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The Effect of Information Feedback on Bidding Behavior: Experimental Study on Regret Theory in Auctions

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Abstract The present study investigates whether information feedback affects bidding behavior in first price auctions. Feedback differences significantly affect bidding in the literature. As a possible explanation, preceding study built regret anticipation model and shown that information feedback on the loser can be a driving force for overbidding relative to risk neutral Nash equilibrium predictions. However, the question if actual regret experience affects bidding remains unanswered. Furthermore, whether an opportunity for regret distort posterior decision is unanswered. Therefore, an experiment was conducted to test whether actual regretful feedback causes overbidding by using a repeated design experiment. Experimental results indicate that feedback information on bidding results does not cause significant overbidding in the first round, but loser regret sensitive bidders tend to overbid in the next round.

Keywords: *first price auctions, overbidding, regret, information feedback, within subject design*

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1. Introduction

Daily choices are often distorted by negative emotions. Regret is one of these emotions we feel after observing negative outcomes of our choices, and it subsequently affects our next choice. In this paper, we use a laboratory experiment to test whether an individual changes behavior when feedback of behavioral outcomes is controlled.

Regret is an emotional state of a person, and, thus, it has been discussed in the context of psychological decision making or statistical decision theory [1,2,3]. Recently, there is a growing body of literature on regret in economic decision making contexts. As such, regret is observed in sequential decision situation, such as Bell's [4] theoretical attempt to combine regret with utility function to explain the Allais Paradox. Furthermore, regret becomes one of the main topics in behavioral economics.

Researchers have built models and studied many aspects of regret in economic decisions. The first paper that introduced regret into auctions is Engelbrecht-Wiggans's [5]. Subsequently, Engelbrecht-Wiggans and Katok [6] analyzed the relationship between regret and risk attitudes in sealed bid auctions. Moreover, studies introduced regret in auctions through a rational expectation model of regret [7,8] [1]. However, it is controversial among experimental economists whether rational expectations for regret affect bidding behavior. While Filiz-Ozbay and Ozbay [7] report significant effects of loser regret anticipation on bidding, Engelbrecht-Wiggans and Katok [8] report a significant effect of winner regret. In contrast, Katuščák [10] and Ratan and Wen [11] report null effects of feedback on bidding behavior. Their result suggest that there are no significant effects of information feedback.

In this paper, the effect of regret is tested by a different setting compared to Filiz-Ozbay and Ozbay [7] and other relevant studies. First, the approach used in this study is a repeated design experiment. Preceding studies used one shot experiment, because regret anticipation theory assumes that feedback affects one's posterior expectation of results, thus, actual information not being necessary. However, it may be possible that the existence of a chance of decision to distort posterior expectations. Furthermore, preceding experimental evidence shows that experimental subjects do not completely learn rules on auctions in one shot experiments, thus making it necessary to repeat auction rounds for them to learn their optimal strategy [12]. Therefore, this paper compares the first shot of repeated rounds to test whether the first shot of repeated experiments has the same effect as the one shot experiment.[2]

Additionally, this study uses within subject comparison, being able to explain individual sensitivity to regretful

[1] Regret is a factor which explain overbidding puzzle in Experimental Economics, see Kagel and Levine [9] for survey.

[2] Filiz-Ozbay and Ozbay [7] and Katuščák [10] have used one shot design with human opponent and Ratan and Wen [11] have used one shot design with computer opponent, while Neugebauer and Selten [12] have shown that bidders change their behavior in repeated rounds of auctions. It is controversial among experimental researcher that one shot has the same effect as repeated shots.

feedback. However, there are advantages and disadvantages of using within subject comparison. While individual sensitivity toward regretful feedback would be clearer in within subject experiment, treatment difference tends to weaken because subjects have experienced both treatments.

The experimental results indicate that feedback has no significant effect on bidding behavior in the first shot of both treatments. After repeating auction rounds, those who obtained feedback on their results had significantly overbid, and regret sensitive bidders tended to overbid in the next period. This paper contributes to extant literature in that information feedback has no significant impact on bidding behavior in the first shot and regretful outcome may induce overbidding in next period by using a repeated first price auction environment.

The structure of this paper is as follows: section 2 builds the model of auction with regret, and shows a numerical example prior to describing the experimental design for testing a model of auction with regret in the long run; experimental results are presented in section 3; and the discussion on the results and the conclusions are provided in section 4.

2. Experimental Design

In this section, the model of regret sensitive bidder and equilibrium bidding function are presented in subsection 2.1, and the experimental design in subsection 2.2.

2.1. Regret Sensitive Bidder Model

Assume first price private value auction, and extend to bidder feeling regret from their bidding result. The model consists of game setting, definition of equilibrium, and prediction.

2.1.1. Game Setting

Consider the auction that sells one object and its values, v, are independently, identically, and uniformly distributed to each bidder. The information of value distribution is private information. The risk neutral bidder decides his bid, b, and when he becomes a winner, his winning profit is v - b, otherwise the profit is zero. When the highest bids are even, the winning prize is awarded to one of the highest bidders randomly.

If the bidder has winner regret, his winning regret is b - z, z denoting the highest bid by the competitor (b > z). If the bidder has loser regret, his losing regret is v - z (z > v). As such, we can describe the amount α (b - z) (where α > 0) as suffering from disutility of winner's regret, and the amount β (v - z) (where β > 0) as suffering from disutility of loser's regret. Consequently, the expected utility function of the bidder is written as

$$\pi(b;v) = (v-b)F(b) - \int_{z;z\le b} \alpha(b-z)\,dF(z) - \int_{z;b\le z\le v} \beta(z-v)\,dF(z). \tag{1}$$

Large capital, F, denotes the cumulative distribution function of bids. Subsequently, the expected utility function of a bidder who has regretful feelings about his own result is organized as first term; the monetary utility as second term; regret when winning, and the third term, as regret when losing.

Assume that each n - 1 bidder's value is independently drawn from a uniform distribution. As such, each bidder uses the bidding strategy b(v) = Av. Therefore, bids of opponents are uniformly and independently distributed on [0, A]. By solving first order condition of (1), regret sensitive bidders have an equilibrium bidding strategy given by

$$\begin{aligned} b^*(v) &= min\left\{A, \frac{(1+\beta)v(N-1)}{(1+\beta)(N-1)+(1+\alpha)}\right\} \\ &= \min\left\{A, \frac{v(N-1)}{(N-1)+\rho}\right\} \end{aligned} \tag{2}$$

where ρ= (1 + α) / (1 + β). If bidders are homogenous in α and β, it is common knowledge to each bidder, and they adopt this strategy, then Nash equilibrium is defined as

$$b^*(v) = \frac{v(N-1)}{(N-1)+\rho}. \tag{3}$$

If there is no regret anticipation in bidding decisions, then ρ is zero, which means the bidding function is equal to the risk neutral Nash equilibrium.

$$b^*(v) = \frac{v(N-1)}{(N-1)} = \frac{N-1}{N}\text{v}. \tag{3'}$$

2.1.2. Feedback Conditioning

In this setting, bidding behavior would be affected by result feedback. First, if feedback is assigned to winners only, the term β disappears, player only worrying about winner regret. Second, loser regret is considered. Third, both information of winners and losers cause the bid to be higher than in the no feedback condition.

2.2. Experimental Procedure

2.2.1. Subjects

The experiments were conducted at the Experimental Laboratory in the Institute of Social and Economic Research, Osaka University. All participants were male students at Osaka University. The reason why we use male subjects is to avoid unobserved heterogeneity by sex differences [13,14]. The number of total subjects is 116. The ages of students were between 18 and 27 (average 21.02, standard deviation 1.59). The experiments consisted of six sessions, each comprising three treatments and one questionnaire. Treatments 1 and 2 were run in different order in each session to eliminate the order effect.

Treatment 1 is first price auction with no feedback, while Treatment 2 is first price auction with feedback. Questionnaires consisted of two answer sheets. Answer sheet 1 is a demographic questionnaire requesting age, experience of participation to economic experiments, experience of using auctions, experience of trading financial products, type of part time job, and smoking habits. Answer sheet 2 is the Holt Laury Lottery [15], which observes the magnitude of risk averseness independently. This paper analyzes the difference in data for Treatments 1 and 2 to test the experimental hypothesis that regret anticipation changes by winning or losing experiences. The difference between Treatments 1 and 2 is only the feedback information.

2.2.2. Experimental Protocol

Subjects were seated by a lottery draw to an isolated box in front of the computer interface. After reading the instruction, the experimental session started. At the beginning of each period, the computer program assigns "value" to each subject, which is randomly drawn from {6, 12, 18, 24, 30}. The subjects announced that a certain integer number between 0 and 30 were randomly assigned. The computer randomly matches opponent with subject in each period, using the random matching protocol. Each auction consists of two participants. As previously mentioned, if a subject is the winner, then his "profit" is "value" minus "bid," otherwise his profit is zero. When the highest bid is even, the computer decides the winner randomly by a 50% probability. The experimental program was built by zTree [16].

2.2.3. Experimental Conditions

Subjects were assigned both two conditions for each treatment, no feedback condition (NF) and feedback condition (FB).

No feedback condition: In the no feedback condition, participants are informed on profit, and know whether they won or lost.

Feedback condition: In the feedback condition, the participants are informed on the winner's value, the winner's bid, the loser's value, the loser's bid, Loser's, and their own profit.

All subjects were assigned both feedback and no feedback conditions. This paper adopts within subject comparison of feedback information.

2.2.4. Experimental Hypotheses

By using the prediction model in section 2, we have three experimental hypotheses. First, second term of model prediction:

Hypothesis 1: If the player feels winner's regret after winning, then bidding data in next period is below Risk Neutral Nash Equilibrium (henceforth RNNE).

Hypothesis 2 is obtained by using the third term of the prediction model.

Hypothesis 2: If the player feels loser's regret after he losing, then bidding data in next period is above RNNE.

Finally, by comparing between FB and NF:

Hypothesis 3: If the player feels winner's regret, then the bid in NF is higher than in FB.

Hypothesis 4: If the player feels loser's regret, then the bid in NF is lower than in FB.

To test hypothesis 1, we pick the value from data satisfying the following condition: if a bidder won, then his winners regret is bid minus assigned value in next period. This variable is compared to the average bid minus value. Subsequently, to test hypothesis 2, we pick the value from data satisfying the following condition: if a bidder loses, then we choose his loser's regret and bid minus assigned value in the next period. Finally, using a linear prediction of bid function, we compare the bid function of FB and NF in the period subsequent to the winner regret period.

3. Results

This section reports basic information (average earning, collected variables, and descriptive statistics) in subsection 3.1. Subsequently, statistical analysis is reported in subsection 3.2, and the statistical model is tested in subsection 3.3. Finally, supporting results are reported in subsection 3. 4.

3.1. Descriptive Statistics

The average earnings of subjects in Treatments 1 and 2 were 115.3 points. The summary bid is reported in Table 2. The result of First price auction is consistent with related literature [16], [17]. The average bid of each treatment and session were significantly above the RNNE bid (p = 0.370).

3.2. Results of Each Experimental Condition

There was no significant difference in average bid/value coefficient between FB and NF conditions (p = 0.125). Figure 1 shows that both NF (b = 0.672) and FB conditions (b = 0.679) were significantly overbid to RNNE (= 0.5).

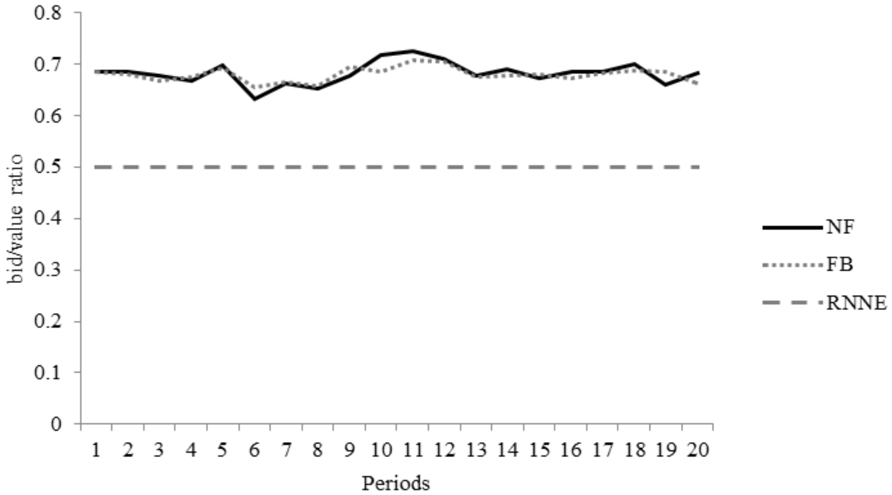

Figure 1. Average bid value coefficient across period

Table 1 shows the test of the prediction of Filiz-Ozbay and Ozbay [7] in this experimental setting. However, the treatment difference on information feedback had no significant difference on bidding behavior.

Table 1. Bid Value Ratio in the First Round

assigned value	FB	NF	Difference (*p-value*)
V=6	0.746	0.708	0.606
n	25	20	
v=12	0.681	0.666	0.773
n	29	30	
V=18	0.747	0.651	0.010*
n	20	18	
V=24	0.634	0.638	0.916
n	21	25	
V=30	0.604	0.604	0.990
n	21	23	
All	0.638	0.662	0.157
n	116	116	

Notes: *p*-value is the two-sided test score.

3.3. Statistical Tests

To test hypothesis 2, the value from data satisfying the following condition was selected: if a bidder loses, then pick his loser regret and bid minus his assigned value in the next period. Comparing this variable to the mean bid minus value, there was significant difference between variables (p = 0.002). To test hypothesis 3, we compared NF and FB conditions. There was no significant difference between variables (p = 0.245). Figure 1 compares the correlation between NF and FB conditions. In all averaged conditions, there was no significant difference.

3.4. Analysis of Regret Experience Effect on Next Period

To analyze the effect of the previous period, this data set was considered as panel data. N equals the number of subjects, and t is the number of periods. It is natural for the decision of subject in period t to be affected by the result of period t-1. As such, we built a linear expectation formation model to estimate the coefficient. Bidding function of subjects who feel winner regret in period t-1 for estimation model is

$$bid_{\mathrm{i,t}} = \beta_0 + \beta_1 Value_{\mathrm{i,t}} + \beta_2 Winner\ Regret_{\mathrm{i,t-1}} + \varepsilon_{\mathrm{i,t}}.$$

Alternatively, the bidding function of subjects who feel loser regret in period t-1 for estimation model is

$$Bid_{\mathrm{I,t}} = \beta_0 + \beta_1 Value_{\mathrm{i,t}} + \beta_2 Loser\ Regret_{\mathrm{i,t-1}} + \varepsilon_{\mathrm{i,t}}.$$

Subsequently, loser regret and bid/value coefficient in t were estimated as shown in Table 2.

There was significant difference between FB and NF treatments in decision-making in period t. This result is consistent with hypothesis 2. In contrast to loser regret, winner regrets were not significantly observed in this experiment. Although loser regret was observed in the experiment, the low value assigned in t did not make a significant difference.

Table 2. Test of Bid Value Coefficient in Period t with Regret in Period t-1

Assigned Value	FB	NF	Difference (*p*-value)
Winner Regret			
V=6	0.707	0.616	0.06
v=12	0.695	0.69	0.755
V=18	0.679	0.679	0.996
V=24	0.696	0.674	0.068
V=30	0.668	0.684	0.182
Loser Regret			
V=6	0.764	0.781	0.411
v=12	0.651	0.667	0.394
V=18	0.676	0.7	0.136
V=24	0.639	0.564	0.000***
V=30	0.577	0.497	0.021**

Notes: Significance levels: * 10%; ** 5%; *** 1%.

To test for each linear coefficient, first one-way ANOVA for each FB and NF conditions were carried out. The null hypothesis for parallel coefficients of FB and NF was rejected (p = 0.78), then test results for two step parewise comparison between FB and NF were examined. The two-step t test result showed that, when subject faces loser regret in period t, t - 1 period's loser regret subjects who assigned a high value (V=24, 30) in period t tend to overbid significantly (V = 24 condition; p = 0.000, V=30 condition; p = 0.021) in FB rather than subjects in NF.

The results (in Table 2) indicated that those who had loser regret (numerically) tend to overbid in the next period. Therefore, a nonlinear probability model with controlling for time trend, amount of profit until decision, and subject level heterogeneity was estimated. The estimation model:

$$Overbid_{\mathrm{i,t}} = \beta_0 + \beta_1 Value_{\mathrm{i,\ t}} + \beta_2 Loser\ Regret_{\mathrm{i,t-1}}$$
$$+ \beta_3 Value_{\mathrm{i,\ t}} * LR_{\mathrm{i,t-1}} + \beta_4 PeriodDummy + Profit_{\mathrm{i,\ t}} + \varepsilon_{\mathrm{i,t}}.$$

Dependent variable Overbid is an indicator the function equals to 1 if bid is overbid to RNNE, and otherwise 0. Independent variables for individuals are Value in period t, Loser Regret in period t-1, Cross term of Value and Loser Regret, Period Dummy, and total profit for subject i in period t.

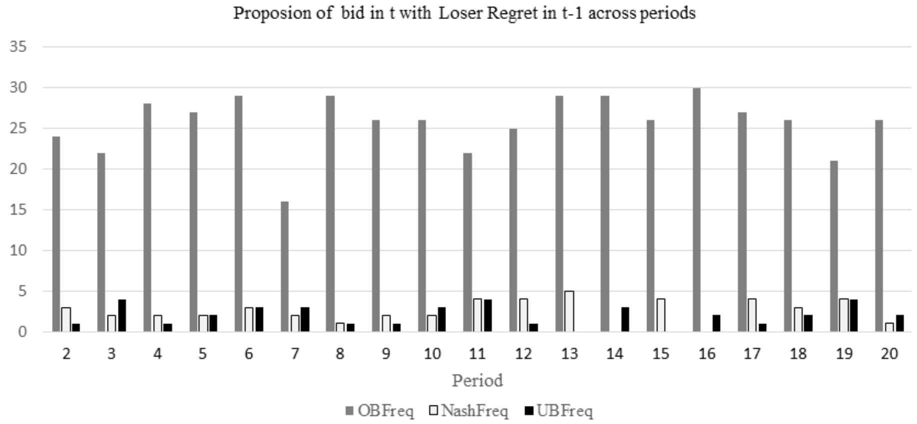

Figure 2. Overbid frequencies in period t with regret in period t-1

Notes: OBFreq; Overbid frequency in period t; NashFreq; Nash equilibrium (= 0.5v) frequency in period t; UBFreq: Underbid frequency in period

After controlling characteristics, the marginal effect of loser regret was significantly associated with overbidding (see Table 3). Moreover, the cross term of assigned valuation in period t and loser regret in period t - 1 was significant at the 5% level. This result indicates that loser regret experience in period t and the higher value assignment increased the probability of overbidding. Although the result of the logit model estimation for the interaction term of loser regret in t - 1 and value in t is consistent with hypothesis 1, the estimate is significant not only in the FB condition but also in NF. The result of the panel logit model estimation implies that the experience of losing in t - 1 period were associated with overbids in period t. Loser subject could not count the difference of bids between winner and loser, but they could conceive loss because feedback on profit was announced in both FB and NF conditions. The announcement that profit is zero might have made loser regret an effect on NF subjects.

The results of this experiment have shown that only hypothesis 2 partially holds, and hypotheses 1, 3, and 4 were rejected. These results are consistent with the rational expectation model of regret [7].

Table 3. Logit Model Estimation

Explanatory Variable: 1 if bid is overbid	Logit model estimation			
	NF(1)	NF(2)	FB(1)	FB(2)
Intercept	1.273***	1.437***	1.363***	1.602***
	(0.184)	(0.192)	(0.191)	(0.201)
V (t)	0.015	0.012	0.009	0.006
	(0.007)	(0.008)	(0.008)	(0.008)
LR(t-1)	0.120***	0.009	0.123***	-0.048
	(0.014)	(0.026)	(0.014)	(0.026)
V(t)*LR(t-1)		0.005***		0.008***
		(0.001)		(0.001)
Periods	0.093***	0.097***	0.135***	0.148***
	(0.017)	(0.017)	(0.017)	(0.018)
Profit until t	-0.023***	-0.024***	-0.030***	-0.033***
	(0.003)	(0.003)	(0.003)	(0.003)
N	458	458	458	458

Notes: Standard error reported in parenthesis. Significance levels: * 10%; ** 5%; *** 1%.

4. Discussions

Experimental hypotheses 1 and 3 are rejected may have due to the design of experimental protocol. There are some disadvantages on giving out winner's regret motives. Filiz-Ozbay and Ozbay [7] and Engelbrecht-Wiggans, and Katok [6] separate winner regret condition from the loser regret condition, and the NF condition to artificially generate winner's regret, the winner knowing his/her result and the opponent's bid. On the other hand, our experimental designs mixed loser and winner regret conditions because we run the experiment over 20 periods. Therefore, winner's regret is hard to observe in this setting.

Experimental hypothesis 2 stands because loser regret is comparatively stronger than winner regret, since asymmetric characteristics of negative and positive feeling have been discussed in behavioral economic literature, for instance loss aversion [18]. Repeated setting may have allowed them to balance their inter temporal portfolio, bidders who have many wins in the first half of the 20 experimental rounds tend to risk bidding to raise profits. Therefore, it can be problematic that regret motives may have affected their inter-temporal risk attitudes.

These results are applicable for the design of auction platform. Though Feedback system seems to affect one's bidding behavior, feedback on win or lose does not affect in our situations.

5. Conclusion

In conclusion, the purpose of this experiment is to explore whether actual loser regret elicits overbidding by using a repeated within subject design experiment. The experimental outcome indicates that information feedback on bidding results causes significant overbidding, and loser rather than winner regret bidders tend to overbid in the next period. As such, these results add new insight to the literature on regret in auctions.

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Statement of Competing Interests

The author have no competing interests.

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