errors in the reported payment requested by subjects. Although these mistakes do not affect payoffs, they reveal something about subjects' understanding about the rule used to compute payoffs. As in CP, we use the term possible misconception to refer to the instances in which a subject may or may not have had a misconception, but could not reveal it as she did not win in either round (her offer price was less than the posted price in both sub-treatments).

The lower part of Table 1 presents evidence on FPM and SPM. As a benchmark, CP report that 11.8% of subjects explicitly revealed a misconception on the experiment card (i.e., they asked to be paid their offer price, not the posted price when the posted price is greater than their offer price). The corresponding FPM rate in BDM1 is 13.4%. As these numbers accord quite well, it can be assumed that a group of first price misconceivers, similar in relative size to that in CP, is present in our data. The proportion of subjects possibly harboring FPM in BDM1 is 31.1%—this number is 33.5% in CP. The BDM1 misconception rate accords well with the misconception rate present in CP, providing evidence that a group of first price misconceivers, as defined in CP, is present and of similar size in our dataset.

The rate of FPM varies over the different sub-treatments. Ex ante we hypothesized the WS treatment would reduce the rate of FPM. It did not. The rate of FPM in WS-BDM, 9.9%, is not statistically different from that in BDM1-1, 6.1%. The similar misconception rates in BDM1-1 and WS-BDM indicate that confronting subjects with both mechanisms simultanenously (that is, giving information on FP in addition to BDM), does not affect FPM.[7]

Result 2. *Revealed misconception is found only for BDM (not for FP) when subjects perform a single task. Revealed misconception increases and is even found in the FP task when*

[7] Subjects make fewer FPM in payoff computation in BDM2: we have 1.9% FPM out of 34% who won at least one card instead of 13.5% versus 69.9% in BDM1.

subjects have to perform simultaneously the misconceived task and the task it is misconceived for.

The rate of SPM in WS-FP, 7.6%, is statistically greater than that in FP1, 1.2%. Unlike the instances of FPM which were expected, the instances of SPM were a surprise. If one treats the SPM rate in FP1, 1.2%, as the baseline SPM rate, the subjects we define as second price misconceivers in WS-FP (7.6%) may in fact be the result of a treatment effect. In other words, seeing both payment mechanisms confused, rather than helped these subjects!

5 Results: BDM, First Price and Competition

The rest of the paper focuses on the first rounds of BDM1, BDM2, FP and on the WS treatment. We compare five sub-treatments: BDM1-1, BDM2-1, FP1, WS-BDM and WS-FP. We repeatedly refer to Tables 2, 3, and 4 which provide various tests of equality regarding different features of the distributions in these five sub-treatments. Table 2 provides results of variance ratio tests, which test the equality of variances across the sub-treatments; Table 3 shows the results of Mann-Whitney U-tests, which test whether two independent samples come from populations with the same distribution; and Table 4 reports the results of Pearson's chi-squared tests, which test whether the two samples came from distributions with the same median.[8]

5.1 First Price Auction (FP1)

Premiss 2 in CP theory says that subjects do not harbor GFM for FP. This premiss is consistent with the experimental literature on first price auctions which has not reported systematic bias in bidder strategy (Kagel and Levin, 1993). CP, however, have also warned us that game procedures can influence misconception in general and GFM in particular. Thus, experiment FP1 is a control experiment that holds constant all game procedure. The environment is identical to BDM1 in all respect but the auction rule used to determined payoffs.

Result 3. *The distribution of bids in FP1 is consistent with subjects bidding the theoretical revenue maximizing bid of \$3.5 with noise.*

This finding is consistent with Premisses 2 and 3. The observation that subjects compute their payoff properly (no SPM in Table 1) also supports the conclusion that GFM does not apply to FP1 even after controlling for all game procedure.

5.2 Comparison of BDM1-1 and FP1

We look at the similarities and differences in the distributions of first round offers of the BDM1 and FP treatments. A quick look at Table 1 shows that the mean of FP1 is higher than that of BDM1-1. Moreover, all tests of distribution similarity are rejected at the 5%

[8]Mann-Whitney U-tests and Pearson's chi-squared tests are used rather than t-tests, as treatment data are not normally distributed.

significance level, except the variance ratio test. The two raw distributions of offers appear to be statistically different. Subjects bid more in FP resulting in the distribution of bids in FP1 stochastically dominating the distribution of bids in BDM1-1.

Result 4. *Subjects bid more in FP1 than in BDM1-1*

This is consistent with CP interpretation of BDM1-1 bids. There are two types of bidders: theoretical BDM and subjects that misconceive BDM for FP. FP1, however, has only FP bidders. Since FP bidders bid more than the theoretical BDM optimum bid, we would expect the FP1 bid distribution to stochastically dominate the BDM1-1 bid distribution.

The optimal bid for non-misconceived subjects is $2 in BDM1-1. About 7.9% of the subjects of bids around $2 in BDM1-1. CP conjectured that these subjects must be BDM optimizers. However, we find a similar fraction of bids around $2 in FP1. Indeed, the proportion of offers within 5 cents of $2 is statistically indistinguishable in BDM1-1 and FP1 (proportions test p-value = 0.9323).

Result 5. *The fraction of subjects that bids near $2 is the same in BDM 1-1 and FP1.*

The proportions of subjects offering within 5 cents of $2 in both sub-treatments is statistically the same, indicating that those bids within 5 cents of $2 in BDM1-1 may not be BDM optimizers as conjectured by CP.[9] It is not possible to associate bids of $2 in BDM as correctly optimized BDM bids because we observe a similar fraction of bids of $2 in FP. These bids are also consistent with the noise associated with FP bids. This qualifies CP's choice to classify $2 bid as BDM optimizers and calls for care in interpreting these bids.

Another type of misconception is present in BDM1-1. There are six offers below 10 cents in BDM1-1, and zero of such offers in FP1. A low offer in the BDM represents a specific type of misconception in which the subjects ensure they will be able to sell their card, but do not process that the random draw could be between $0 and $2. The proportions of offers less than 10 cents are statistically different at the 10% level of significance, but not at the 5% level of significance.

5.3 Competition: BDM1-1 versus BDM2-1

The purpose of including the BDM2 treatment is to inspect the response of CP's first price misconceivers to a change in game parameter. The optimal offer in BDM2-1 is $2—just as in BDM1 and WS-BDM; however, the optimal offer under first-price misconception is $3.00, not $3.50 as in BDM1-1. This is because of the addition of a second random price calls for a more aggressive bid. According to Premiss 2, the group of misconceivers should respond to this change in game parameter. As a result, one would expect the BDM2-1 bid distribution to shift to the left relative to that of BDM1-1.

Result 6. *Subjects do not bid less when there is an additional random price.*

The mean of BDM2-1 is $3.27, higher than that of BDM1-1, $2.93. The medians and modes of the distributions are both equal to $3.00. The mean and median of the BDM2-1

[9] The same conclusion holds if we look at BDM2-1 instead. The proportions of offers within 5 cents of the optimum in BDM1-1 and BDM2-1 are practically the same, 7.9% and 8.8%, respectively.

bid distribution are not lower relative to those of the BDM1-1 bid distribution. Figure 1 shows the CDFs for BDM1-1 and BDM2-1 graphed one upon another. When comparing BDM1-1 and BDM2-1s distributions, Mann-Whitney's two sample U-test provides a p-value of 5.9%, while Pearson's chi-squared test provides a p-value of 21%. A variance ratio test shows that at the 1% level of significance, the two samples have different variances. There is clearly some evidence for, and some evidence against, these samples coming from the same distribution.

The same conclusion holds if we look instead at the proportions of offers within 5 cents of \$3.00, 26.2% in BDM1-1 and 20.1% in BDM2-1. These figures are not statistically different from one another (proportions test p-value = 0.1947), casting doubt on CP's claim that a group of subjects harboring a first price misconception, but otherwise behaving substantially as game theory predicts, actually exists. If this group were to exist, and was of any meaningful size, there would be a statistically greater proportion of offers within 5 cents of \$3.00 in BDM2-1 than BDM1-1. This is not the case. It is also of interest to note that the proportions of offers within 5 cents of \$3.50 are statistically indistinguishable in both BDM1-1 and BDM2-1 at all conventional levels of significance.

Experimental evidence from FP auctions shows that bidders respond to the number of bidders by putting more aggressive (lower in our experiment) bids as predicted by theory (Kagel and Levin, 1993). However, we reject the prediction that GFM subjects respond to and increase in competition (decrease their offer with an additional bidder.) Misconception does not carry through for this auction dimension. Based on this alone, the hypothesis that misconceived BDM bidders behave like FP optimizers is squarely rejected.

This finding must be constrasted with CP Result 4. CP have four sub-treatments. In these sub-treatments, the range of of the random price is $[0, \overline{p}]$ and $\overline{p}$ take values $4, 5, 6, 7, 8$. The optimal FP bid is $1 + 0.5\overline{p}$. Thus, varying $\overline{p}$ by one unit, as CP do in Result 4, is equivalent to increasing the number of random offers from one to two, as we do in BDM2. The point is that CP vary a game parameter (upper bound of random price) that asks for the same FP response as the game parameter we vary (number of random offers). The average offer increases almost monotically with $\overline{p}$ across sub-treatments and this is despite the fact that they have relatively few observations in each subtreatment (about 40). In contrast, we find no response to an increase in competition when we increase the number of bidders (and we have about 160 subjects in each sub-treatment). To conclude, our result is not due to having a small sample and it is not due either to measuring too small a potential response.

5.4 Simultaneous Task Completion (WS)

In the WS treatment, we present the BDM and FP tasks simultaneously. The only difference between the BDM1-1 (FP1) card and the WS-BDM (WS-FP) card is that the WS cards were presented together. We included this treatment to inspect the behavior of subjects when confronted with both payment mechanisms. Seeing the WS-FP (WS-BDM) card may have influenced the offers made in WS-BDM (WS-FP). Explicitly telling subjects that the two cards implement different mechanisms could have two effects. If comparing information helps subjects understanding the two tasks, we would expect them to consider different strategies in both sub-treatments which would drive the distributions apart, toward their respective optima. Alternatively, doing both task together may increase confusion. Subjects have to absorb and process more information. This increase in complexity may lower task comprehension and increase GFM.

Result 7. *When subjects are asked to complete both BDM and FP tasks simultaneously, bidding strategies do not differ across tasks.*

Results of variance ratio and Wilcoxon matched-pairs signed-rank tests indicate that the offer distributions of WS-BDM and WS-FP cannot be distinguished statistically.[10] Figure 2 shows the CDFs of WS-BDM and WS-FP graphed one upon the other. The fact that the two curves are almost identical is certainly surprising, but may testify to the difficulty subjects have when determining an optimal strategy in the BDM. Despite being explicitly told that the two cards have different payment mechanisms, subjects tend to behave more or less identically in both, in a fashion more consistent with a first price bidding behavior.

Interestingly, this treatment displays the highest fraction of errors in payoff computation (9.9% FPM in BDM and 7.6% SPM in FP). This is certainly consistent with the view that doing both tasks together increases confusion in payoff computation. Confusion about the difference in the payment mechanisms, seen in the high rates of both first and second price misconception, may also be responsible for the statistically indistinguishable distributions of the sub-treatments.

This finding should be constrasted with Bartling, Engl, and Weber (2014) who show that it is possible to reduce GFM (and induce subject to reveal their true preference) using the strategy method. The strategy method decomposes the BDM tasks into simpler subtasks and doing so may help comprehension. On the other hand, adding the FP task to the BDM task appear to decrease comprehension.

These findings also clash with Premise 1. If two categories of bidders were present, we should reject the hypothesis that the offer distributions are statistically the same. Instead, we cannot reject that the two distributions are the same. We do not see two distinct group of bidders in the WS treatment. Keeping in line with CP's theory, we have to conclude that the WS treatment eliminates BDM optimizers. Only FP misconceivers are left. This treatment provides support for a strong interpretation of CP's theory. The fact that a change in frame in WS appears to increase, instead of reducing GFM, also suggests that GFM is context dependent.

We also compare bidding strategies within subjects across the BDM and FP auction. Figure 3 provides a scatter plot of matched offers in the WS treatment with one outlier removed. All data points in Figure 3 are weighted by frequency: the larger the circle, the greater the number of subjects with offers at that point on the graph. It is evident that a majority of subjects offer similar amounts in both sub-treatments, and that roughly the same number of subjects offer more in one sub-treatment than the other.

Result 8. *Decision noise is present both within and across subjects.*

Overall, 43.5% of subjects offered a higher amount in WS-FP, 35.9% offered a higher amount in WS-BDM, and 20.6% offered the same amount in both. This last figure increases to 24% if we consider bids in WS-FP and WS-BDM that were within 5 cents of each other.

[10] The two distributions are statistically indistinguishable from that of FP1s, but statistically different from that of BDM1-1s at the 5% level.

The average offer change for the subjects that offered a higher amount in WS-FP and for the subjects that offered a higher amount in WS-BDM, are statistically the same.[11] According to Premiss 2, subjects should understand that both cards correspond to the same game. However, the large majority of subjects make different offers. This highlights the importance of within subject noise in bids.

Table 5 summarizes the matched offers of subjects in terms of their optimality. To do this, the offers from WS-BDM and WS-FP have been standardized: $2 has been subtracted from all WS-BDM offers and $3.50 has been subtracted from all WS-FP offers. The absolute value of each standardized offer has been taken to treat deviations of equal magnitude from optimality in either direction equally. Overall, 70% of subjects offered an amount closer to the FP optimum in WS-FP than the BDM optimum in WS-BDM, while 24% of subjects did the opposite, and 6% of subjects made offers that were equidistant from optimality in both treatments.

6 Conclusions

This paper develops three new treatments to explore the robustness of the theory of game form misconception that CP proposed to explain bidding mistakes in BDM. CP theory is based on three premises: (a) bidders are composed of two groups, BDM optimizers and misconcieved subjects, (b) misconceived subject confuse BDM for a FP auction, (c) all bidders make decisions with noise. The new evidence presented in this paper is broadly broadly consistent with these three premises. Some of the evidence, however, points toward a qualified interpretation of the theory of GFM:

1. An increase in competition does not increase the aggressiveness of first price misconceivers as should happen under GFM.

2. We do not find any evidence for pure BDM optimizers who bid without noise the first time they bid in BDM.

3. Showing subjects both BDM and FP tasks simultaneously does not decrease misconception.

The first finding calls for caution when applying CP theory of GFM. The third finding supports CP claim that a theory of perception is an important missing element to understand bidding decisions. More importantly, our results could help researchers who use the BDM and second price auctions in practice to better interpret bids. Economists have long been puzzled by bidding behavior in BDM and second price auctions. CP's theory of GFM offers a promising framework to interpret systematic deviations from optimal bidding. CP's theory is also relevant to those who design mechanisms to achieve particular ends because it shows that untrained subjects can make systematic and predictable mistakes that are not necessarily representative of behavior in the field by experienced subjects.

[11] A proportion ratio test fails to reject the null of similar proportions when comparing the proportion of subjects who offered a higher amount in WS-BDM, versus those who offered a higher amount in WS-FP at all conventional levels of significance.

References

Kagel, J. H., and D. Levin. 1993. Independent private value auctions: Bidder behaviour in first-, second-and third-price auctions with varying numbers of bidders. *The Economic Journal*:868–879.

Bartling, B., Engl, F., & Weber, R. A. (2014). Game form misconceptions do not explain the endowment effect. *CESifo Working Paper Series* No. 5094. Available at SSRN: http://ssrn.com/abstract=2536297.

Becker, G. M., DeGroot, M. H., & Marschak, J. (1964). Measuring utility by a single response sequential method. *Behavioral Science, 9*(3), 226-232.

Benartzi, S., & Thaler, R. H. (2007). Heuristics and biases in retirement savings behavior. *The Journal of Economic Perspectives, 21*(3), 81-104.

Binmore, K.,& Samuelson, L. (1994). An economist's perspective on the evolution of norms. *Journal of Institutional and Theoretical Economics (JITE)/Zeitschrift für die gesamte Staatswissenschaft*, 45-63.

Cason, T. N., & Plott, C. R. (2014). Misconceptions and game form recognition: Challenges to theories of revealed preference and framing. *Journal of Political Economy, 122*(6), 1235-1270.

Cooper, D. J., & Fang, H. (2008). Understanding overbidding in second price auctions: An experimental study*. *The Economic Journal, 118*(532), 1572-1595.

Goeree, J. K., Holt, C. A., & Palfrey, T. R. (2002). Quantal response equilibrium and overbidding in private-value auctions. *Journal of Economic Theory, 104*(1), 247-272.

Harrison, G. W. (1990). Risk attitudes in first-price auction experiments: A Bayesian analysis. *The Review of Economics and Statistics, 72*(3), 541-546.

Heitjan, D. F. (1989). Inference from grouped continuous data: a review. *Statistical Science, 4*(2) 164-179.

Horowitz, J. K. (2006). The Becker-DeGroot-Marschak mechanism is not necessarily incentive compatible, even for non-random goods. *Economics Letters, 93*(1), 6-11.

Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1991). Anomalies: The endowment effect, loss aversion, and status quo bias. *The Journal of Economic Perspectives, 5*(1) 193-206.

Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1990). Experimental tests of the endowment effect and the Coase theorem. *Journal of Political Economy, 98*(6),1325-1348.

Karni, E., & Safra, Z. (1987). "Preference reversal" and the observability of preferences by experimental methods. *Econometrica: Journal of the Econometric Society, 55*(3), 675-685.

List, J. A. (2004). Neoclassical theory versus prospect theory: Evidence from the marketplace. *Econometrica, 72*(2), 615-625.

Plott, C. R., & Zeiler, K. (2005). The willingness to pay-willingness to accept gap, the "endowment effect", subject misconceptions, and experimental procedures for eliciting valuations. *American Economic Review, 95*(3), 530-545.

Selten, R. (1991). Evolution, learning, and economic behavior. *Games and Economic Behavior, 3*(1), 3-24.

Simon, H. A. (1956). Rational choice and the structure of the environment. *Psychological Review, 63*(2), 129-138.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science, 185*(4157), 1124-1131.

Table 1: Descriptive Statistics & Data Patterns

	BDM1-1	BDM1-2	BDM2-1	BDM2-2	WS-BDM	WS-FP	FP1	FP-2
mean ($)	2.93	2.82	3.27	2.93	3.19	3.24	3.30	3.20
median ($)	3.00	2.94	3.00	3.00	3.14	3.32	3.25	3.23
mode ($)	3.00	3.00	3.00	3.00	3.00	4.00	4.00	3.00
sd ($)	0.98	1.17	1.21	1.21	1.07	1.11	0.92	0.91
variance ($\$^2$)	0.97	1.36	1.47	1.47	1.14	1.24	0.85	0.83
max ($)	5.00	8.70	10.00	7.00	7.00	9.00	5.10	5.00
min ($)	0.00	0.00	1.00	0.00	0.01	0.49	1.00	1.00
offer≤0.10 (count)	6	6	0	4	3	0	0	0
1.95≤offer≤2.05 (count)	13	22	14	21	10	12	7	3
3.45≤offer≤3.55 (count)	16	9	16	14	26	18	13	8
2.95≤offer≤=3.05 (count)	43	25	32	21	35	24	11	16
offer≥5.00 (count)	0	1	4	3	1	1	2	0
offer≤0.10 (%)	3.7%	3.7%	0.0%	2.5%	1.8%	0.0%	0.0%	0.0%
1.95≤offer≤2.05 (%)	7.9%	13.5%	8.8%	13.3%	5.8%	7.1%	8.2%	3.6%
3.45≤offer≤3.55 (%)	9.8%	5.5%	10.1%	8.9%	15.2%	10.6%	15.3%	9.6%
2.95≤offer≤3.05 (%)	26.2%	15.3%	20.1%	13.3%	20.5%	14.1%	12.9%	19.3%
offer≥5.00 (%)	0.0%	0.6%	2.5%	1.9%	0.6%	0.6%	2.4%	0.0%
First Price Misconception (count)	10	15	2	1	17	-	-	-
Total First Price Misconception (count)	22		3		17	-	-	
Second Price Misconception (count)	-	-	-	-	-	13	1	2
Total Second Price Misconception (count)	-		-		-	13	3	
Possible Misconception, but not shown (count)	51		105		67		42	
First Price Misconception (%)	6.1%	9.2%	1.3%	0.6%	9.9%	-	-	-
Total First Price Misconception (%)	13.4%		1.9%		9.9%	-	-	
Second Price Misconception (%)	-	-	-	-	-	7.6%	1.2%	2.4%
Total Second Price Misconception (%)	-		-		-	7.6%	3.5%	
Possible Misconception, but not shown (%)	31.1%		66.0%		39.2%		49.4%	
N	164	163	159	158	171	170	85	83

Theoretical optima: BDM1, BDM2, & WS-BDM: $2.00; FP & WS-FP: $3.50

Theoretical optima under first price misconception: BDM1 & WS-BDM: $3.50; BDM2: $3.00

Table 2: Results of Variance Ratio Tests

	BDM1-1	BDM1-2	BDM2-1	BDM2-2	WS-BDM	WS-FP	FP1	FP-2
BDM1-1		0.7114** (0.0306)	0.6602*** (0.0088)	0.6586*** (0.0085)	0.8482 (0.2899)	0.7807 (0.1123)	1.138 (0.5140)	1.1645 (0.4439)
BDM1-2			0.9281 (0.6372)	0.9258 (0.6265)	1.1923 (0.2574)	1.0975 (0.5493)	1.5995** (0.0175).	1.637** (0.0136)
BDM2-1				0.9975 (0.9874)	1.2847 (0.1090)	1.1825 (0.2839)	1.7234*** (0.0063)	1.7638*** (0.0048)
BDM2-2					1.2879 (0.1060)	1.1855 (0.2774)	1.7277*** (0.0061)	1.7682*** (0.0047)
WS-BDM						1.0864 (0.5901)	1.3415 (0.1322)	1.373 (0.1077)
WS-FP							0.6862* (0.0544)	1.4916** (0.0432)
FP1								1.0235 (0.9169)

Table shows F-statistics with p-values in parentheses.
$*p < 0.10$, $**p < 0.05$, $***p < 0.01$, $****p < 0.001$

Table 3: Results of Mann-Whitney Two-Sample U-tests

	BDM1-1	BDM1-2	BDM2-1	BDM2-2	WS-BDM	WS-FP	FP1	FP-2
BDM1-1		1.095 (0.2737)	1.890* (0.0588)	0.456 (0.6487)	2.163** (0.0306)	-2.758*** (0.0058)	-2.498** (0.0125)	-2.044** (0.0410)
BDM1-2			-3.106*** (0.0019)	-0.762 (0.4459)	-3.347**** (0.0008)	-3.601**** (0.0003)	-3.359**** (0.0008)	-2.948*** (0.0032)
BDM2-1				2.846*** (0.0044)	-0.104 (0.9173)	-0.568 (0.5703)	-0.763 (0.4455)	-0.274 (0.7840)
BDM2-2					-2.276** (0.0228)	-2.594*** (0.0095)	-2.498** (0.0125)	-2.060** (0.0394)
WS-BDM						-1.020 (0.3079)	-0.710 (0.4780)	-0.138 (0.8901)
WS-FP							-0.172 (0.8635)	0.410 (0.6820)
FP1								0.809 (0.4183)

Table shows U-statistics with p-values in parentheses.
Wilcoxon matched-pairs signed-rank test used when data is matched.
$*p < 0.10$, $**p < 0.05$, $***p < 0.01$, $****p < 0.001$

Table 4: Results of Pearson's Chi-Squared Tests

	BDM1-1	BDM1-2	BDM2-1	BDM2-2	WS-BDM	WS-FP	FP1	FP-2
BDM1-1		- -	1.5744 (0.210)	0.0267 (0.870)	3.8147* (0.051)	7.5763*** (0.006)	5.939** (0.015)	4.3484** (0.037)
BDM1-2			5.4765** (0.019)	1.5719 (0.210)	9.3036*** (0.002)	14.7374**** (0.000)	11.2209*** (0.001)	8.9643** (0.003)
BDM2-1				- -	0.4531 (0.501)	1.1102 (0.292)	2.1845 (0.139)	1.0833 (0.2980)
BDM2-2					3.1331* (0.077)	6.5691** (0.010)	5.2218** (0.022)	3.751* (0.053)
WS-BDM						- -	0.863 (0.353)	0.1611 (0.688)
WS-FP							0.1255 (0.723)	2.0719 (0.150)
FP1								- -

Table shows χ^2 statistics with p-values in parentheses.
$*p < 0.10$, $**p < 0.05$, $***p < 0.01$, $****p < 0.001$

Table 5: WS Treatment Data

	#	%
Closer to optimum in WS-FP than optimum in WS-BDM	119	70
Closer to optimum in WS-BDM than optimum in WS-FP	41	24
Same distance from optimum in WS-FP and WS-BDM	10	6
Offers within 5 cents of each other	41	24
Offers within 10 cents of each other	41	24
N	170	100

Figure 1: Cumulative Density Function Comparisons for Various Sub-Treatments

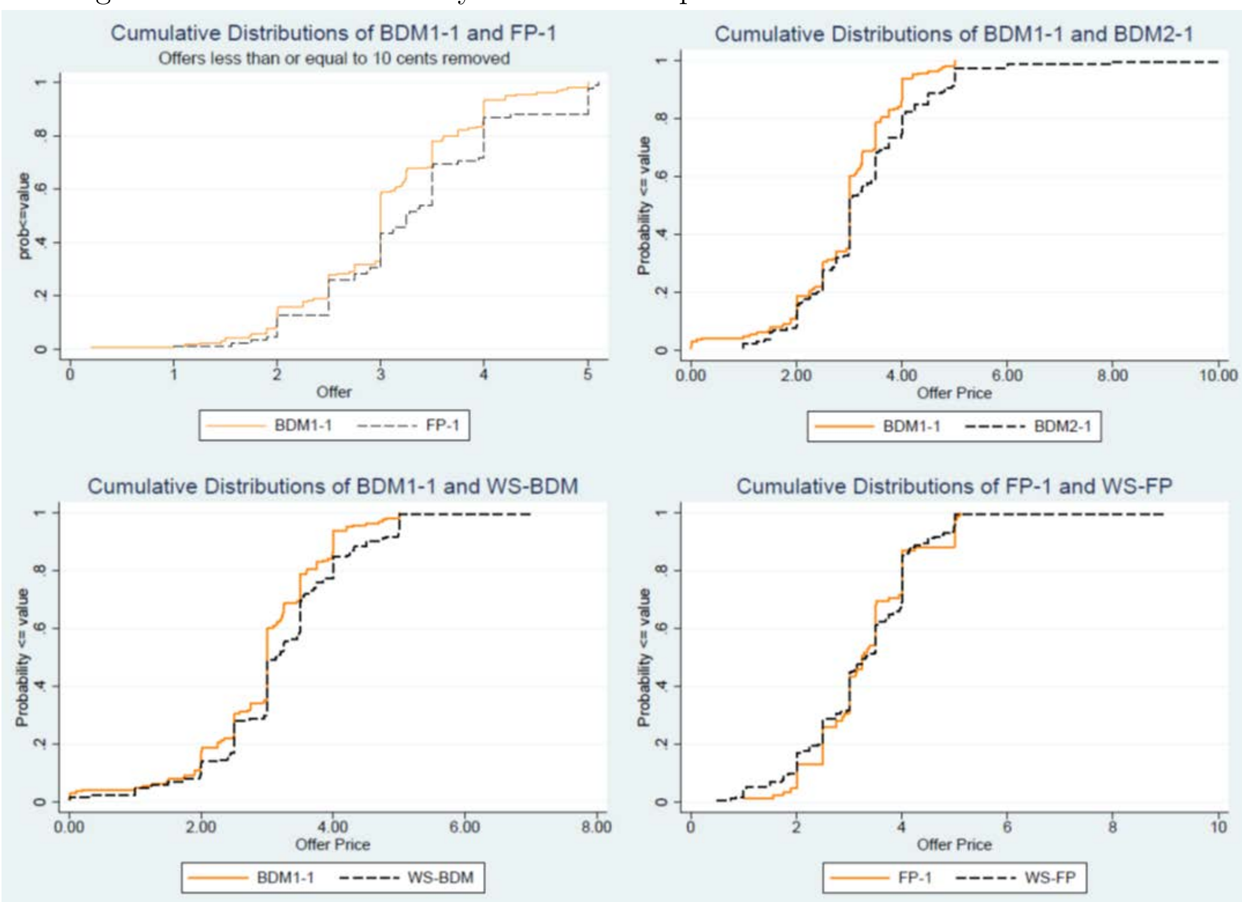


Figure 2: CDF Comparison of WS Sub-treatments

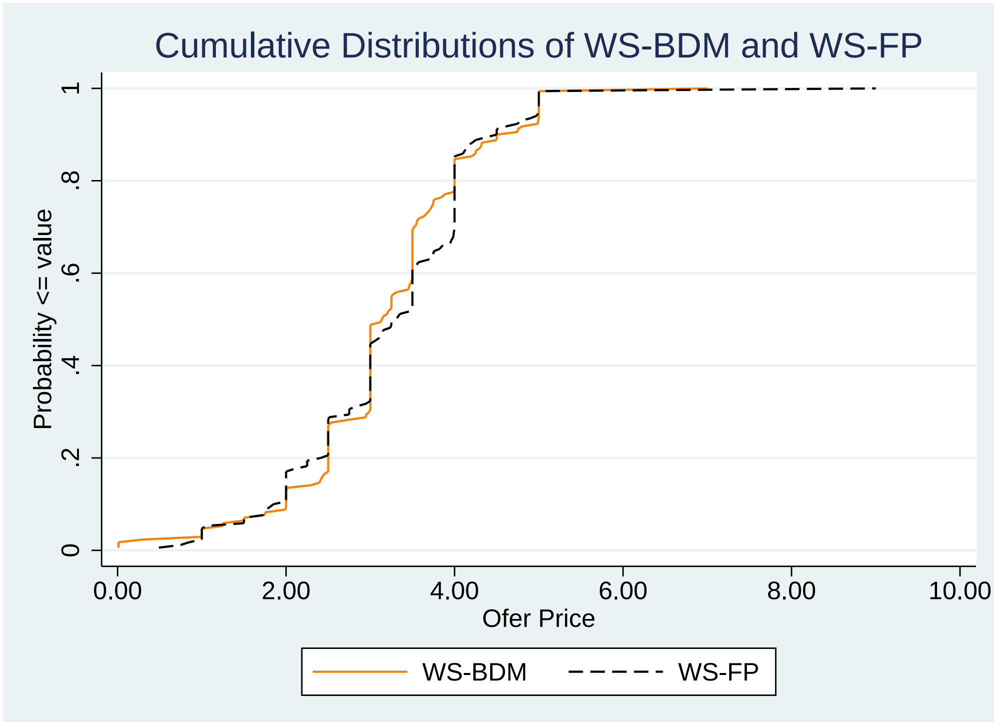
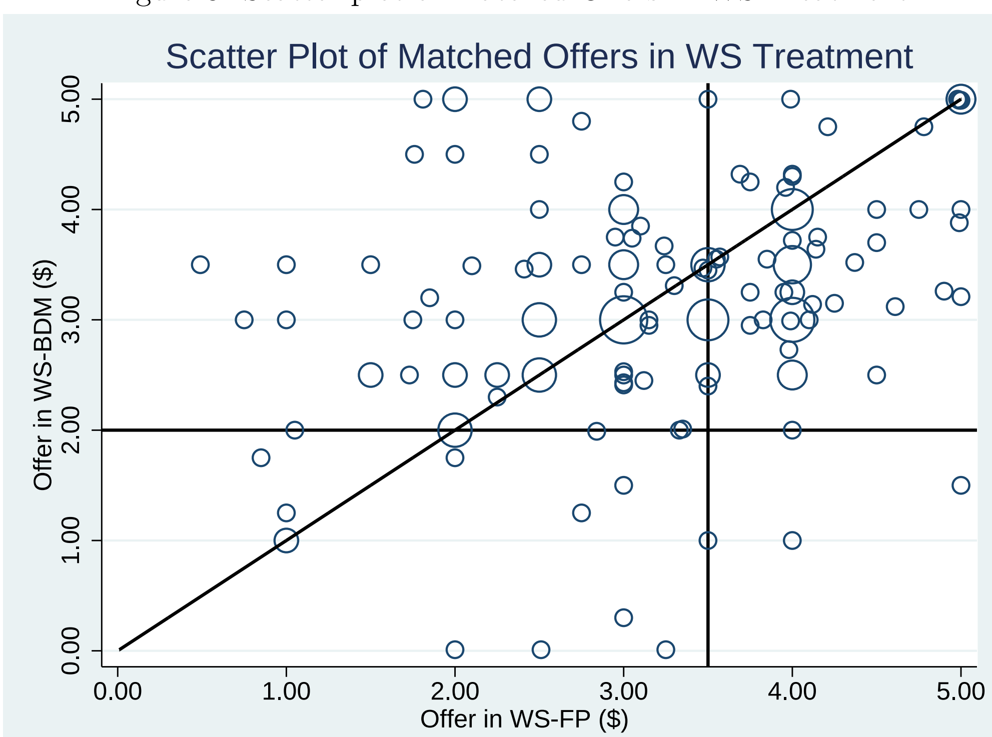


Figure 3: Scatter plot of Matched Offers in WS Treatment



7 Appendix

7.1 Replication of CP Results 3 and 5

Result 3: Subjects that chose the theoretically optimal offer price (near $2) on the first card also usually choose the theoretically optimal offer price on the second card. Subjects who did not choose optimally on the first card tend to choose a different offer price on the second card.

BDM1: Of the 163 subjects that completed both cards, 150 did not choose within 5 cents of $2 on the first card. Of these 150, 119 (79.3%) chose a different offer price on the second card and 31 (20.7%) indicated the same offer price. Of the 163 subjects, 13 chose within 5 cents of $2 on the first card. Of these 13, 10 (76.9%) chose the same offer price and 3 (23.1%) chose a different offer price on the second card. The hypothesis that the stability of choice is the same for those who chose optimally and those who did not choose optimally on the first card is strongly rejected (Fishers exact test p-value= 0.000).
BDM2: Of the 158 subjects that completed both cards, 144 did not choose within 5 cents of $2 on the first card. Of these 144, 116 (80.6%) chose a different offer price on the second card and 28 (19.4%) indicated the same offer price. Of the 158 subjects, 14 chose within 5 cents of $2 on the first card. Of these 14, 9 (64.3%) chose the same offer price and 5 (35.7%) chose a different offer price on the second card. The hypothesis that the stability of choice is the same for those who chose optimally and those who did not choose optimally on the first card is strongly rejected (Fishers exact test p-value= 0.001).

Result 5: Subjects who were exposed to their mistake (in the sense that a different offer amount would have increased their payoff) were more likely to choose a correct offer in round 2.

Of the subjects that did not offer within 5 cents of $2 in the first round of BDM1, the fractions of subjects who offered $2 in the second round are identical for those who were exposed to a round one error and those who were not. In BDM2 the fraction of subjects who offered $2 in the second round is greater for those who were exposed to a round one error than those who were not (Fisher's Exact test p-value = 0.7142). In both BDM1 and BDM2, subjects who were exposed to their error were more likely to move towards or onto the optimum, $2. This finding is statistically significant in BDM1 (Fisher's exact test p-value < 0.002), but not in BDM2 (Fisher's exact test p-value = 0.0674). Subjects exposed to a round 1 error in BDM1 were less likely to move away from the optimum than those who were not. This result is statistically significant (Fisher's exact p-value < 0.01). Subjects exposed to a round 1 error in BDM2 were less likely to move away from the optimum than those who were not; however this result is not statistically significant (Fisher's Exact test p-value = 0.8432).

7.2 Evidence of Heaping

It is of interest to note that in all but one sub-treatment, over half of offers are equal to either full dollar or half dollar amounts. The data, therefore, are coarse. In a discussion on

Table 6: Adjustment of Round 1 to Round 2 Offers for Subjects Choosing Incorrectly in BDM1-1

	Exposed to Round 1 Error	Not Exposed to Round 1 Error
Total Subjects	41 (100%)	109 (100%)
Move onto optimum ($2)	3 (7.3%)	8 (7.3%)
Move Toward Optimum	25 (61.0%)	35 (32.1%)
Choose same offer ratio	7 (17.1%)	25 (22.9%)
Move away from optimum	6 (14.6%)	41 (37.6%)

Table 7: Adjustment of Round 1 to Round 2 Offers for Subjects Choosing Incorrectly in BDM2-1

	Exposed to Round 1 Error	Not Exposed to Round 1 Error
Total Subjects	41 (100%)	103 (100%)
Move onto optimum ($2)	3 (7.3%)	6 (5.8%)
Move Toward Optimum	22 (53.7%)	39 (37.9%)
Choose same offer ratio	4 (9.8%)	25 (24.3%)
Move away from optimum	12 (29.3%)	33 (32.0%)

missing data, Heitjan and Rubin (1991) note:

> In a number of common situations ... data are neither entirely missing not perfectly present. Instead, we observe only a subset of the complete-data sample space in which the true, unobservable data lie; we refer to this kind of incomplete data as coarse data. Coarse data arise in various ways. Perhaps the most elementary form of coarseness is rounding, which occurs when data values are observed or reported only to the nearest integer. A related problem is that of heaping, which includes the phenomena known as digit preference. A data set is said to be heaped if it includes items reported with various levels of coarseness. For example, histograms of age often exhibit heaps at common ages such as integral multiples of ten years with adults, or integral multiples of six or twelve months with children. (p. 2244)

The data collected in our sample is most definitely heaped. Many subjects show a digit preference for even dollar or half dollar amounts. It is possible that some subjects rounded their offers to the nearest dollar or half dollar as well. Table 8 provides a summary of the extent of heaping present in the data.

According to Heitjan (1989), when dealing with univariate "grouped continuous data", such as the data gathered in this experiment, "the simple mean, $\bar{y}$, is a good estimate of $\mu = EX$, and $\frac{s}{\sqrt{n}}$ is a good summary of the uncertainty about μ in $\bar{y}$. Second, s^2 is not a good estimate of $\sigma^2 = VarX$, but can be improved by subtracting $\frac{h^2}{12}$, where h is the width of the rounding interval for X" (p. 165). Based on the data presented in Table 8, the rounding interval could be interpreted as 50 cents. Correcting the variances of each offer distribution by a constant 0.0208 should have little or no effect on the results of variance ratio tests. The distributional tests performed in this paper, Mann-Whitney U-Tests, Wilcoxon matched-pairs signed-ranked tests, and Pearson's chi-squared tests do not take variances into account

Table 8: Offers at Dollar and Half Dollar Amounts (Count and Percentage)

Offer ($)	BDM1-1	BDM1-2	BDM2-1	BDM2-2	WS-BDM	WS-FP	FP1	FP-2
2.00	9	19	12	18	7	12	7	2
2.50	13	15	11	8	18	14	11	4
3.00	40	24	31	18	32	22	11	16
3.50	15	9	15	12	19	16	12	8
4.00	12	19	11	10	13	28	13	10
4.50	1	1	6	3	3	3	0	1
5.00	3	4	8	7	11	7	8	5
Total	93	91	94	76	103	102	62	46
2.00	5%	12%	8%	11%	4%	7%	8%	2%
2.50	8%	9%	7%	5%	11%	8%	13%	5%
3.00	24%	15%	19%	11%	19%	13%	13%	19%
3.50	9%	6%	9%	8%	11%	9%	14%	10%
4.00	7%	12%	7%	6%	8%	16%	15%	12%
4.50	1%	1%	4%	2%	2%	2%	0%	1%
5.00	2%	2%	5%	4%	6%	4%	9%	6%
Total	57%	56%	59%	48%	60%	60%	73%	55%

and therefore their results will not change if the variances are corrected. The test results presented in this paper should not be affected by this phenomena.

7.3 Information about Experiments

Decision card used for BDM1 treatment and WS-BDM sub-treatment:

DECISION CARD

This card is worth $2.00 to you.

You can sell it by giving us an offer price.

Located under the tape on the other side of this card is a posted price.

You can uncover and view the posted price **only** after you have written down your offer price below.

The posted price was drawn randomly between $0 and $5 (in increments of $0.01). Every possible value had an equal chance of being selected.

If your offer price is **below or equal to the posted price** on the back of the card, then you sell your card at the posted price.

If your offer price is **above the posted price** on the back of this card, then you do not sell your card, but you do collect the $2.00 value of the card.

Write down your offer price: ________

The posted price is under the tape. It is to be viewed only after you have written down your offer price on the other side.

COVERED POSTED PRICE HERE

Check the appropriate box to calculate your earnings:

☐ My offer price is **below or equal to the posted price**.
Pay me the posted price of $________

☐ My offer price is **above the posted price**.
Pay me $2.00.

Your ID number:

Table 9: Payout Information by Treatment

	BDM1	BDM2	WS	FP	TOT
Average	$5.52	$4.43	$5.00	$4.50	$4.91
Min	$3.27	$2.00	$2.58	$2.00	$2.00
Max	$9.75	$7.66	$9.13	$7.00	$9.75
N	164	159	171	85	579