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Learning differences in mixed common value auctions

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**Learning differences in mixed common value auctions**

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**Abstract**

I examine the behavior of subjects in common value auctions with both experienced and inexperienced bidders in the same market. Subjects know that they are competing against both experienced and inexperienced subjects and can observe bidding behavior of their opponents after an auction round. The existence and common knowledge of mixed experience levels in the same auction market affects the bidding behavior of inexperienced bidders, and gender plays an important role: Inexperienced males bid more aggressively in auction market with mixed bidders compared to markets with only inexperienced bidders, but inexperienced females bid less aggressively. The mixed markets only have an effect on inexperienced bidders. Experienced bidders (males and females) do not react significantly different in mixed auction markets than in markets with only experienced bidders.

**Keywords:** common value auction, auction experiments, learning, gender

**JEL classification:** D44, C91

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## 1 Introduction

In this paper, I present an experiment testing the behavior of experienced and inexperienced bidders in common value auctions with 'mixed' markets. In mixed markets, there are both experienced and inexperienced bidders competing against each other and observing each others bidding behavior. This is the first common value auction experiment with mixed markets, and it turns out that a mixed market environment has a great influence on the bidding behavior of the inexperienced bidders.

A common value auction is an auction, in which the true value of the item is the same for all the bidders. At the time of bidding, though, the bidders are uncertain about this value. Each has a private estimate (her signal) and needs to base her bid primarily on this estimate. Estimates are distributed around the true value, so that the high signal holder likely has an overly optimistic estimate of this value. With unbiased signals and symmetric bidders, rationality requires that bidders discount their estimates. The term 'winner's curse' describes the situation, in which the high bidder does not discount her signal enough and submits a bid higher than the true value. In this case, the price of the object is higher than the value is worth to the bidder. The literature calls this the 'winner's curse' because this situation results in negative profits.

The winner's curse is common in both field settings and experiments (see e.g. Capen et al. 1971, Lorenz and Dougherty 1983 for evidence in field data and Kagel and Levin 2002 for an overview on the experimental literature). Inexperienced bidders are the ones most likely to suffer from it because they tend to bid too aggressively. Frequently, they earn negative profits on average and go bankrupt. But bidders learn over time how to avoid losing money: Experienced subjects bid much more successfully, making positive average profits.

Behavior of inexperienced and experienced bidders is quite different in common value auctions. This raises the question whether it influences bidding behavior whether bidders in an auction market have the same or different levels of experience. Clearly, in 'real' auction markets, experience levels of bidders tend to be heterogeneous. And several experimental studies of common value auctions and other games indicate that behavior of subjects is indeed dependent on the composition of the group they play with.

For example, subjects learn from observation of peers and from imitating the especially successful ones (e.g. Garvin and Kagel 1994, Offerman and Sonnemans 1998, Merlo and Schotter 2003, Armantier 2004 among others). On the other hand, Andreoni and Miller (1995) show that playing against a successful opponent can sometimes hinder learning. And for experienced subjects, Slonim (2005) finds that they condition their behavior on the entry of inexperienced subjects in a beauty contest game.

However, all previous studies on common value auctions have been done with exclusively homogeneous markets of either only experienced or only inexperienced bidders. I design an experiment with both experienced and inexperienced bidders in the same auction market and compare the behavior of both to a benchmark treatment with either only inexperienced or only experienced bidders. Overall, there are three treatments: a mixed treatment with two experienced and two inexperienced bidders in an auction market, an inexperienced treatment with four inexperienced bidders in a market, and an experienced treatment with four experienced bidders in a market.

In each treatment, bidders know the composition of the auction market. After an auction round, they can observe bidding behavior of their opponents, i.e. their bids along with their signals. Bidder identification is suppressed. In the mixed treatment, information about an opponent's type - I for inexperienced and E for experienced - is also provided with bidding behavior.

The first hypothesis is that the inexperienced bidders in the mixed treatment learn faster than in the inexperienced treatment. The tool of learning, besides own experience, is the observation of the bidding behavior of opponents. In the mixed treatment, the inexperienced subjects have some experienced opponents that are likely to be successful. With good role models to imitate, learning should speed up for the inexperienced bidders in the mixed treatment.

For the experienced bidders, the matter is different. They tend to bid lower than the inexperienced ones because they have gained some understanding of the game. The mixed treatment serves as a test of this understanding. The experienced bidders are faced with overly aggressive inexperienced opponents that are more likely to win the auction. Will this induce the experienced bidders to lower their bids and fall back to overly aggressive behavior because they want to increase their likelihood of winning? The

second hypothesis of this study is that the experienced bidders in the mixed treatment bid more aggressively than the experienced bidders in the experienced treatment.

It turns out that the data can not be organized in a meaningful way without taking gender into account. Casari et al. (2004) as a study on bidding behavior in common value auctions with homogeneous markets finds significant gender effects for inexperienced bidders: Inexperienced females start out bidding much more aggressively than inexperienced males. But they also learn at a faster rate, so that by the end of the session, the gap between males and females disappears. There are no significant gender effects for experienced bidders. I replicate both of these findings in the inexperienced and experienced treatments. In the mixed treatment, however, I find very interesting new gender effects: The inexperienced males in the mixed treatment bid more aggressively than their counterparts in the inexperienced treatment, while inexperienced females in the mixed treatment bid less aggressively than their counterparts in the inexperienced treatment. In fact, in my data, bidding behavior of inexperienced males and females is indistinguishable. These findings have important implications. First, learning and adaptation mechanisms of males and females may be very different. And the finding of a gender difference in previous studies may not be as crucial because it disappears in the more realistic setting of heterogeneous markets.

Experienced bidders do not behave differently in the mixed and experienced treatments. This implies that I have to reject the hypothesis that experienced subjects in the mixed treatment lower their bids and become more aggressive again. This suggests that their understanding of the structure of the game is relatively deep and that they are not tempted to bid more aggressively even if their opponents, the inexperienced bidders, do.

## **2 Theoretical Background: Risk Neutral Nash Equilibrium Bidding**

The symmetric risk neutral Nash equilibrium (RNNE) for first price sealed bid common value auctions can be found in Wilson (1977) and Milgrom and Weber (1982). My experimental design has the following specifications: There are four bidders in each auction market, competing for an item with a common value of  $x_0$ . The value of  $x_0$  is

drawn from a uniform distribution on [50, 950]. Bidders do not know the value of  $x_0$  at the time of bidding, but each receives a private signal drawn from a uniform distribution on  $[x_0-12, x_0+12]$ .<sup>2</sup> Each bidder submits a sealed bid. The high bidder receives the item and pays her bid, so that her profit is the true value  $x_0$  minus her bid. The other bidders receive zero profit for this auction period.

I restrict my attention to signals in the region (62, 938). The bulk of the observations lie in this region, and bidders do not have additional end-point information to calculate the expected value of the item. In this region, the risk neutral Nash equilibrium bidding function takes the following form:<sup>3</sup>

$$b(s_i) = s_i - 12 + h(s_i) \quad (1)$$

$$h(s_i) = (24/n + 1) \exp(-(n/24)(s_i - 62)) \quad (2)$$

$s_i$  is bidder  $i$ 's signal and  $n$  is the number of bidders in the auction market. The non-linear term  $h(s_i)$  approaches zero fast if the signal is larger than 62 and is insignificant in all regressions. I will omit it in further discussions, but include it in all relevant regressions.

Kagel and Richard (2001) show that the function

$$b_i(s_i) = s_i - 12 \quad (3)$$

is a better approximation of observed bidding behavior than (1). They also show that the best response to (3) is to bid according to (3). When bidders bid above (3), it is solely a failure to account for the adverse selection in this bidding environment.

I will generally characterize bidding behavior of subjects by their bid factor:

$$bidfactor_i = s_i - b(s_i) \quad (4)$$

The bid factor is a convenient measure of the aggressiveness of bidding behavior. It indicates the discount from a subject's signal. According to (3), the Nash equilibrium bid factor for this environment is 12.

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<sup>2</sup> This information structure is the one of affiliated private values found in Milgrom and Weber (1982).

<sup>3</sup> For a complete derivation of the risk neutral Nash equilibrium bidding function, including signals outside the specified region, refer to Kagel and Levin (1986) and Kagel and Richard (2001).

### 3 Experimental Design and Data Description

In each treatment, the range of possible common values, the range of the signals conditional on the common value, and the number of bidders in an auction market are the same.

There are 25 auction rounds in each session. In each auction round, subjects are randomly distributed into auction markets of four bidders.<sup>4</sup> In each auction period, a new common value  $x_0$  is drawn randomly and independently from previous and future periods. Each bidder receives a signal as an independent draw from the interval  $[x_0-12, x_0+12]$ . The experiment is done on computers. The subjects see their signal on the screen, together with the range of possible values of  $x_0$  given their signal  $s_i$ :  $[\max(\$50, s_i-12), \min(\$950, s_i+12)]$ . Each active subject is asked to submit a bid larger than zero. The item is awarded to the high bidder with a profit of  $x_0-b_i$ .<sup>5</sup> All other bidders receive zero profit for this auction round.

After the high bidder is determined, bidders receive information about the current auction period, including their own profit, bids and signals of their opponents (bidder identification was suppressed), the common value of the item  $x_0$ , the price of the item as the bid of the high bidder, and the profit of the high bidder. In the mixed treatment, the type of their opponents - inexperienced or experienced - is given along with their bids and signals.

Each subject is given an initial cash balance of \$15, from which negative profits are subtracted and to which positive profits are added. A subject that goes bankrupt before the end of the session, i.e. whose cash balance drops below zero, is no longer permitted to bid.

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<sup>4</sup> The number of bidders in an auction market is always four. If the total number of bidders is not dividable by four, some subjects were randomly selected to be inactive in that period.

<sup>5</sup> There is a hidden reserve price of  $x_0-24$  in this experiment. Subjects know that if the high bid turns out to be below the reserve price, the item is not awarded in this period and all bidders receive a profit of zero. The actual reserve price is revealed only after the auction period. The reserve price serves as a means to constrain the possible earnings of subjects. In fact, however, the item was sold in every round of every session.

There are three treatments to compare the mixed market with two relevant benchmark treatments. There is the mixed treatment as the main treatment and the experienced and inexperienced treatments as benchmark treatments.

**Mixed treatment.** In this treatment, there are two inexperienced and two experienced bidders in each auction markets. This is common knowledge. On the feedback screen, subjects can identify experienced and inexperienced opponents.<sup>6</sup>

**Inexperienced treatment.** In this benchmark treatment, auction markets consist of four inexperienced bidders. This is common knowledge.

**Experienced treatment.** In this benchmark treatment auction markets consist of four experienced bidders. This is common knowledge. All subjects in this treatment have the same level of experience, because they have all participated in one prior session of the inexperienced treatment.

Table 1 shows the total number of participants and the number of males and females for each session.<sup>7</sup> Participants are undergraduate students from The Ohio State University who were enrolled in economics classes. In week 1, I recruited subjects for two sessions of the inexperienced treatment. In the invitation email, subjects were told that they had to participate in two different sessions, and that after the first session, they would only receive half of their earnings. The remaining half of week 1's earnings and a \$20 participation fee would be paid after the completion of the second session, along with the earnings for that session. Subjects had strong incentive to return and selection effects for the returning bidders were avoided. All except 1 of 60 initial bidders returned for the second session.

In the inexperienced treatment, instructions were read aloud.<sup>8</sup> Subjects also had a hard copy to read along. There were two dry-run auctions (not payoff-relevant) to familiarize the subjects with the software and the computer screens. Then there were 25 payoff-

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<sup>6</sup> In fact, whenever the total number of experienced and inexperienced bidder is such that not all can be divided into markets with two experienced and two inexperienced bidders, as many markets as possible with two and two bidders are formed. The (randomly selected) remaining bidders are first divided into markets with four bidders of the same experience level and then, if there are still some left, into markets of four bidders, irrespective of their type. Subjects can identify the composition of the current auction market on the screen, but observations with compositions other than two experienced and two inexperienced bidders are not included in the data analysis.

<sup>7</sup> All Tables and Figures are in Appendix A.

<sup>8</sup> Instructions can be found in Appendix B.

relevant auction rounds. At the end of the session, subjects were paid half of their earnings and were told that they would be invited back next week.

In week 2, the subjects from the inexperienced treatment were invited back and randomly divided into one experienced and two mixed treatments. I also recruited new inexperienced subjects for the mixed treatment.

The experienced treatment had the same structure as the inexperienced treatment, but with a short summary-version of instructions. At the end of the session, subjects received the second half of their earnings from week 1, \$20 participation fee, and their total earnings from week 2.

For the mixed treatment, the inexperienced subjects were invited at an earlier time than the experienced subjects. Instructions were given as in the inexperienced treatment. A colleague received the experienced subjects and told them to wait for a short while before entering the room. Once the inexperienced subjects had no more questions, the experienced ones were invited in. Summary instructions were read aloud to both experienced and inexperienced. There were two dry runs. After 25 auction rounds, the experienced subjects received their remaining earnings from week 1, \$20 participation fee, and their total earnings from week 2. The inexperienced subjects received their total earnings for the session along with a \$6 participation fee.

Notice that by the way the instructions were written and read to the subjects, all experienced and all inexperienced subjects were given exactly the same instructions, independent of the treatment.

#### **4 Bidding Behavior**

I estimate the bid factor as defined in (4). Theoretically, the bid factor is a constant discount from the signal. Previous studies have shown that subjects' bidding behavior changes over time, so the regressions also include a learning term as one of the independent variables. I use an adjustment term defined in Casari et al. (2004) because it has proven to be a powerful explanatory variable:  $learn_t = 1/\ln(t+1)$ , where  $t$  is the actual number of auctions played by a subject, including the current one. This function is

convex in the number of rounds and diminishes over time, assuming that the heaviest learning takes place in early rounds.

A dummy *male* takes the value 1 if the subject is male and 0 otherwise. The *female* dummy takes the value 1 for female subjects. Since I pool the data for subjects of the same experience level, I also have treatment dummies. The dummy *inexperienced* (*experienced*) takes the value 1 for the inexperienced (experienced) treatment, the dummy *mixed* for the mixed treatment. I use a random-effects estimation for the bid factor of subject  $i$  in round  $t$ . The usual assumptions on random-effects estimation apply.

$$\begin{aligned} bidfactor_{it} = & \beta_0 + \beta_1 * male_i + \beta_2 * in\ exp._i + \beta_3 * male_i * in\ exp._i + \\ & + \beta_4 * learn_t * mixed_i * male_i + \beta_5 * learn_t * mixed_i * female_i + \\ & + \beta_6 * learn_t * in\ exp._i * male_i + \beta_7 * learn_t * in\ exp._i * female_i + (u_i + \varepsilon_{it}) \end{aligned} \quad (5)$$

$\beta_0$  is the intercept of the bid factor of a female in the mixed treatment,  $(\beta_0 + \beta_1)$  is the intercept of a male in the mixed treatment,  $(\beta_0 + \beta_2)$  the intercept of a female in the inexperienced treatment, and  $(\beta_0 + \beta_1 + \beta_2 + \beta_3)$  the intercept of a male in the inexperienced treatment.  $\beta_4$  describes the magnitude of adjustment of a male subject in the mixed treatment, and  $\beta_5$ ,  $\beta_6$ , and  $\beta_7$  the adjustment of a female in the mixed treatment and male and female in the inexperienced treatment, respectively. For experienced subjects, similar interpretations of the coefficients apply.

Alternatively, I could have estimated the bid function as in (1), with the bid as the dependent and the signal as an additional independent variable. The coefficients of the independent variables other than the signal would not have changed, and the signal would have a coefficient that is statistically indistinguishable from one.

#### 4.1 Bidding Behavior of Inexperienced Subjects

Table 2 gives the estimation results for the inexperienced subjects. All coefficients except  $\beta_1$  are statistically significant at either the 5% or 10% level. The bidding behavior of both males and females in the mixed and the inexperienced treatments have a significant intercept and adjust over time.

The males in the inexperienced treatment have the highest intercept, and so the least aggressive bidding behavior. At the same time, they have the lowest rate of adjustment

over time. The females in the inexperienced treatment have the lowest intercept, and so the most aggressive bidding behavior. But they also have a relatively high rate of adjustment and change to a less aggressive bidding behavior fast.

The males and females in the mixed treatment are indistinguishable. They have an intermediate bidding behavior, more aggressive than the males in the inexperienced treatment, but less aggressive than the females in the inexperienced treatment.

The data of the benchmark treatment replicates the findings of previous studies, such as Casari et al. (2004): With only inexperienced bidders in an auction market, females start out considerably more aggressive than males, but learn at a faster rate. I use a Mann-Whitney test (see Table 3) to show that in early rounds, 2-5, there is a significant difference in average bid factors of males and females in the inexperienced treatment that disappears in later rounds, 20-25. Because of a faster rate of adjustment, females catch up with males by the end of the session (see also Figure 1).

The main treatment is the mixed treatment. The gender dummy in the mixed treatment is not significant, nor is the adjustment over time different for males and females (see Table 2 and Figure 2). The Mann-Whitney tests in Table 3 confirm that average bid factors are not different, neither in early nor in late rounds. The gender difference of the inexperienced treatment does not appear in the mixed treatment.

While across-gender differences appear, interesting within-gender differences appear with the mixed treatment. Inexperienced males bid more aggressively in mixed markets than with only inexperienced opponents. But inexperienced females bid less aggressively in mixed markets than when they only have inexperienced opponents.

More aggressive bidding results in lower, potentially even negative (winner's curse), profit. Table 4 gives average profits for inexperienced subjects. As expected, inexperienced subjects in all treatments receive negative average profits, both conditional on winning and overall. While the average profits are not statistically significantly different, they point in the same direction as the bid factors: Lower bid factors lead to larger losses. Conditional on winning, the least aggressive males, the ones in the inexperienced treatment, receive the highest profits, while the females in the inexperienced treatment as the most aggressive ones receive the lowest. Profits of males and females in the mixed treatment are higher than the ones of females in the

inexperienced treatment, but lower than the ones of the males in the inexperienced treatment. Notice that it is possible that the ranking of overall profits is reversed because inexperienced subjects in the mixed treatment win more often than subjects in the inexperienced treatment because they face the experienced bidders as less aggressive opponents.

Another characteristic of inexperienced bidding behavior is a high frequency of bankruptcy. A subject is bankrupt as soon as her cash balance drops below zero. Because of frequent overbidding and negative average profit, inexperienced subjects are likely to go bankrupt. As expected, the inexperienced subjects in all treatments have a high frequency of bankruptcy. But again, the ones with higher bid factors have a lower frequency than the ones with lower bid factors. Males in the inexperienced treatment have the lowest rate of bankruptcy, and the females in the inexperienced treatment have the highest. Consistent with their intermediate bid factors, males and females in the mixed treatment have an intermediate bankruptcy rate.

#### **4.2 Bidding Behavior of Experienced Subjects**

The estimation results are given in Table 5. Only the coefficient of the intercept is significant. It is similar to the one inexperienced bidders display in later rounds. But it is still below the RNNE bid factor. There is no significant adjustment over time, so I also did the regression without the learning terms. Still, only the intercept is significant. The experienced bidders do not behave differently with mixed opponents than with only experienced opponents (see also Figures 3 and 4). They have relatively high bid factors to begin with, do not adjust over time, and also do not condition their bid factors on the composition of the auction market.

### **5 Discussion**

The results presented here clearly show the interesting treatment effect of the mixed market, while the results of the benchmark treatments are similar to those found in previous studies, such as Garvin and Kagel (1994) and Casari et al. (2004). In the

inexperienced benchmark treatment, subjects start out bidding very aggressively. There is a high frequency of bankruptcies and average negative profits. However, subjects learn to adjust their bids over time, so that by the end of the 25 auction rounds, they have established a relatively high bid factor. There is, in addition, a significant gender difference: Males start out much less aggressively, but also adjust their bidding behavior less over time. Females start out very aggressive, but learn much faster than males, so that by the end of the session, there is no gender difference any more.

In the mixed treatment, experienced and inexperienced subjects compete against each other. The introduction of experienced opponents has a significant effect on the behavior of both inexperienced males and females. Both behave differently in mixed markets than in those with only experienced opponents. But they change their behavior in the opposite direction.

While there is a gender difference in the inexperienced treatment, inexperienced males and females in the mixed treatment bid very similar to each other. This suggests that the gender difference found in previous studies might not be of importance in real auction markets because they are usually mixed.

Since the gender difference disappears, the mixed market has the opposite effect on inexperienced males and females: Males bid more aggressively in mixed markets, while females bid less aggressively.

For inexperienced males, having experienced opponents has a negative influence on their bidding behavior, but for the inexperienced females it has a positive effect. So, males and females clearly react different in economic environments. And males and females learn differently and use different stimuli to adjust their behavior.

Not all of the inexperienced subjects take advantage of the additional source of learning offered by the observation of experienced opponents. Females do, but males do not. Females seem to understand that there is an opportunity to imitate experienced opponents, and they already start to observe in the dry run.<sup>9</sup> Figure 5 shows that the inexperienced females bid very close to the experienced, and in the last round, their

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<sup>9</sup> Recall that the inexperienced bidders in the mixed treatment are told that they have experienced opponents and that the difference in behavior is already apparent in early rounds. The experienced bidders in the mixed treatment have an average bid factor of 7.155 in the two dry runs, and there is a much lower standard error than for the bid factors of inexperienced bidders in the dry runs.

behavior is almost indistinguishable. The males, however, rather become more aggressive in mixed markets.

In a study on gender differences in high ranking positions, Niederle and Vesterlund (2005) conduct an experiment in which males and females perform tasks in both non-competitive and competitive environments. While they find no gender difference in the performance in the competitive task, they find differences in how optimistic males and females are about their performance. And they find differences in how likely males and females are to enter a competitive task. Males are much more optimistic about their future performance than females, and tend to enter competitive tasks much more, and in fact too frequently. This observation can serve as an initial explanation for the gender differences that I find in this experiment. Men prefer competitive environments and are very optimistic about their performance. Bidding against experienced opponents is clearly more competitive than bidding against inexperienced opponents. Males react to this by being overly competitive. They believe that they can do better than the experienced opponents and submit bids that are too high.

Females, on the other hand, are pessimistic about their performance in competitive tasks. So, they are more open to learning from others, in this case the experienced bidders. In the mixed treatment, they know whom to imitate. Experienced bidders can be distinguished as being successful. Characteristics, such as pessimistic expectation about own performance, might be a downside in other environments, but can very well be a force that improves learning behavior in others, such as common value auctions.

The experienced bidders do not behave differently in the two treatments. Especially, they do not become more aggressive in the mixed markets with overly aggressive inexperienced opponents. This indicates that the experienced subjects gained some understanding of the game and do not revert to unsuccessful behavior. They start out bidding relatively high in both treatments and do not change their behavior too much over time. This finding is reassuring for two reasons: First, it implies that experience indeed lead to a successful adaptation to the environment. And second, the experienced bidders can indeed serve as good role models in mixed markets because they stick to successful bidding behavior.

## 6 Conclusion

I examine the behavior of experienced and inexperienced bidders in mixed common value auctions that have both experienced and inexperienced bidders. I compare the behavior of subjects in the mixed treatment to two benchmark treatments, one with only inexperienced and one with only experienced bidders. In the mixed treatment, there are two experienced and two inexperienced bidders. In the benchmark treatment, all four bidders are either experienced or inexperienced.

The mixed treatment is a bidding environment that has never been studied before. It turns out that inexperienced bidders behave very differently in mixed markets than in markets with only inexperienced bidders. And gender effects are crucial in this study. Males and females behave differently in mixed markets compared with their counterparts in markets with only inexperienced bidders, so that the mixed market has the opposite on males than on females.

Similar to previous studies, I find in the inexperienced treatment, the one with only inexperienced subjects, that female bidders start out bidding much more aggressively than males. But they also learn at a faster rate, so that by the end of the session, the gender difference disappears. In this benchmark treatment, inexperienced bidders make negative profits on average and have a high frequency of bankruptcy. In the experienced treatment, the findings are also similar to previous ones. Experienced bidders bid much less aggressively than inexperienced ones and there is no gender effect.

In the mixed treatment, inexperienced males and females bid very similar to each other: there is virtually no gender difference. But this implies that compared to the inexperienced benchmark treatment, males and females react differently to having some experienced opponents. Inexperienced males bid more aggressively in mixed markets, while females bid less aggressively.

An initial explanation for this gender difference is drawn from Niederle and Vesterlund (2005) who find, in a different experience, gender differences in expectations about performance in competitive tasks. Males are attracted to competitive environments and overestimate their performance. Bidding in a market with successful experienced opponents induces them to become very competitive and, as a result, too aggressive.

Niederle and Vesterlund (2005) also find that females underestimate their performance in competitive tasks. This could be the factor that induces them to imitate the experienced opponents. In this case, the mixed market enhances female learning and hinders male learning.

The experienced bidders do not behave differently in the mixed market and the benchmark treatment. Even when facing overly aggressive opponents, the inexperienced bidders, in the mixed market, they do not become more aggressive. This implies a relatively deep understanding of the bidding environment because they are not tempted to bid more aggressively.

This study shows the interesting effects of the mixed markets and implies very different adaptation behavior of inexperienced males and females to economic environments. It is an interesting avenue for future research to investigate further the differences of males and females in learning and reacting to competitive environments. My design only allows me to draw some initial hypotheses that are clearly worthwhile to be investigated deeper.

## Appendix A

**Table 1: Data Description**

Session	Treatment	Experience	Gender	# Participants
1	Inexp.	Inexperienced	All	30
			Female	12
			Male	18
2	Inexp.	Inexperienced	All	30
			Female	16
			Male	14
3	Mixed	Inexperienced	All	15
			Female	8
			Male	7
		Experienced	All	15
			Female	7
			Male	8
4	Mixed	Inexperienced	All	14
			Female	8
			Male	6
		Experienced	All	14
			Female	7
			Male	7

5	Exp.	Experienced	All	27
			Female	11
			Male	16

**Table 2: Bid Factor Regression for Inexperienced Subjects**

Bidfactor	Coefficient
Male	-.3941 (1.2123)
Inexp.	-1.995* (1.0813)
male*inexp.	2.9437 ** (1.4831)
learn*male*inexp.	-2.1275*** (.5315)
learn*male*mixed	-4.2407*** (.8441)
learn*female*inexp.	-4.8442*** (.6475)
learn*female*mixed	-4.4788*** (.8248)
Intercept	8.4845*** (.8511)

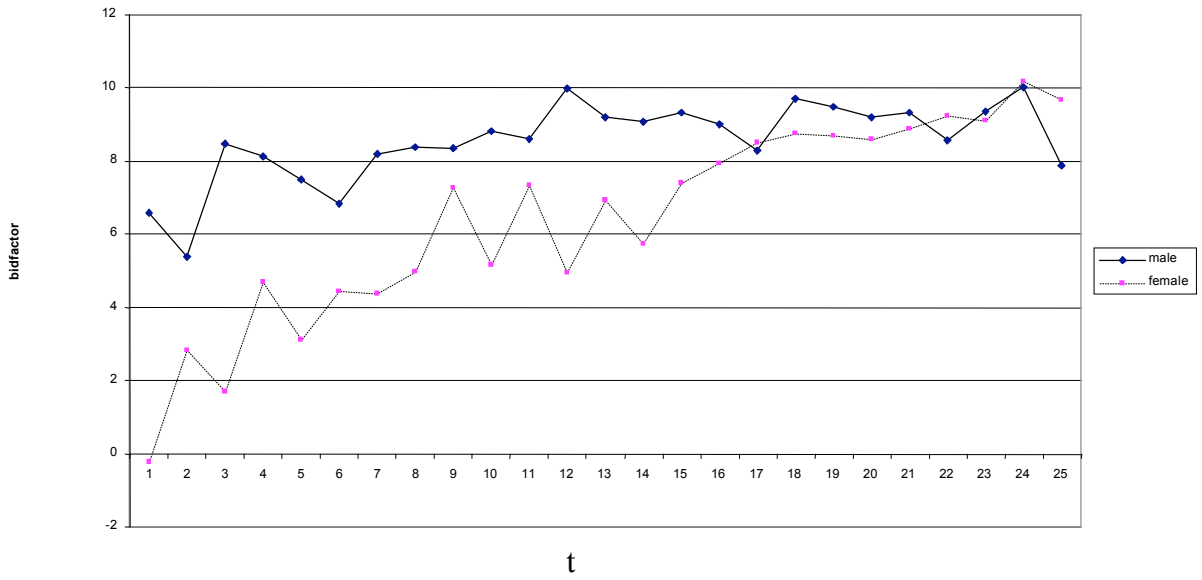
Note: Standard errors in parentheses.

\*\*\* significant at 1% level

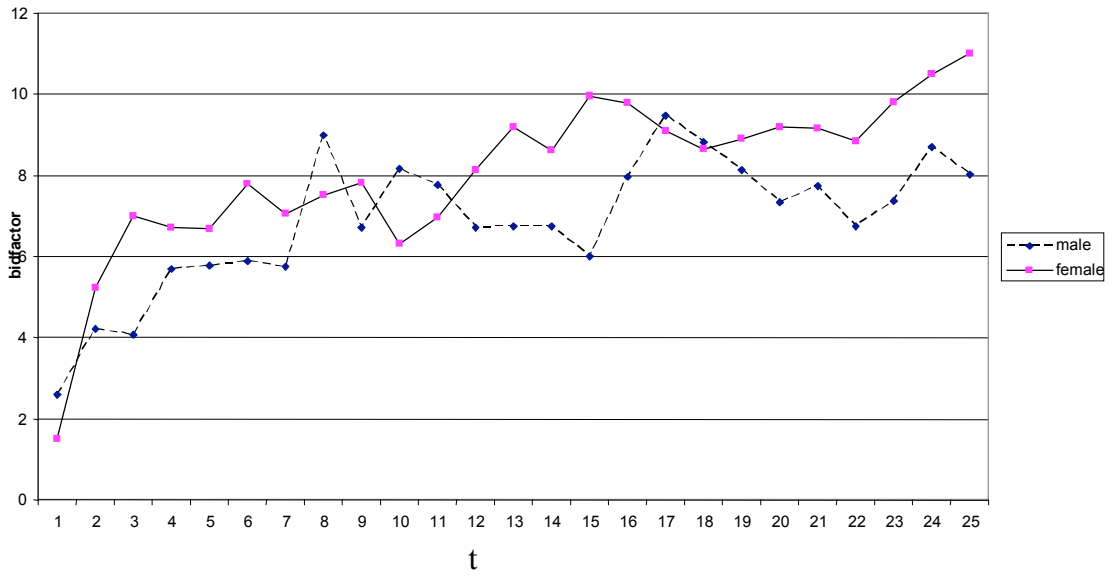
\*\* significant at 5% level

\* significant at 10% level

**Figure 1: Average Bid Factors of Inexperienced Subjects in the Inexperienced Treatment**



**Figure 2: Average Bid Factors of Inexperienced Subjects in the Mixed Treatment**



**Table 3: Average Bid Factors of Inexperienced Subjects**

	Males <sup>a</sup>	Females <sup>a</sup>	Mann-Whitney
Inexperienced Males=Females, Rounds 2-5	6.9428 (.6581)	2.8251 (.8157)	$z = -3.579$ Prob> z  = 0.0003
Inexperienced Males=Females, Rounds 20-25	9.1766 (.6996)	8.2061 (1.284)	$z = -0.849$ Prob> z  = 0.3958
Mixed Males=Females, Rounds 2-5	3.9096 (1.4694)	6.4015 (1.0729)	$z = 0.979$ Prob> z  = 0.3275
Mixed Males=Females, Rounds 20-25	7.5849 (1.1709)	9.3324 (.9199)	$z = 1.015$ Prob> z  = 0.3099
Inexperienced males= =Mixed males, Rounds 2-5			$z = -1.761$ Prob >  z  = 0.0783
Inexperienced males= =Mixed males, Rounds 10-15			$z = -1.925$ Prob >  z  = 0.0542
Inexperienced males= =Mixed males, Rounds 20-25			$z = -1.285$ Prob >  z  = 0.1988
Inexperienced females= =Mixed females, Rounds 2-5			$z = 2.469$ Prob >  z  = 0.0136
Inexperienced females= =Mixed females, Rounds 10-15			$z = 1.073$ Prob >  z  = 0.2831
Inexperienced females= =Mixed females, Rounds 20-25			$z = 0.646$ Prob >  z  = 0.5184

a: Standard Errors in Parentheses

**Table 4: Average Profits by Subject and Bankruptcies**

Profit	Mean <sup>b</sup> Conditional on winning	Mean <sup>b</sup> Overall	Predicted Average RNNE Profit By round	Bankruptcies
Male, Inexperienced	-.4758856 (.7007)	-.4549349 (.3300)	1.281359 (.1831)	0.22 (7/ 32)
Female, inexperienced	-5.482816 (1.1271)	-2.605233 (.6919)	1.246731 (.18261)	0.64 (18/ 28)
Male, mixed	-1.627323 (1.1024)	-1.100391 (.6976)	1.16568 (.1597)	0.31 (4/ 13)
Female, mixed	-4.910825	-3.988962	.9835368	0.44

	(2.1405)	(1.9546)	(.2036)	(7/ 16)
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b: Standard Error in Parentheses.

**Table 5: Bid Factor Regression for Experienced Subjects**

Bidfactor	Coefficient <sup>a</sup>	Coefficient <sup>a</sup>
Male	.7998 (.9219)	.8426 (1.2044)
Exp.	-1.5829 (1.0319)	-1.28 (1.3117)
male*exp.	1.2927 (1.3627)	1.3595 (1.7545)
learn*male*exp.	.2834 (.5028)	-
learn*male*mixed	-.5836 (.51)	-
learn*female*exp.	.1837 (.6655)	-
learn*female*mixed	-.5855 (.5294)	-
Intercept	9.0937*** (.6678)	8.7717*** (.8671)

a: Standard errors in parentheses.

\*\*\* significant at 1% level

\* significant at 10% level

Figure 3: Average Bid Factors of Experienced Subjects in Experienced Treatment

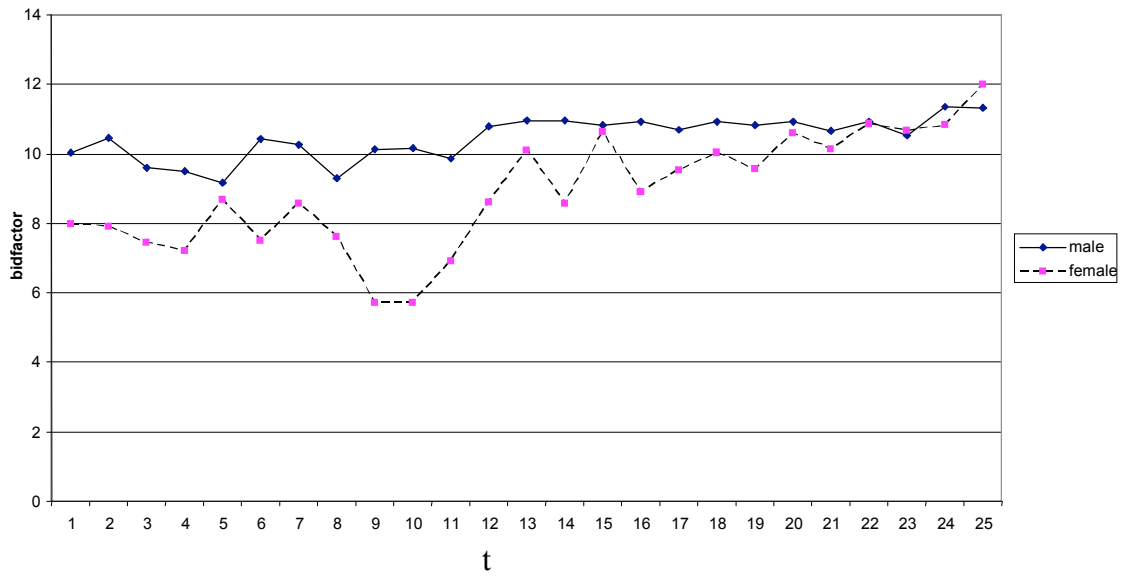


Figure 4: Average Bid Factors of Experienced Subjects in Mixed Treatment

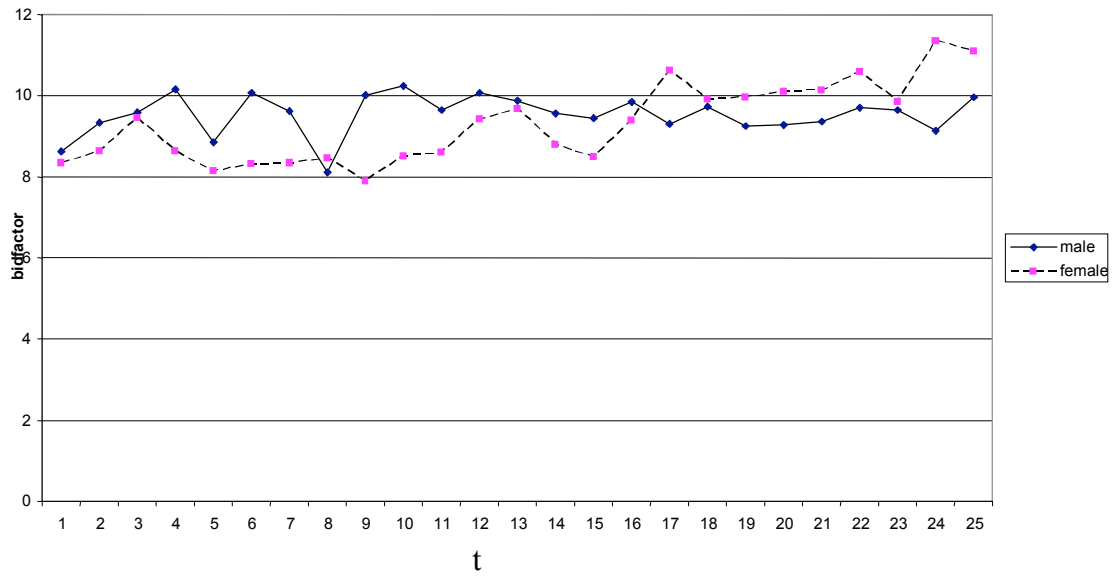
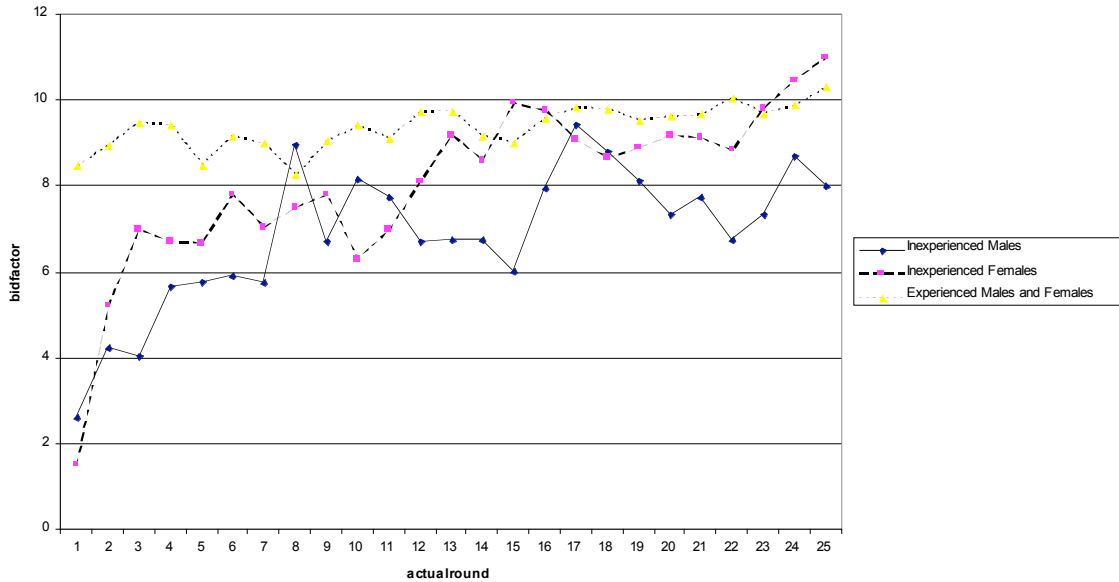


Figure 5: Inexperienced Males and Females and Their Experienced Opponents



## Appendix B

### Instructions for the Closed Market

#### INSTRUCTIONS

This is an experiment in the economics of market decision making. The National Science Foundation and Ohio State University have provided funds for conducting this research. The instructions are simple, and if you follow them carefully and make good decisions, you may earn a **CONSIDERABLE AMOUNT OF MONEY** which **WILL BE PAID TO YOU IN CASH**.

1. In this experiment there will be a market in which you will act as buyers of a fictitious commodity in a sequence of trading periods. A single unit of the commodity will be auctioned off in each trading period. There will be several trading periods.

- Your task is to submit bids for the commodity in competition with other buyers. The precise value of the commodity at the time you make your bids will be unknown to you. Instead, each of you will receive information as to the value of the item, which you should find useful in determining your bid. The process of determining the value of the commodity and the information you will receive will be described shortly.
- The high bidder earns the item and makes a profit equal to the difference between the value of the commodity and the amount he/she bid. That is

$$(\text{VALUE OF ITEM}) - (\text{HIGHEST BID}) = \text{PROFITS}$$

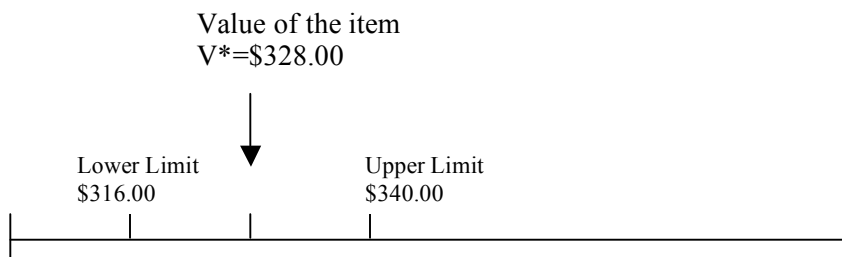
for the high bidder. If this difference is negative, it represents a loss.

If you do not make the high bid on the item, you will earn zero profit. In this case, you neither gain nor lose money from bidding on the item.

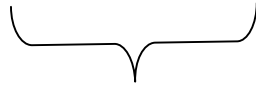
- The value of the auctioned item ( $V^*$ ) will be assigned randomly and will lie between \$50.00 and \$950.00 inclusively. For each auction, ANY VALUE within this interval has an EQUALLY LIKELY chance of being drawn. The value of the item can never be less than \$50.00 or more than \$950.00. The  $V^*$  values are determined randomly and independently from auction to auction. As such, a high  $V^*$  in one period tells you nothing about the likely value in the next period – whether it will be high or low. It doesn't even preclude drawing the same  $V^*$  value in later periods.
- Private Estimates of  $V^*$ :

Although you do not know the value of the item  $V^*$  prior to bidding, you will receive information which will narrow down the range of possible values. This will consist of a randomly drawn number from the interval whose lower bound is  $V^* - \$12.00$ , and whose upper bound is  $V^* + \$12.00$ . ANY VALUE within this interval has an EQUALLY LIKELY chance of being drawn and being assigned to you as your own private estimate of  $V^*$ . (Each bidder gets their own private estimate – different random draws from the interval  $V^* - \$12.00$  and  $V^* + \$12.00$ .)

For example, suppose that  $V^* = \$328.00$ . Then each of your private estimates will consist of a randomly drawn number that will lie between \$316.00 ( $\$328.00 - \$12.00$ ) and \$340.00 ( $\$328.00 + \$12.00$ ). Any number in this interval has an equally likely chance of being drawn as your own private estimate. The line diagram below shows what is going on in this example.



\$50.00



\$950.00

Private Estimates may be  
anywhere in this interval

The data below provide some examples of the private estimates drawn in past auctions with 4 bidders. (Note that we have ordered these estimates from lowest to highest.)

Value of the item  $V^* = \$328.00$  Private Estimates:

323.89

324.58

335.82

339.45

You will note that some private estimates are above the  $V^*$  and some are below the  $V^*$ . Over a sufficiently long series of auctions, the differences between your private estimate and  $V^*$  will average out to zero (or very close to it). For any given auction, however, your private estimate can be above or below the value of the item  $V^*$ . That is the nature of the random selection process generating the private estimates.

You will also note that  $V^*$  must always be greater than or equal to your private estimate minus \$12.00. The computer calculates this for you and notes it. Further,  $V^*$  must always be less than or equal to your private estimate plus \$12.00. The computer calculates this for you and notes it.

Finally, you may receive a private estimate below \$50.00 (or above \$950.00). There is nothing strange about this, it just indicates that  $V^*$  is close to \$50.00 (or \$950.00).

- At the beginning of today's session, you will be given a starting cash balance of \$15.00. The starting cash balance, and whatever subsequent profits you earn from the auction permit you to suffer losses in one auction to be recouped in part or in total in later auctions. However, should your cash balance drop to zero (or less) during the experiment you will not longer be permitted to participate in today's session. Instead, you will be asked to leave the auction. You ARE permitted to bid in excess of your cash balance in any given period.
- There are \_\_\_ participants in this experiment. In each trading period you will be randomly assigned to one of two positions: Either you will bid in one of the \_\_\_ markets with each four bidders or you will randomly be selected to be inactive in that period. The random assignment is done after each trading period so that the others bidding in your market will probably be different every period. The \_\_\_ auction markets operate simultaneously each period but are separate in the sense that bids in one market are irrelevant to the other market. At the end of each

period, you will only see results of the market in which you were participating. Results posted on your computer screen will include the value of the item  $V^*$ , the private estimates of all bidders in your market along with their bids, and the earnings of the high bidder. Inactive bidders will not see any results for that period.

8. No one may bid less than \$0.00 for the item and bids must be rounded to the nearest penny to be accepted. In case of ties for the high bid, the computer will randomly determine who will earn the item.

There will be a reserve price of  $V^* - \$24.00$  in each auction. If the high bid is below the reserve price the item will not be sold that auction period and the high bidder will earn \$0.00.

9. You are not to speak or in any way communicate with any other participant while the experiment is in progress. This is important to the validity of the study and will not be allowed.

Let's summarize the main points:

Auction Rules:

1. The high bidder earns the item and makes a profit = value of item  $V^*$  - amount he/she bid. All other bidders earn zero. Profits can be positive or negative.
2. Prior to bidding, the value of  $V^*$  is unknown to you but is always between \$50.00 and \$950.00. Any value in this interval has an equally likely chance of becoming  $V^*$ .
3. Your private estimate of  $V^*$  will be randomly drawn from the interval  $V^* - \$12$  and  $V^* + \$12$ . Any value in this interval has an equally likely chance of being drawn as your own private estimate of  $V^*$ . Note that  $V^*$  can never be more than your private estimate plus \$12 and never be less than your private estimate minus \$12.
4. In each auction period, you can be an active or inactive bidder. Active bidders are randomly assigned to separate markets with 4 bidders each.

YOUR TOTAL EARNINGS FOR THIS SESSION come from these sources:

1. Starting cash balance of \$15.00
2. Auction earnings as explained above. There will be 2 practice runs of the auction with no money at stake. This will be followed by 25 auctions played for cash.

Your cumulative earnings, which are shown on your computer screen, are the sum of 1 and 2 above. Should they become zero or negative during the experiment, you will no longer be permitted to participate in today's session.

As announced in the email, PAYMENTS IN CASH to you will be made as follows:

1. Today you receive half of your total earnings of today's session.

2. The other half of today's total earnings will be paid after the completion of the second session. Then you will also receive the total earnings of the second session along with the \$20 participation payment.

## **Instructions for the Open Market**

### INSTRUCTIONS

This is an experiment in the economics of market decision making. The National Science Foundation and Ohio State University have provided funds for conducting this research. The instructions are simple, and if you follow them carefully and make good decisions, you may earn a **CONSIDERABLE AMOUNT OF MONEY** which **WILL BE PAID TO YOU IN CASH**.

In this experiment there will be a market in which you will act as buyers of a fictitious commodity in a sequence of trading periods. A single unit of the commodity will be auctioned off in each trading period. There will be several trading periods.

Your task is to submit bids for the commodity in competition with other buyers. The precise value of the commodity at the time you make your bids will be unknown to you. Instead, each of you will receive information as to the value of the item, which you should find useful in determining your bid. The process of determining the value of the commodity and the information you will receive will be described shortly.

The high bidder earns the item and makes a profit equal to the difference between the value of the commodity and the amount he/she bid. That is

$$(\text{VALUE OF ITEM}) - (\text{HIGHEST BID}) = \text{PROFITS}$$

for the high bidder. If this difference is negative, it represents a loss.

If you do not make the high bid on the item, you will earn zero profit. In this case, you neither gain nor lose money from bidding on the item.

The value of the auctioned item ( $V^*$ ) will be assigned randomly and will lie between \$50.00 and \$950.00 inclusively. For each auction, ANY VALUE within this interval has an **EQUALLY LIKELY** chance of being drawn. The value of the item can never be less than \$50.00 or more than \$950.00. The  $V^*$  values are determined randomly and independently from auction to auction. As such, a high  $V^*$  in one period tells you nothing about the likely value in the next period – whether it will be high or low. It doesn't even preclude drawing the same  $V^*$  value in later periods.

Private Estimates of  $V^*$ :

Although you do not know the value of the item  $V^*$  prior to bidding, you will receive information which will narrow down the range of possible values. This will consist of a randomly drawn number from the interval whose lower bound is  $V^* - \$12.00$ , and



Finally, you may receive a private estimate below \$50.00 (or above \$950.00). There is nothing strange about this, it just indicates that  $V^*$  is close to \$50.00 (or \$950.00).

At the beginning of today's session, you will be given a starting cash balance of \$15.00. The starting cash balance, and whatever subsequent profits you earn from the auction permit you to suffer losses in one auction to be recouped in part or in total in later auctions. However, should your cash balance drop to zero (or less) during the experiment you will not longer be permitted to participate in today's session. Instead, you will be asked to leave the auction. You ARE permitted to bid in excess of your cash balance in any given period.

In each trading period you will be randomly assigned to one of two positions: Either you will bid in one of the several markets with each four bidders or you will randomly be selected to be inactive in that period. The random assignment is done after each trading period so that the others bidding in your market will probably be different every period.

We will be conducting several auction markets simultaneously in each period. These markets will be separate in the sense that bids in one market are irrelevant to the other market. At the end of each period, you will only see results of the market in which you were participating. Results posted on your computer screen will include the value of the item  $V^*$ , the private estimates of all bidders in your market along with their bids and the earnings of the high bidder. Inactive bidders will not see any results for that period.

No one may bid less than \$0.00 for the item and bids must be rounded to the nearest penny to be accepted. In case of ties for the high bid, the computer will randomly determine who will earn the item.

There will be a reserve price of  $V^* - \$24.00$  in each auction. If the high bid is below the reserve price the item will not be sold that auction period and the high bidder will earn \$0.00.

You are not to speak or in any way communicate with any other participant while the experiment is in progress. This is important to the validity of the study and will not be allowed.

You are all inexperienced bidders, having never participated in an auction like this before. In a moment we will be inviting in a number of experienced bidders who have participated in an experiment just like this one last week. Markets will either have inexperienced and experienced buyers, only inexperienced buyers, or only experienced buyers. The number of experienced and inexperienced bidders in your market for the current period will be noted on your computer screens. Notice that these numbers might differ from auction period to auction period.

(The following instructions were read after the experienced bidders were invited in)

In today's session, we are mixing inexperienced and experienced bidders together to see what happens when we do so. The students who have just entered the room have all participated in an experiment just like this one some time last week. The students who were in the room when you all just entered are inexperienced bidders. They have never participated in an experiment like this before.

There are a total of \_\_\_ participants in this experiment. \_\_\_ of you are inexperienced, participating in this experiment for the first time. There are \_\_\_ experienced bidders all of which have participated in the same experiment last week. They are experienced buyers.

Markets will either have inexperienced and experienced buyers, only inexperienced, or only experienced buyers. The number of experienced and inexperienced buyers in your market for the current period will be noted on your computer screen. Notice that these numbers might differ from auction period to auction period.

The \_\_\_ auction markets operate simultaneously each period but are separate in the sense that bids in one market are irrelevant to the other market. At the end of each period, you will only see results of the market in which you were participating. Results posted on your computer screen will include the value of the item  $V^*$ , the private estimates of all bidders in your market along with their bids and types (E for experienced and I for inexperienced), and the earnings of the high bidder. Inactive bidders will not see any results for that period.

Let's summarize the main points:

Auction Rules:

5. The high bidder earns the item and makes a profit = value of item  $V^*$  - amount he/she bid. All other bidders earn zero. Profits can be positive or negative.
6. Prior to bidding, the value of  $V^*$  is unknown to you but is always between \$50.00 and \$950.00. Any value in this interval has an equally likely chance of becoming  $V^*$ .
7. Your private estimate of  $V^*$  will be randomly drawn from the interval  $V^* - \$12$  and  $V^* + \$12$ . Any value in this interval has an equally likely chance of being drawn as your own private estimate of  $V^*$ . Note that  $V^*$  can never be more than your private estimate plus \$12 and never be less than your private estimate minus \$12.
8. In each auction period, you can be an active or inactive bidder. Active bidders are randomly assigned to separate markets with 4 bidders each. Markets have experienced and inexperienced bidders, only experienced bidders, or only inexperienced bidders. The numbers of experienced and inexperienced bidders in your market for the current period will be noted on your computer screen. Notice that these numbers might change from period to period.

YOUR TOTAL EARNINGS FOR THIS SESSION come from these sources:

3. Starting cash balance of \$15.00
4. Auction earnings as explained above. There will be 2 practice runs of the auction with no money at stake. This will be followed by 25 auctions played for cash.

Your cumulative earnings, which are shown on your computer screen, are the sum of 1 and 2 above. Should they become zero or negative during the experiment, you will no longer be permitted to participate in today's session.

PAYMENTS IN CASH to you will be made as follows:

3. You will receive today's total earnings.
4. If this is your first session, you will also receive a participation payment of \$6.
5. If this is your second session, you will also receive half of last session's total earnings and the \$20 participation payment.

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