BIDDING BEHAVIOR AND DECISION COSTS IN FIELD EXPERIMENTS

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Whether rationality of economic behavior increases with expected payoffs and decreases with the cognitive cost it takes to formulate an optimal strategy remains an open question. We explore these issues with field data, using individual bids from sealed-bid auctions in which we sold nearly $10,000 worth of sports cards. Our results indicate that stakes do indeed matter, as high-priced ($70) cards produced more of the theoretically predicted strategic behavior than did lower-priced ($3) cards. We find additional evidence consistent with the importance of cognitive costs, as subjects more experienced with sports card auctions exhibited a greater tendency to behave strategically than did less experienced bidders. (*JEL* D44, C93)

I. INTRODUCTION

Positive opportunity costs of mental effort may invalidate the predictions of traditional models of rational (or hyperrational) agents. Conlisk (1996) uses deliberation costs as a recurring theme when discussing four important reasons for incorporating bounded rationality in economic models. Smith and Walker (1993) and Smith and Szidarovszky (1999) present effort models that predict individual behavior will more closely match the predictions of rational-behavior theories as (1) the stakes of the decision increase, and (2) the decision costs decrease. Smith and Walker (1993) find evidence of these two effects in a comprehensive review of 31 published laboratory experiments. Camerer and Hogarth (1999) extend Smith and Walker's survey by examining 74 experimental papers and find evidence in favor of the cognitive-effort theory, noting that "higher levels of incentives have the largest effects in judgment and decision tasks" (p. 34). Although the laboratory evidence is compelling, there has been little verification of these predictions outside the laboratory.[1]

The present article fills this gap by examining field data from 214 multiunit sports card auctions carried out in an active marketplace: on the floor of a sports card show. We auctioned four types of trading cards with book values ranging from $3 to $70, providing significant variation in the stakes of the auction. Our auctions also included two distinct types of subjects: Some auctions had sports card dealers bidding against each other, whereas others had individual card collectors as the participants. This variation allows us to explore the second dimension of decision-cost theory: Do dealers, who commonly participate in sports card auctions and therefore likely require less effort to bid optimally, bid more rationally than nondealers? Our measure of "rational" bidding comes from multiunit auction theory, which predicts strategic "demand reduction" in uniform-price auctions.[2] For each type of

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1. Note, however, the similarities of increasing rewards with the parallel literature that compares hypothetical and actual responses within incentive compatible mechanisms. See, e.g., List (2001) and List and Shogren (1998).

2. A recent wave of theoretical literature has investigated equilibria in uniform-price auctions with multiunit demand (e.g., Noussair [1995], Katzman [1995], Tenorio [1997], Engelbrecht-Wiggans and Kahn [1998], and Ausubel and Cramton [1997]). One main result is that in uniform-price auctions, bidders have a dominant strategy to truthfully reveal their demands for the first unit of the good, but they have an incentive to reduce their bids below their valuations for additional units. The incentive is that one's bid on an additional unit might end up

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bidder and each type of card, we measure this demand-reduction behavior in the uniform-price auction relative to a control (the multiunit Vickrey [1961] auction) where bidders are predicted to fully reveal their demands.

Our sports card data, generated from sales of 428 cards with a combined book value of nearly $10,000, provide two major insights. First, we find that the predicted strategic behavior is considerably greater when the auctioned cards have higher values. Second, dealers exhibit more of the predicted strategic behavior than do nondealers, for both lower and higher priced cards. One conjecture to explain this finding is that nondealers may find that the cognitive effort required to bid strategically exceeds the benefits, especially for low-valued cards. By contrast, dealers have more experience with auctions and make their living by buying/selling/trading cards, so their cognitive costs are likely much lower than those of nondealers. These two findings are consistent with recent theoretical models of monetary rewards and decision costs, and extend previous experimental evidence from the laboratory into the field.

II. EXPERIMENTAL DESIGN

As mentioned, recent theoretical literature has suggested that demand reduction inherent in uniform-price auctions with multiunit demand can induce inefficient allocations and possible reductions in auction revenue. To avoid the inefficiencies associated with the uniform-price auction, theorists have identified an alternative mechanism, the generalized Vickrey auction, which gives bidders a dominant strategy of revealing their true valuations for all units of the good. In this multiunit Vickrey auction, as in the uniform-price auction, each bidder can submit up to n different sealed bids on individual units, and the highest n bids are declared winners. If a bidder submits one or more of the winning bids, his or her price for the first unit equals the highest rejected bid submitted by someone else, and his or her price for the kth unit equals the kth highest of the rejected bids submitted by others.[3] This is a special case of a Groves-Clarke mechanism for dominant-strategy truth telling.[4]

For our purposes, the auction literature provides predictions about strategic behavior on which to base a test of cognitive costs and rewards. Theory predicts second-unit bids to be lower in the uniform-price auction than in the Vickrey auction. If deliberation costs are important, then we should find that demand reduction in the uniform-price auctions is more prevalent for higher-priced cards, because bidders will tend to invest more effort in thinking about the subtle strategic incentives when they stand to gain more from such effort. We have a similar prediction about dealers versus nondealers. Dealers routinely participate in sports card auctions both to sell and acquire their card stocks; even though they may never have participated in these particular auction formats, they may exert less cognitive effort to find optimal strategies than nondealers with less prior auction experience of any kind. Because dealers make their living selling cards and typically sell cards for higher prices than nondealers, the monetary rewards to strategic behavior may also be much larger for dealers. Both effects predict more strategic demand reduction for dealers than nondealers.

To test these predictions, we combine data from two field experiments. The first data set is taken from List and Lucking-Reiley (2000), who gathered data at a 1998 Orlando trading card show. The second data set is new and was gathered at a 2001 Tucson trading card show. In the first experiment (denoted experiment I), we conducted 82 Vickrey and 82 uniform-price auctions. Our participants were of two types: card dealers and nondealers, each bidding against rivals of the same type. The auctioned sports cards fit into two price categories: low (book

determining the price paid for winning a single unit, so a lower bid has some chance of increasing one's consumer surplus. The economic consequences of demand reduction include inefficient allocations and possible reductions in auction revenue.

3. Technically, these rules are demand-revealing only in cases where every bidder's demand curve is either flat or downward-sloping, as is assumed in the theoretical works cited. If bidders have upward-sloping demands, then this simple pricing rule is invalid; a slightly more complicated set of instructions would be required to implement a Groves-Clarke truth-telling mechanism.

4. See Groves (1973) and Clarke (1971). Intuitively, the key feature of this mechanism is that when bidders truthfully reveal their willingness to pay for the goods, the price rule ensures that each winning bidder pays an amount equal to the surplus he or she displaces from the other bidder(s) who would have won in his or her absence.

value of $3) and high (book value of $70). For the low-priced card auctions, we chose a Joe Montana 1982 Topps football card and a 1989 Michael Jordan Hoops basketball card. For the higher-valued auctions, we selected a Cal Ripken Jr. 1982 Topps baseball card and a Barry Sanders 1989 Score football card. In experiment II, we conducted 25 Vickrey and 25 uniform-price auctions for the 1982 Topps Joe Montana football card using both dealers and nondealers. In both experiments, all auctions for a given card type displayed the same sports cards to bidders, and identical copies were sold to winning bidders after the auctions concluded.

To perform the simplest field experiment, we chose a design with two bidders and two cards per auction. Two bidders were invited to submit two bids each for two identical sportscards, in an auction with no reserve price. We chose the auction format and card type for each subject according to a predetermined schedule, to avoid accidentally introducing experimenter bias. After receipt of bids from a group of subjects within a treatment, we randomly matched pairs of bidders to determine the outcome of each two-person auction. Each participant's experience typically followed four steps: (1) inspecting the good, (2) learning the auction rules, (3) placing two bids, and (4) concluding the transaction. No subject participated in more than one auction.[5]

III. RESULTS

The upper panel in Table 1 provides a breakdown of the number of auctions completed. The numbers in the table represent the number of auctions run for each treatment type. For example, in experiment I we ran 15 uniform-price dealer auctions for Cal Ripken Jr. cards, which implies that we sold 30 Cal Ripken Jr. cards to dealers in uniform-price auctions. The lower panel in Table 1 presents descriptive statistics of our bidding data. In List and Lucking-Reiley (2000), we noted that the data in experiment I provide evidence of strategic demand reduction—across all five treatments, second-unit bids are lower in the uniform-price auctions than in the Vickrey auctions. Here, we push these data somewhat harder and note that the amount of demand reduction appears to vary both with the stakes of the experiment ($3 versus $70 cards) and with the level of bidder experience (nondealers versus dealers).

Before comparing the strategic behavior across dealers and nondealers, we point out two apparent differences in their underlying demands for cards. First, evidence from both experiments suggest that dealers' demands tend to be situated at a higher level than those of nondealers for the Joe Montana card (book value $3), which was the only card auctioned to both types of bidders. In both Vickrey and uniform-price auctions and for both first and second units of the good, mean bids are higher for dealers than for nondealers. Second, dealers' demands also appear to be less steeply sloped for the Montana card. In the Vickrey auction, where bids should equal bidders' true values, we find that dealers value a second unit at $0.77 and $0.73 (about 38%) lower than a first unit, on average, while the corresponding decline for nondealers is significantly larger, at $0.90 and $0.86 (about 60%–66%). This second effect also appears in the data for $70 cards, though the comparison is less clean because the cards auctioned to the two groups were not identical. First-unit bids on $70 cards are relatively similar across subject types, but demands are again less steeply sloped for dealers than for nondealers. The mean decline between first and second Vickrey auction bids is $7.83 (16%) for dealers, but $23.00 (44%) for nondealers.

Strategic Behavior is Evident Primarily for High-Priced Cards

The third and fourth columns in the lower panel of Table 1 provide strong evidence of strategic demand reduction. As the theory predicts, second-unit bids are typically lower in the uniform-price auction than in the Vickrey auction. Average Vickrey bids exceed average uniform-price bids by approximately $12 for the high-priced cards and by only $0.05–$0.30 for the low-priced cards. One exception to this finding is average second-unit bids in the nondealer Montana auctions in experiment II.

The figures present a graphical depiction of the data. First, consider the data

5. Experimental instructions are available on request. For more details about the experimental procedure, see List and Lucking-Reiley (2000).

TABLE 1
Experimental Design and Descriptive Statistics

Card Type	Book Value ($)	Nondealers		Dealers	
		Uniform	Vickrey	Uniform	Vickrey
Experiment I					
Barry Sanders 1989 Score	70	17	17	—	—
Cal Ripken Jr. 1982 Topps	70	—	—	15	15
Michael Jordan 1989 Hoops	3	25	25	—	—
Joe Montana 1982 Topps	3	15	15	10	10
Experiment II					
Joe Montana 1982 Topps	3	15	15	10	10

	Descriptive statistics			
	Bid #1		Bid #2	
	Vickrey	Uniform	Vickrey	Uniform
Experiment I				
Sanders [ND]	$51.82	$62.35	$28.82	$16.62
	23.44	*25.67*	*19.98*	*15.40*
Ripken [D]	49.60	62.67	41.77	30.60
	15.19	*15.28*	*14.46*	*13.43*
Jordan [ND]	1.73	1.83	0.91	0.82
	1.51	*1.35*	*1.04*	*0.85*
Montana [D]	2.03	2.49	1.26	0.94
	0.86	*2.18*	*0.84*	*0.85*
Montana [ND]	1.37	1.40	0.47	0.42
	1.33	*1.44*	*0.53*	*0.61*
Experiment II				
Montana [D]	1.88	1.95	1.15	0.63
	1.46	*1.09*	*0.92*	*0.72*
Montana [ND]	1.45	1.44	0.59	0.63
	1.55	*1.38*	*0.65*	*0.69*

Notes: Figures in the top panel represent the number of auctions run for each treatment. For example, the first row indicates that we ran 17 uniform-price auctions and 17 Vickrey auctions, for a total of 68 Barry Sanders cards sold. Each auction had two invited bidders who submitted up to two bids each. Figures in the lower panel represent means [standard deviations] in plain (italic) text. [ND] denotes nondealer treatment; [D] denotes dealer treatment. Bid #1 (#2) data consists of the first (second) bid submitted by each bidder.

from auctions for $70 cards: Ripken (dealers) in Figure 1 and Sanders (nondealers) in Figure 2. In each case, we note that the distribution of uniform-price (second) bids clearly lies to the left of the distribution of Vickrey bids, which we interpret as strategic demand reduction in the uniform-price auctions. In stark contrast are nondealers' second-unit bids on the $3 cards: Jordan in Figure 3 and Montana in Figure 4 (pooled data from experiments I and II). In these cases, the Vickrey and uniform-price bid distributions look nearly indistinguishable from each other, though the mean Vickrey bid remains numerically slightly higher than the mean uniform-price bid.

For each of the seven different card treatments, we compute: (1) t statistics for the hypothesis that mean second-unit bids are equivalent across auction formats, and (2) nonparametric Mann-Whitney rank-sum tests of treatment differences. The rank-sum test is a standard nonparametric test that has a null hypothesis of no

FIGURE 1
Dealer 2nd-unit Bids (Ripken)

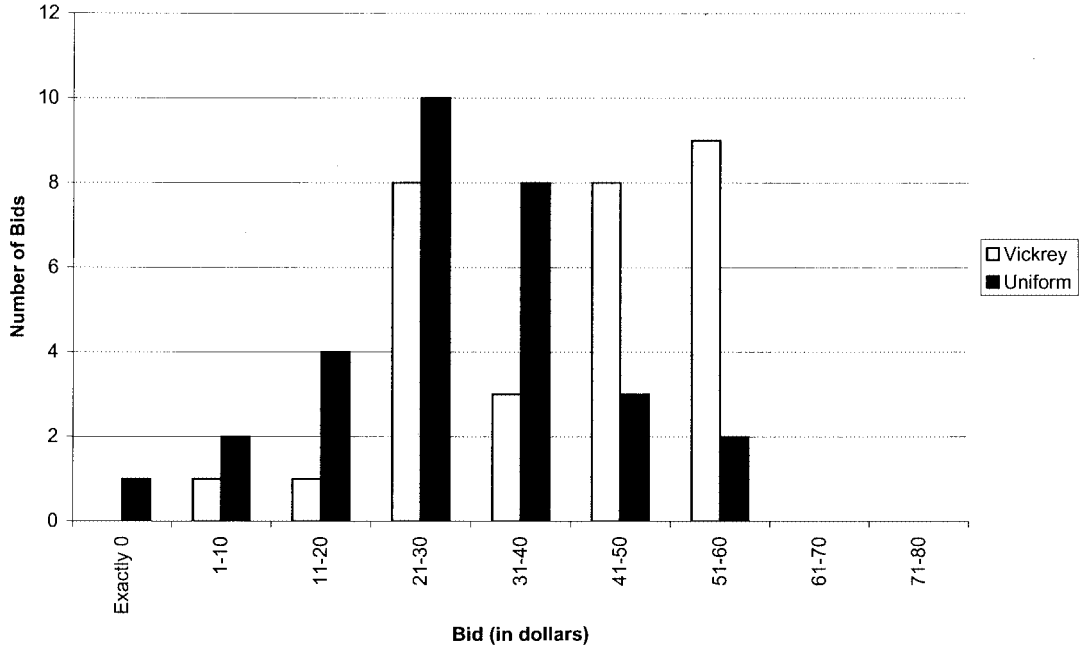


FIGURE 2
Nondealer 2nd-unit Bids (Sanders)

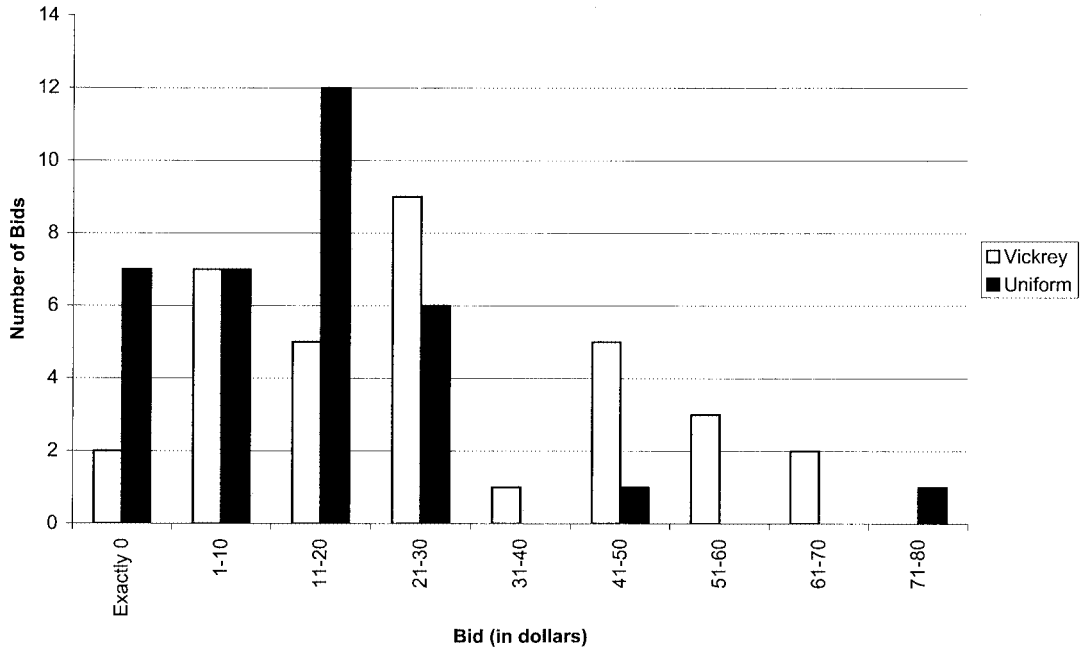


FIGURE 3
Nondealer 2nd-unit Bids (Jordan)

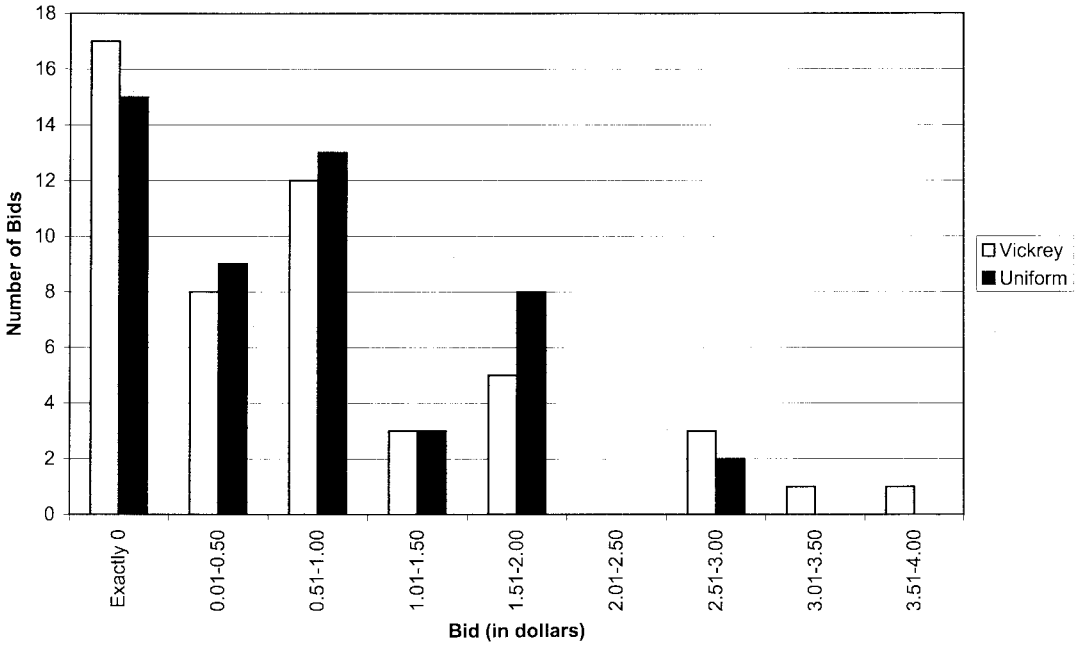
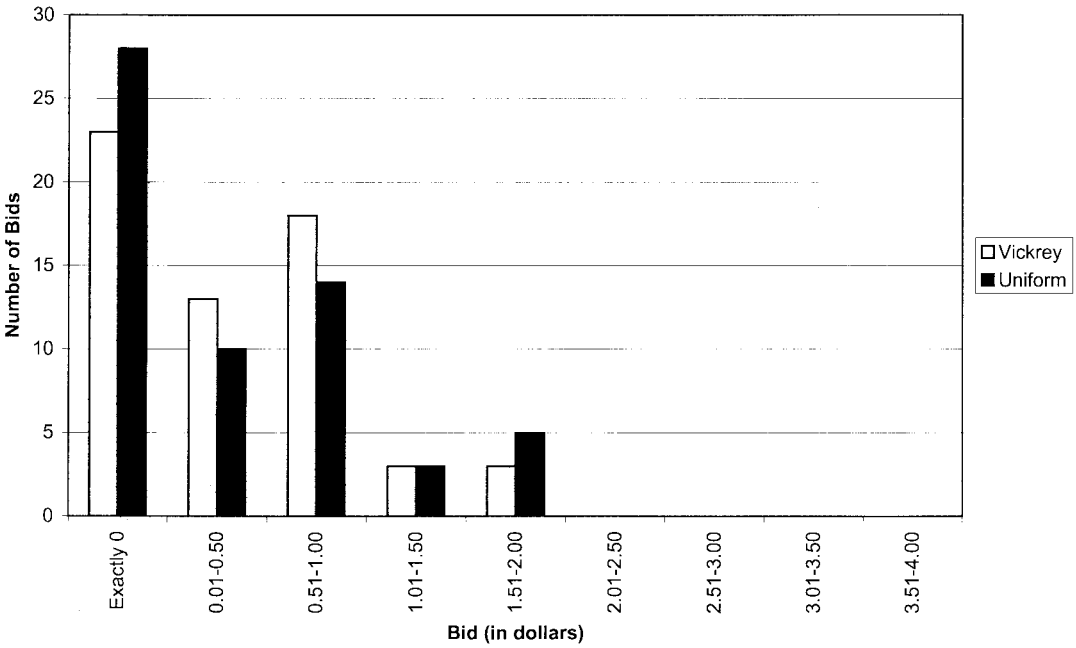


FIGURE 4
Nondealer 2nd-unit Bids (Montana)



treatment effect, or that the two samples are derived from identical populations. Results are always consistent with one another; to conserve space we present only the parametric results: experiment I, $t_{\text{Sanders,ND}} = 2.82$, $t_{\text{Ripken,D}} = 3.10$, $t_{\text{Jordan,ND}} = 0.47$, $t_{\text{Montana,D}} = 1.19$; $t_{\text{Montana,ND}} = 0.34$; experiment II, $t_{\text{Montana,D}} = 1.99$; $t_{\text{Montana,ND}} = -0.24$.[6] The t statistics all have the expected positive sign (expect for experiment II, nondealer Montana), indicating that mean second-unit bids were larger in the Vickrey auctions than in the uniform-price auctions.[7] The differences, however, are statistically significant only for the two high-value cards and in one of the low-value card auctions (experiment II, dealer Montana).

We conclude that the demand-reduction effect appears larger when the stakes are higher. This is true not only in dollar magnitude but also relative to the variance of bids (as measured by t tests). Subjects may have considered the stakes in the \$3 card auctions not to be large enough to warrant careful consideration of strategies and therefore made less than perfectly strategic second-unit bids.[8] This is consistent with the previously cited literature on deliberation costs in laboratory experiments.

Strategic Behavior Increases with Experience

We also find evidence in favor of a second prediction of cognitive-cost theory: that strategic behavior is more pronounced when agents have more experience. Because dealers generally have more experience with auctions than nondealers, we examine differences in strategic behavior between dealers and nondealers. We focus on bidding behavior for the Joe Montana card, the only card bid on by both dealers and nondealers. Descriptive statistics in the lower panel of Table 1 indicate some evidence of dealers behaving more strategically than nondealers. The difference in mean second-unit bids between the Vickrey and uniform-price auctions is \$0.32 and \$0.52 for dealers (roughly 25%–45% of the mean Vickrey bid), but only \$0.05 and −\$0.04 for nondealers. Although the nondealer differences are not significantly different from zero at conventional levels using a Mann-Whitney rank-sum test of treatment differences or a parametric t test, we find significant differences for dealers in experiment II in both the nonparametric and parametric statistical tests: $t = 1.99$, and marginal significance in experiment I

6. We report results of a large-sample t test, which requires no distributional assumptions. We are making the large-sample assumption with sample sizes as small as 20; to check robustness we also conducted small-sample t tests. The results were never qualitatively different.

7. Further evidence of demand reduction can be obtained by examining the difference between each bidder's first- and second-unit bids, a measure of the steepness of each bidder's downward-sloping bid schedule. In each case, the mean difference between first-unit and second-unit bids is much larger in the uniform-price than in the Vickrey auction. For example, differences between bid one and bid two were \$7–\$23 in the Vickrey auctions for expensive cards, compared with \$30–\$45 in the uniform-price auctions. For the low-priced cards, bids differed by \$0.80–\$0.95 in the Vickrey auctions, and up to \$1.50 in the uniform-price auctions. We note one caveat to this differencing approach: We typically do not find equality of first-unit bids across auction formats (especially for high-priced cards).

8. Note that the crux of our argument in this section relies on the assumption that the optimal strategy always involves demand reduction and that the \$70 card auctions have higher expected rewards than the \$3 card auctions. Because the theoretically optimal strategy varies with the true distribution of bidder values, neither of these conjectures is necessarily true. It is possible that because of intrinsic differences in bidder values, some cards should have more demand reduction than others in Nash equilibrium. Because we are not using induced values, true values are not directly observable. Fortunately for our purposes, the main difference between the shapes of the low-stakes and the high-stakes value distributions is that the low-stakes cards appear to have values skewed toward zero. The theory generally predicts the opposite of what we observe: When values are more concentrated at zero, there should be more strategic demand reduction in uniform-price auctions. Although not proven in general, this claim is substantiated by several examples provided in Engelbrecht-Wiggans and Kahn (1998) and Ausubel and Cramton (1996). The intuition for this claim (more demand reduction with lower distributions of values) is that the gains from demand reduction are greater when one's second-unit bid is more likely to actually determine the price, which can only occur when other bids are sufficiently low. Thus differences in bid distributions do not appear to be the reason for the observed lessening of demand reduction in our low-stakes experiments. Furthermore, as a consistency check, we examined the Vickrey bids across the \$70 and \$3 auctions as an informal test of the expected rewards hypothesis. Though this procedure represents a rough test because it relies on truthful revelation and low relative cognitive costs in the Vickrey auctions (in the present context, there is really no way to determine how people mentally process auction mechanisms), we find that expected profits are \$29.58 (Sanders) and \$18.50 (Ripken) in the \$70 auctions and \$1.50 (Jordan) and \$1.06 (Montana) in the \$3 auctions, which are significantly different at conventional levels.

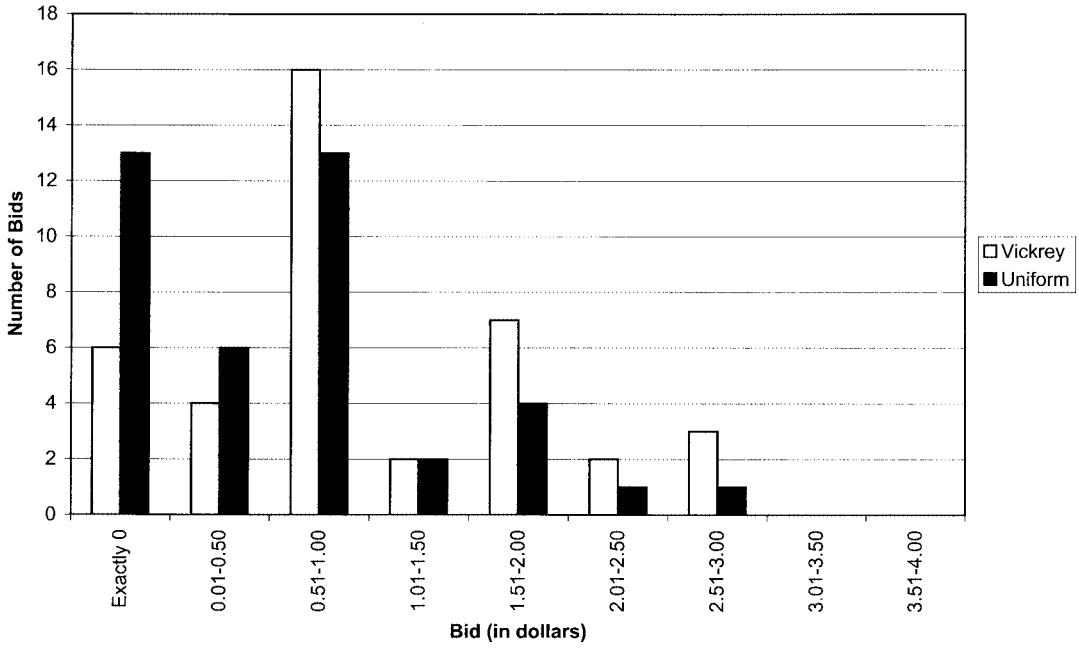
($t = 1.19$). These results are considerably strengthened if we pool the data across experiments I and II. On doing so, we compute a t statistic equal to 2.25 for the dealer data, which allows us to reject the null at the $p < 0.05$ level (results are consistent when using a nonparametric test). Even after pooling the nondealer data, we cannot reject the null at conventional significance levels using either a nonparamteric or parametric test.

Figure 4 provides a visual comparison of the nondealer second-unit bids for the Joe Montana card. Figure 4 reveals very little difference in the distribution of bids between the two auction formats. By contrast, Figure 5 (pooled dealer Montana data) shows stark differences in dealers' bidding behavior between auction formats. Besides the fact that there are many more zero bids in the uniform-price auction than in the Vickrey auction (13 versus 6), the distribution of uniform-price bids lies to the left of the distribution of Vickrey bids.

An alternative test of demand reduction provides stronger statistical support of the experience hypothesis. As in List and Lucking-Reiley (2000), we examine whether the slopes of individuals' bid schedules are steeper in the uniform-price auction than in the Vickrey auction. In other words, we test whether the difference between an individual's first-unit bid and second-unit bid is greater in the uniform-price auction, as predicted by demand-reduction theory. Though dealers' bid schedules are slightly flatter than nondealers' bid schedules in the Vickrey auction (consistent with better resale opportunities for multiple units), their bid schedules are somewhat steeper than those of nondealers in the uniform-price auction. Once again, performing parametric and nonparametric tests of differences in bid differences across auction types, we find statistical significance at the $p < 0.04$ (experiment I) and $p < 0.07$ (experiment II) in the dealer data using a one-sided alternative and no statistical significance (one-sided p values: $p = 0.44$ and $p = 0.40$) for nondealers. On pooling the data we again find much stronger evidence of demand reduction in the dealer data—now we can reject the null at the $p < 0.01$ level using a one-sided alternative.

FIGURE 5

Dealer 2nd-unit Bids (Montana)



IV. CONCLUDING REMARKS

Recent evidence from the laboratory indicates that predictions of rational models may fail if the cognitive costs of finding optimal strategies are large compared to their expected rewards. We explore this issue in the field by auctioning off nearly $10,000 worth of sports cards in 214 different auctions. Our results suggest that strategic behavior and expected payoffs are positively correlated: Bidders exhibited strategic demand-reduction behavior much more for high-priced cards than they did for lower-priced cards. A second result is that subjects more experienced with sports card auctions exhibited a greater tendency to engage in demand reduction than did less experienced subjects. The effect of the size of the stakes is much more pronounced than the effect of the bidder type. In particular, we find pronounced evidence of strategic behavior for goods worth around $70. For goods worth around $3, by contrast, we find no evidence of strategic behavior for inexperienced bidders and some evidence of strategic behavior for experienced bidders. The size of the stakes and bidder experience both help explain when strategic behavior is more likely.

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