Summer 10-6-2011

MEASURING REGRET: EMOTIONAL ASPECTS OF AUCTION DESIGN

Philipp Astor

Marc Adam

Caroline Jähnig

Stefan Seifert

MEASURING REGRET:
EMOTIONAL ASPECTS OF AUCTION DESIGN

Astor, Philipp J., Forschungszentrum Informatik (FZI), Haid- und Neu-Str. 10-14, 76131 Karlsruhe, Germany, astor@fzi.de

Adam, Marc T. P., Karlsruhe Institute of Technology (KIT), Englerstr. 14, 76131 Karlsruhe, Germany, marc.adam@kit.edu

Jähnig, Caroline, Georg-August-Universität Göttingen, 37073 Göttingen, Germany, christine-caroline.jaehnig@wiwi.uni-goettingen.de

Seifert, Stefan, Karlsruhe Institute of Technology (KIT), Englerstr. 14, 76131 Karlsruhe, Germany, stefan.seifert@kit.edu

Abstract

Recent research strengthens the conjecture that human decision-making stems from a complex interaction of rational judgment and emotional processes. A prominent example of the impact of emotions in economic decision-making is the effect of regret-related information feedback on bidding behaviour in first-price sealed-bid auctions. Revealing the information "missed opportunity to win" upon losing an auction, results in higher bids. Revealing the information "money left on the table" upon winning an auction, results in lower bids. The common explanation for this pattern is winner and loser regret. However, this explanation is still hypothetical and little is known about the actual emotional processes that underlie this phenomenon. This paper investigates actual emotional processes in auctions with varying feedback information. Thereby, we provide an approach that combines an auction experiment with psychophysiological measures which indicate emotional involvement. Our economic results are in line with those of previous studies. Moreover, we can show that loser regret results in a stronger emotional response than winner regret. Remarkably, loser regret is strong for high values of "missed opportunity." However, the pattern for different amounts of "money left on the table" is diametric to what winner regret theory suggests.

Keywords: Auctions, Emotions, Regret, Design Research Methods and Methodologies, Design of Information Systems

1 Introduction

Auctions have turned out to be "one of the greatest success stories of web-based services" (Ariely and Simonson, 2003). However, our understanding of how rational and emotional processes of human decision-making interact in the context of electronic markets is rather limited. Over the last years theoretical research has provided sophisticated economic models which investigate rational bidding behavior (e.g. Krishna, 2002). However, these models do not consider emotional aspects of human decision-making. Moreover, experimental tests have shown that the models often fail to accurately predict human decisions. Besides their mathematical beauty, normative models alone are thus not sufficient to fully capture human decision-making.

Engelbrecht-Wiggans (1989) states that a bidder's behavior in a first-price sealed-bid (FPSB) auction does not only depend on the *monetary* profit she expects to gain, but also on two specific *emotions*, namely loser and winner regret. In a FPSB auction, each bidder submits a single sealed-bid. The bidder who has placed the highest bid obtains the item and has to pay the amount of her bid. The bidder suffers from loser regret if she loses the auction, but learns that the object was sold for a price below her own valuation. This means that with a higher bid she could have won the item and made a profit. Contrariwise, a bidder suffers from winner regret if she wins a FPSB auction but gets notice of the second highest bid. She then knows that she has paid more than necessary because with any bid just slightly above the second highest bid she would have won the item at a lower price. The prerequisite for experiencing winner or loser regret is the *feedback* or the information provided in a FPSB auction. In order to experience loser regret (winner regret), the highest bid (second-highest bid) must be revealed to the bidders. Engelbrecht-Wiggans and Katok (2008) confirm this theory by analyzing in a laboratory experiment. However, so far little is known about the actual emotional processes which are responsible for the observed change in behavior.

In this paper, we seek to shed more light on the question to what extent different feedback provided after an auction impacts the emotions and the decisions of human bidders. More specifically, we conduct a laboratory experiment in which we vary the feedback provided to auction participants and measure their physiological correlates of emotional processing. In line with Engelbrecht-Wiggans (1989) and Engelbrecht-Wiggans and Katok (2008), we find a systematic relation between feedback information and bidding behavior. In addition, our results provide psychophysiological evidence for the emotional processing of feedback information in electronic auctions. In terms of psycho-physiology, loser regret results in higher physiological responses than winner regret. Thereby, we confirm the theoretical assumption of Engelbrecht-Wiggans and Katok (2008) that the intensity of loser regret increases with the amount of missed profit. In contrast to the theoretical assumptions of Engelbrecht-Wiggans and Katok, however, winning an auction at an unfavorable price does *not* significantly arouse bidders. To the contrary, winning the auction with exactly the right bid or only one unit too much results in a very strong emotional response. This finding can be explained by considering relief and rejoice as two intense and influential emotions in the bidding process. The remainder of this paper is structured as follows. In Section 2, we provide an overview of how feedback in Information Systems can induce emotions of winner and loser regret. Section 3 presents the experimental design of our study. In Section 4, we present and discuss the economic as well as the psychophysiological results of the experiment. Section 5 concludes.

2 Regret in Electronic Auctions

2.1 Regret in Economic Decision-Making

Electronic market design is far from being a trivial task (Weinhardt et al., 2003). As Roth (2002) put it, "markets don't always grow like weeds - some of them are hothouse orchids." Especially auctions allow for a large spectrum of design parameters, and even slight variations in the auction mechanism

can lead to large disparities in bidding behavior and, subsequently, in auction outcome and seller revenue (Milgrom, 2004). The success of auction design crucially depends on a profound understanding of human behavior, e.g. the behavior of market participants interacting in an electronic market. In this respect, Engelbrecht-Wiggans and Katok (2007) note: "Since the quality of the resulting auction design depends on the predictive ability of the theory, we need a good predictive theory." In contrast, if the understanding of the agent behavior is rather limited, the market outcome may deviate considerably from the objectives of the market engineer and even result in massive losses. Thereby, regret is highly important in human decision-making.

Regret can be defined as an aversive emotion a decision-maker experiences upon the discovery that she could have gained a higher level of utility if she had taken a different choice in the past (Humphrey, 2004). Emphasizing the importance of regret in human emotional processing Levinson (1978) argues that "regret is a common, possibly a universal, human experience." Because regret is an aversive emotion, human decision-makers tend to anticipate future regret and consequently seek to avoid this emotion by changing their behavior. Ivanova-Stenzel and Salmon (2004) argue that even if "feelings of regret" are considered irrational from a theoretical perspective, this "does not preclude their existence." Gilovich and Medvec (1995) show that regret is an essential experience in order to learn how to take advantageous decisions in the future and Coricelli at al. (2007) state that regret seems also from a neuroscience perspective to be central in human decision making. In terms of the prominent somatic marker hypothesis of Bechara and Damasio (2005) the auction outcome is a *primary inducer* of regret, while thinking about the auction outcome during the process of decision-making is regarded as a *secondary inducer*. Crone et al. (2004) show that those individuals, who process secondary inducers more strongly, take on average more advantageous decisions.

2.2 Winner and Loser Regret in Auctions

Engelbrecht-Wiggans (1989) introduces a model of post-auction regret in first-price sealed-bid (FPSB) auctions. According to this model, a bidder's utility does not only depend on her monetary profit, but also on winner and loser regret. The author argues that a winner will experience winner regret if upon winning she is informed about the second highest bid. Engelbrecht-Wiggans refers to this feeling as "money left on the table" regret, because *ex post* the winner could have gained a higher profit with a lower bid. In contrast, the loser of an auction will suffer from loser regret if she becomes informed about the highest bid. Engelbrecht-Wiggans refers to this feeling as "missed opportunity" regret, because *ex post* the loser of a FPSB auction may have gained a profit by raising her bid. If bidders know that they will receive post-auction information regarding the highest and second highest bid, they can anticipate winner and loser regret during decision-making and reflect this concern in their bidding strategy. If bidders put equal weights on winner and loser regret, Engelbrecht-Wiggans shows analytically that their utility maximizing bidding strategies are independent of regret. If, however, bidders put more weight on loser (winner) regret, they place higher (lower) bids in equilibrium.

Vickrey (1961) derives a symmetric risk neutral Nash equilibrium (RNNE) bidding strategy. However, it is a well-established result of experimental economics that human individuals place higher bids than Vickrey's RNNE suggests (cf. Kagel, 1995). Cox et al. (1988) explain bids above RNNE levels by bidders with constant relative risk aversion (CRRA). Following the argumentation of Engelbrecht-Wiggans (1989) however, bidding above the RNNE can also be explained with anticipated loser regret. In this spirit, Kagel (1995) argues that "risk aversion is one element, but far from the only element, generating bidding above the RNNE." Engelbrecht-Wiggans and Katok (2009) explicitly test the CRRA model against the regret model in a laboratory experiment. They find "virtually no support for the risk aversion model," but strong support for the regret model. Emphasizing the importance of regret in economic decision-making in general, the authors show that regret theory can also explain contradictory results of various studies, which cannot be explained with risk aversion.

Filiz-Ozbay and Ozbay (2007) conduct a laboratory experiment in order to analyze the impact of winner and loser regret in FPSB auctions. In a between-subject design, individuals participate in a

FPSB auction, in which either the highest bid (loser regret), the second highest bid (winner regret), or no such information (no feedback) is revealed. In order to exclude learning effects, the authors opted for a one-shot design, in which bidders simultaneously place bids for a couple of auctions out of which only one is randomly chosen and conducted. Filiz-Ozbay and Ozbay find support for anticipated loser regret, as bidders place significantly higher bids under this condition. However, subjects do not seem to anticipate winner regret, as these bids are not significantly different from those in the no feedback treatment. Based on a post-auction questionnaire, in which subjects subjectively report on their individual feelings of regret, Filiz-Ozbay and Ozbay conclude that loser regret is significantly stronger than winner regret. However, although winner regret is not reflected in the bidding behavior, it is still experienced as soon as the auction outcome is revealed.

In contrast to Filiz-Ozbay and Ozbay (2007), Engelbrecht-Wiggans and Katok (2008) explicitly include learning effects in their laboratory experiment by letting bidders consecutively take part in a series of FPSB auctions. Additionally, Engelbrecht-Wiggans and Katok run a treatment, in which both, the highest and the second highest bids are revealed. They find support for the theory of loser regret. Further, the authors report a significant decrease of bids over time in the winner regret treatment and a slight decrease in the treatment with both types of regret. Engelbrecht-Wiggans and Katok conclude that individuals can only reflect winner regret in their behavior, if they have "actually experienced it several times." However, although winner regret can supposedly be learned over time, individuals still "put more weight on the loser's regret than on the winner's regret."

3 Experimental Design

The main focus of this paper is to investigate the impact of different information feedback elements on the emotional processing and bidding behavior of human individuals in electronic markets. In short we focus on the following research questions: (1) Can the emotional processes of regret be manipulated by systematically varying information feedback and (2) how are these emotions reflected in bidding behavior? Therefore, we conduct a laboratory experiment, in which we manipulate the feedback information in FPSB auctions. The experiment is closely linked to the experiment conducted by Engelbrecht-Wiggans and Katok (2008). However, while Engelbrecht-Wiggans and Katok cannot determine to what extent the information feedback induces the emotion regret, we use psychophysiological measurements in order to directly determine the intensity of emotions in the moment they actually occur. More specifically, we continuously measure the participants' skin conductivity as a proxy for their emotional processing (cf. Dawson et al., 2007). Skin conductivity is a reliable indicator for arousal it reflects the intensity of an ongoing emotional process. In compliance with the theory of induced values (Smith, 1976), all decisions in this experiment are directly related to real monetary payoffs. This means that each bidder has to accumulate so-called *monetary units (MU)*, which are individually converted into Euro and paid out in cash after the experiment. Thereby, 1 MU is equivalent to €0.03. Initially subjects are endowed with 100 MU as a lump sum payment. Monetary units were chosen to keep the payment scheme simple and that feasible bids were integers. This procedure is state-of-the-art in economic experiments (Guala, 2005). With respect to reliability of economic experiments Falk and Heckman (2009) note that "behavior in the laboratory is reliable and real: Participants in the lab are human beings who perceive their behavior as relevant, experience real emotions, and take decisions with real economic consequences."

3.1 Treatment Structure

In the experiment, each bidder takes part in a series of 50 FPSB auctions. Similar to Engelbrecht-Wiggans and Katok (2008), each subject bids against two computerized agents to exclude social preferences and other interpersonal effects. Thus, there is no strategic interaction with other human bidders in this experiment. In each auction, the human and the computerized bidders each receive an individual valuation v_i for the item for sale in the auction. Then, each bidder i individually has to decide for an integer bid b_i between 0 MU and 100 MU. The bidder who placed the highest bid wins

the auction and has to pay the amount of her bid. The incentive for participating is to obtain the profit $\Pi_i = v_i - b_i$ in the case of winning. In the case of a draw, the human bidder automatically wins. The computerized agents independently draw valuations form a uniform distribution with support on the integer set {0, 1, 2, …, 100} MU. Following the symmetric Nash equilibrium of (Vickrey, 1961), each computerized agent places a bid b_i according to the function $b_i(v_i) = (2/3)v_i$ in all treatments. Thereby, the computerized agents assume that the valuations of the human bidder stem from the same distribution as their own valuations. However, following the approach of Engelbrecht-Wiggans and Katok (2008), the human bidder receives her valuation from a permutation of the values 50 MU, 60 MU, 70 MU, 80 MU, and 90 MU. The bidder keeps a randomly chosen valuation for 10 consecutive auctions. For instance, a bidder receives the valuation of 80 in the first auction and then keeps this valuation until she receives a new valuation in the eleventh auction.

	Treatments		
	Loser Regret (LR)	No Regret (NR)	Winner Regret (WR)
Revelation of "missed opportunity" to losing bidders	yes	no	no
Revelation of "money left on the table" to winning bidders	no	no	yes
Number of subjects	24	30	24
Number of sessions	4	5	4

Table 1. Experimental Design

As depicted in Table 1, the experiment comprises three treatments: Loser Regret (LR), Winner Regret (WR), and No Regret (NR). The experiment is based on a between-subject design (Kagel, 1995), i.e. subjects exclusively participate in the LR, WR, or NR treatment. The treatments vary in the form of feedback information provided to the bidders after an auction ends. In the *Loser Regret (LR)* treatment, bidders are provided with information regarding the highest bid in case of losing an auction. The amount of "missed opportunity" is provided, i.e. the maximum profit a bidder could have gained *ex post* by placing a higher bid. This amount equals to the own valuation v_i minus the highest bid. Thereby, a bidder can learn *ex post* that she actually could have gained a profit by placing a *higher* bid. In the *Winner Regret (WR)* treatment, bidders are provided with information regarding the second-highest bid in case of winning an auction. The amount of "money left on the table" is provided, i.e. the difference between the winning bid and the second highest bid. Thereby, a bidder can learn *ex post* that she actually paid too much and could have gained a higher profit by placing a *lower* bid. In contrast, in the *No Regret (NR)* treatment, bidders are only informed whether they won or lost an auction. They do not obtain any information regarding bids of the other bidders.

The experimental system is implemented using z-Tree (Fischbacher, 2007). In order to allow for analyzing physiological reactions in response to single information events, the feedback information is provided in timed intervals. After the end of an auction, first a bidder is only informed whether she won or lost the auction. After 5 seconds, the "missed opportunity" and "money left on the table" information is displayed in the LR and WR treatments, respectively. In the NR treatment, no additional information is provided.

3.2 Procedure and Physiological Measurements

This laboratory experiment was conducted at the Karlsruhe Institute of Technology (KIT). Participants were recruited from a pool of undergraduate students using the *ORSEE* software environment (Greiner, 2003). Altogether 78 (19 female and 59 male) subjects participated in 13 sessions. Each session lasted approximately 1.5 hours. In this experiment, the average payment was €19.82, with €12.30 and €23.01 being the minimum and maximum payments, respectively. During the whole experiment, participants' skin conductivity was recorded with a constant current amplifier measurement system and Ag/AgCl (silver/silver chloride) electrodes. The electrodes were attached on the thenar and hypothenar eminences of the palm of the non-dominant hand by use of standard EDA

electrode paste (cf. Boucsein, 1992). Following the recommendations of Schmidt and Walach (2000) an initial 5 minute rest period is conducted during this preparation phase for calibration purposes. Moreover, participant interactions with the experimental system is limited to mouse inputs and participants are equipped with a pair of ear-muffs to avoid sensitivity to background noise. All sessions were conducted in spring 2010 with an average room temperature of 25 °C (77 °F). These values are within the methodological recommendations of the Society for Psychophysiological Research (cf. Fowles et al., 1981). One subject had to be removed from the whole dataset due to failed comprehension. For one session in the NR treatment, physiological measurements failed to operate. Moreover, 12 participants turned out to be non-responders regarding electrodermal activity, i.e. they do not show physiological responses. Hence, the economic analysis is based on 77 participants. The physiological analysis is based on 59 participants.

4 Results

In this section we present and discuss the economic as well as the psychophysiological results of the experiment. The key focus of the study is to investigate how the provision of loser and winner regret information changes the emotional processing of participants, and if this emotional process is linked to actual bidding behavior.

4.1 Feedback Information and Bidding Behavior

First we focus on how different feedback information influences bidding behavior. Following the theoretical predictions of Engelbrecht-Wiggans (1989), providing the bidders with the loser (winner) regret information should result in higher (lower) bids. This is reflected in the Hypotheses H1 and H2:

- **Hypothesis H1.** Bidders place higher bids, if they are informed about missed opportunities (LR treatment) in comparison to the NR treatment.
- **Hypothesis H2.** Bidders place lower bids, if they are provided with the information how much money they "left on the table" (WR treatment) in comparison to the NR treatment.

Figure 1 depicts box plots for the distribution of bids in the three treatments of the experiment. The box plots show the quartiles of the bids, as well as the minimum and maximum observation. As stated in hypothesis H1, the bids in the LR treatment are above the bids in the NR treatment. Moreover, and in line with hypothesis H2, the bids in the WR treatment are below the bids in the NR treatment. In order to analyze whether the results are comparable with previous work, we calculate the ratio of a bidder's valuation and her actual bid, the so-called bid/value ratio *(b/v)*.

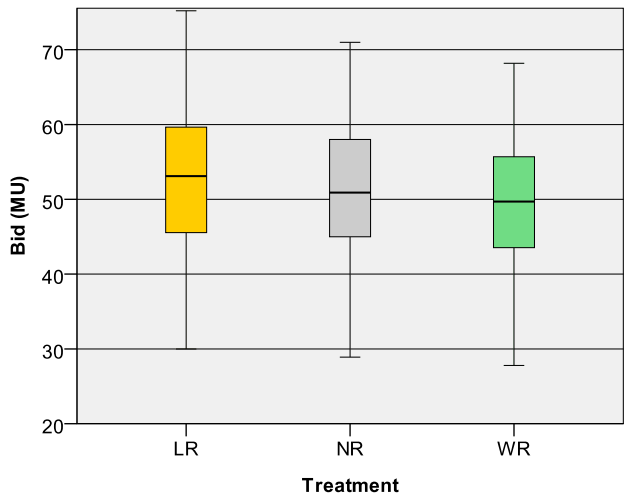

Figure 1. Bids for each treatment

The average bid/value ratios of our experiment are summarized along with the previous results in the literature in Table 2. In parentheses, the standard deviations are given. Our economic results are in line with those of previous studies. Filiz-Ozbay and Ozbay (2007) observe *bid/value* ratios of 0.79 and 0.77 for subjects in the NR and LR treatments, respectively.

	LR	NR	WR
Filiz-Ozbay et al. (2007) (4 bidders per auction)	0.87	0.79	0.77
Engelbrecht-Wiggans (2008) (3 bidders per auction)	0.776 (.048)	0.715 (.069)	0.697 (.065)
Present study (3 bidders per auction)	0.756 (.057)	0.729 (.061)	0.696 (.050)

Table 2. Summary of Bid-Value Ratios

In contrast, subjects in the LR condition place significantly higher bids (0.87). Engelbrecht-Wiggans and Katok (2008) report average bid-value ratios of 0.77 for LR bids. Subjects exposed to LR and NR place bids of 0.72 and 0.70, respectively. In all three experiments, the bidders on average place their bids above the theoretical benchmark of the Nash equilibrium bidding strategy.

	Coefficient β	Standard error	Standardized β	Significance
c (constant)	18.888	1.991		< .001
v (valuation)	.465	.651	.767	< .001
LR	1.858	.651	.100	< .005
WR	-2.292	.767	-.124	< .001
R^2 (corrected R^2)	.626 (.623)			
Observations	385			

Table 3. Regression model for the bids

We use an OLS regression model, in order to test the statistical significance of loser regret and winner regret on the bidders' bids. Different to Engelbrecht-Wiggans and Katok (2008) we explicitly look at the valuation (50, 60, 70, 80, 90) as independent and the bid as dependent variable rather than only the bid/value ratio as dependent variable. Thus, with 77 subjects in the economic analysis and 5 observations per subject, the regression is based on 385 observations. Table 2 shows the results of the OLS regression. In line with hypothesis H1, bidders place *higher* bids in the LR treatment in comparison to the NR treatment ($p < .01$). Therefore, we can reject the null hypothesis that "missed opportunity" feedback information has no impact on bidding behavior in favor for hypothesis H1. Moreover, and in line with hypothesis H2 bidders place *lower* bids in the WR treatment in comparison to the loser regret treatment ($p < .001$). Therefore, we can also reject the null hypothesis that "money left on the table" feedback information has no impact on bidding behavior in favor for hypothesis H2. In summary, we conclude from the economic data that bidders place higher bids in the LR treatment (hypothesis H1) and lower bids in the WR treatment (hypothesis H2). When taking a closer look at the constant term c of the regression, one can observe that c is above zero (18.888). Thus, including a bidder's valuation v in the analysis allows for a more finely grained analysis than the simplified bid/value ratio used for reasons of comparability with the other studies in Table 3 which implicitly assume that c is zero.

4.2 Feedback Information and Emotional Processing

Little is known about subjects' *actual* emotional processing in response to varying regret feedback information in FPSB auctions. Engelbrecht-Wiggans and Katok (2008) argue that the utility a bidder derives from a FPSB auction does not only depend on the monetary gains and losses, but also on the degree of winner and loser regret. According to Engelbrecht-Wiggans and Katok (2008) the perceived *ex ante* expected utility of a bidder with valuation v and bid b is

$$\Pi(\mathrm{b},\mathrm{v}) \equiv (v-b)F(b) - \int_{z:z\leq b} \alpha(b-z)dF(z) - \int_{z:b\leq z\leq v} \beta(v-z)dF(z)$$

where z denotes the highest bid made by the competitors (Engelbrecht-Wiggans and Katok, 2008). F denotes the cumulative distribution function of z. The first part of the formula refers to the expected monetary payoff as postulated by standard auction theory. The latter part takes into account the disutility of winner regret and loser regret, respectively. The amount of "missed opportunity" translates into $(v-z)$. The amount of "money left on the table" translates into $(b-z)$. The coefficients α and β refer to the weight of winner and loser regret, respectively. Engelbrecht-Wiggans and Katok (2008) theoretically show that if bidders *equally* weigh winner and loser regret ($\alpha = \beta$), then regret has no influence on decision-making in FPSB auctions. However, the authors conclude from their experimental results that "participants put more weight on the loser's regret than on the winner's regret" ($\alpha < \beta$). We specifically analyze the bidders' emotional response in the very moment the bidders learn about their "missed opportunity" and "money left on the table," respectively. Thereby, we test the conjecture that the loser regret is weighted stronger than winner regret ($\alpha < \beta$). This translates into hypothesis H3.

- **Hypothesis H3.** The emotional response to the feedback information in the LR treatment ("missed opportunity") is stronger than in the WR treatment ("money left on the table").

The emotional response is assessed by analyzing the skin conductivity data. The bidders' log transformed average skin conductance response amplitudes (SCR.amp) in response to receiving the "missed opportunity" and "money left on the table" feedback information for the LR and WR treatment are depicted in Figure 3. As by construction there is no such feedback information provided in the NR treatment, there are also no physiological responses to feedback information in the NR treatment. The SCR.amp is a proxy for the intensity of immediate emotions induced by a discrete stimulus. As this response usually occurs 1 to 3 seconds after the event (e.g. Boucsein, 1992; Schmidt and Walach, 2000), only amplitudes are taken into account, which are observed in that specific time frame. Furthermore, amplitudes have to comply with a predefined amplitude criterion, i.e. amplitudes have to be greater or equal to 0.01 µS (cf. Fowles et al., 1981). The SCR.amp values are obtained by decomposing skin conductivity into its tonic and phasic components with the *Ledalab* analysis software (Benedek and Kaernbach, 2010). Following the recommendation of Venables and Christie (1980), all SCR.amp values *x* are then transformed according to *log(x+1)* in order to reduce the inherent skewness of SCR.amp values. In the analysis, we focus specifically on the average SCR.amp in response to learning different feedback information in the LR and WR treatment, respectively.

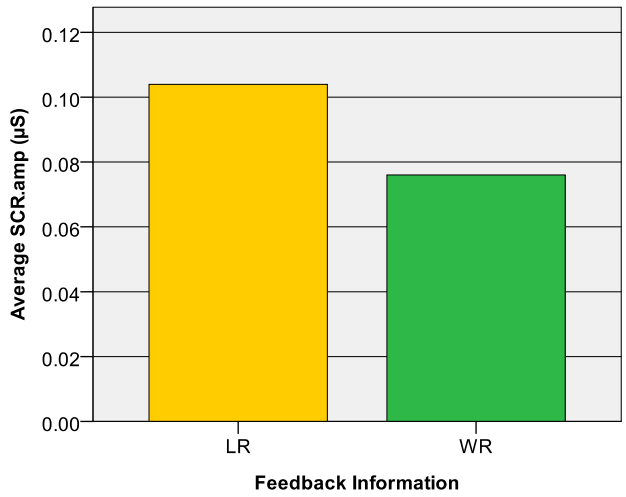

Figure 2. Average SCR.amp to Loser Regret Information and Winner Regret Information

As depicted in Figure 2, the physiological response to the feedback information in the LR treatment is stronger than the response to the feedback information in the WR treatment. Therefore, we reject the null hypothesis in favor of H3 (0.104 µS vs. 0.076 µS, two-tailed *t*-test, $p < .05$). The bidders in fact show a stronger emotional response to the feedback information in the LR treatment. This is in line with the assumption of Engelbrecht-Wiggans and Katok (2008) that the participants weigh the loser regret information stronger than the winner regret information ($\alpha < \beta$). After observing the differences between the WR and LR treatment, we will now turn our focus on subjects' varying physiological responses within the two regret treatment groups.

4.3 Emotional Processing of the Loser Regret Information

First we take a closer look on the emotional processing of the LR feedback information. Engelbrecht-Wiggans and Katok (2008) state that "regret enters additively into the bidder's utility function, and that the effect of regret on the bidder's utility function is proportional to the amount of regret suffered." Following this statement, we would assume that the experienced regret increases with the value of the "missed opportunity." In the utility function of Engelbrecht-Wiggans and Katok (2008) as depicted in Section 4.2, this translates into the term $\beta(v - z)$. If this is true, the bidders' emotional response should be stronger for increasing values of $(v - z)$. This translates into hypothesis H4:

- **Hypothesis H4.** The emotional response to the feedback information in the LR treatment is stronger for high amounts of "missed opportunity" than for low amounts of "missed opportunity."

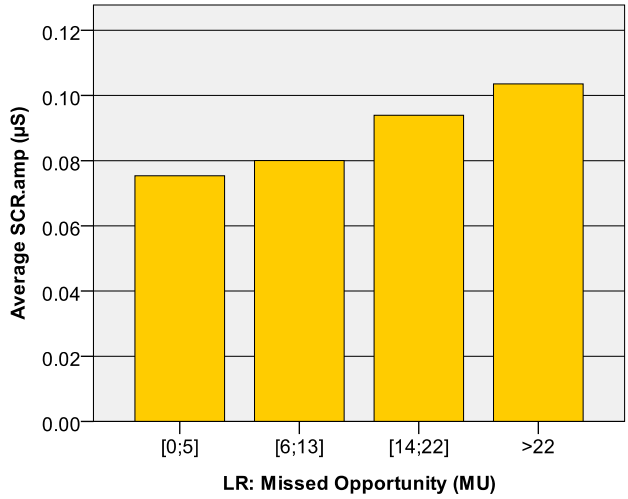

Figure 3. Mean SCR to different classes of Loser Regret Information (each class n = 51)

The bidders' log transformed average skin conductance response amplitudes (SCR.amp) in response to learning the regret information in the LR treatment for different amounts of "missed opportunity" is depicted in Figure 3. Each class consists of 51 observations. Figure 3 indicates that the psychophysiological response increases with higher amounts of "missed opportunity." This is in line with our hypothesis H4. Unfortunately, the correlation between the emotional response and the increasing degrees of "missed opportunity" is not significant for these 4 classes. Therefore, we cannot reject the null hypothesis. We attribute this to the high between-subject variability of skin conductivity and the low number of observations for different degrees of "missed opportunity." When taking instead of 4 classes two classes each with 102 observations, a simple one-sided *t*-test reveals that the emotional response to the two different classes of MO is significantly different at $p < 0.09$. At this stage, we can conclude that "missed opportunity" leads an intense emotional response, which is stronger than the "money left on the table" information. The question whether higher amounts "missed opportunity" result in stronger emotional responses will have to be investigated in future research.

4.4 Emotional Processing of the Winner Regret Information

In the next step the emotional processing of the WR feedback information will be analyzed. According to Engelbrecht-Wiggans and Katok (2008) the winner regret should also rise with increasing amounts of "money left on the table." In the utility function as depicted in Section 4.2, this is reflected in the term $\alpha(b-z)$. When regret increases with the amount of money left on the table this also should be observable within the physiological data. This translates into hypothesis H5:

- **Hypothesis H5.** The emotional response to the feedback information in the WR treatment is stronger for high amounts of "money left on the table" than for low amounts of "money left on the table."

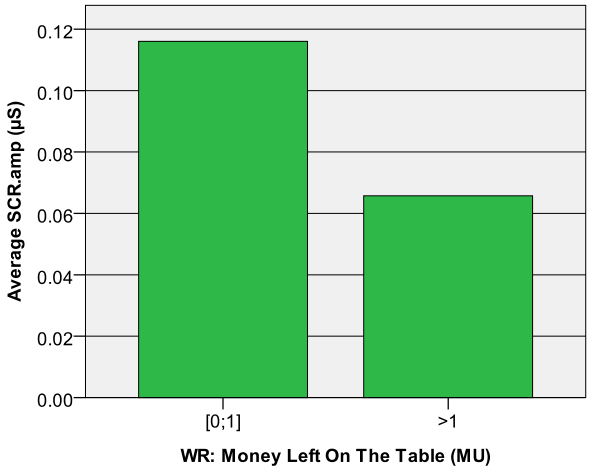

Figure 4. Average SCR.amp to different classes of Winner Regret Information

In contrast to the last section, the physiological data does not support the model of Engelbrecht-Wiggans and Katok (2008) regarding the winner regret. Quite to the contrary, the bidders experience high intensities of emotional processing for *low* values of $(b-z)$. The bidders' log transformed average skin conductance response amplitudes (SCR.amp) in response to learning the regret information in the WR treatment for different amounts of "money left on the table" is depicted in Figure 4. Very small values of "money left on the table" (i.e. values of 0 or 1) induce very high physiological responses. On the other hand, high amounts of "money left on the table" result in relatively small responses (0.116 vs. 0.066, two-tailed *t*-test, $p < .05$). Taking into account the physiological data, it seems that actually the experience of winning an auction with a very small amount ahead reveals *relief* or a *thrill of winning* and is central to participants. Suffering from winner regret on the other hand, when winning at a not optimal price, does not seem to be central in subjects' emotional experience. Therefore, we state that winner regret is only minor and not that important in subjects' emotional processing compared to loser regret. This high response can be interpreted as relief or even thrill of winning instead of winner regret, since the bidder won by a very small amount.

4.5 Discussion

The hypotheses in the present study are closely linked to those of Engelbrecht-Wiggans and Katok (2008). The majority of the initial hypotheses are supported by our data. This confirms the view that emotions, more specifically regret, can be deliberately elicited by well planned design features of Information Systems. In addition our data strengthens the claim that these design features can also influence bidding decisions. Our results do not only support the original view of how regret effects bidding behavior. The original hypothesis that the intensity of winner regret increases with the amount of "money left on the table" is challenged by the present study. With the support of physiological measures it becomes apparent that bidders show a stronger reaction to near gains, than to huge

amounts of "money left on the table." Different explanations for this deviation from theory are possible. It is possible that feelings of relief and rejoice outweigh the importance of winner regret. Engelbrecht-Wiggans and Katok (2008) point to a similar explanation.

Regarding their experiment Engelbrecht-Wiggans and Katok (2008) state "that subjects tend to anticipate loser's regret, but tend not to anticipate winner's regret until they have experienced it a couple of times." Since *loser regret* is more intuitive than *winner regret*, this could be an explanation for the differing emotional responses. Alternatively, *loser regret* after losing an auction could simply be more arousing than *winner regret* after the experience of winning. The good experience of winning cannot be distracted by the information of how much "money (was) left on the table."

5 Conclusion and Outlook

Including emotions into economic models of human behavior in electronic markets has been long overdue. Engelbrecht-Wiggans (2008) has developed such a model for bidding in FPSB auctions that includes two very decision relevant emotions, namely loser regret and winner regret. Although the model has been tested empirically the integration of emotions into the bidding process is based on purely theoretical assumptions. The present study fills this gap by actually measuring bidders' physiological reactions to regret relevant information. Resulting from the cited previous work on regret in FPSB auctions two major research questions were posed: (1) Can the emotional processes of regret be manipulated by systematically varying information feedback and (2) how are these emotions reflected in bidding behavior? The first questions can be answered with a clear "yes." As depicted in Figure 2 bidders experience more intense emotions, upon receiving loser regret information compared to receiving winner regret information. The second research question can only be answered in parts. Even though different feedback information elicits different physiological patterns and significantly different bidding behavior, the relationship between bidding behavior and emotional response is a complex interaction of rational and emotional processes, including regret and relief. In order to better understand this relationship, there is a need for future research.

In this paper we provide physiological evidence for winner and loser regret. Moreover, physiological data strongly indicates that the original assumption of Engelbrecht-Wiggans (2008) about the weight with which bidders incorporate winner regret into their bid needs to be reviewed and possibly renewed. We conclude that emotional processes can be deliberately manipulated by Information Systems design. We also conclude that psychophysiology is a valuable methodology to move forward from purely theoretical assumptions about emotions in decision making. Developing this approach further will give detailed information about how different facets of information systems are emotionally processed by the recipient and how they ultimately stimulate behavior.

Since using physiological measures in analyzing the interplay of Information Systems design, emotions and behavior is a rather new approach, opportunities for future research are extremely broad. In the present study we have only reported on skin conductivity as an indicator for the intensity of emotions. Including further physiological parameters, e.g. the heart rate, yields the possibility to extract more information about the quality of emotions. Given the fundamental impact of emotions, further analyzing the impact of information feedback with physiological measures seems a promising approach.

References

Ariely, D., and Simonson, I. (2003). Buying, bidding, paying or competing? Value assessment and decision dynamics in online auctions. *Journal of Consumer Psychology*, (13), 113–123.

Bechara, A., and Damasio, A. R. (2005). The somatic marker hypothesis: A neural theory of economic decision. *Games and Economic Behavior*, 52(2), 336–372.

Benedek, M., and Kaernbach, C. (2010). Decomposition of skin conductance data by means of nonnegative deconvolution. *Psychophysiology*, 47(4), 647-658.

Boucsein, W. (1992). *Electrodermal Activity* (1st ed.). Berlin: Springer.
Coricelli, G., Dolan, R. and Sirigu, A. (2007). Brain, emotion and decision making: the paradigmatic example of regret. *TRENDS in Cognitive Sciences*. 11(6), 258-265.
Cox, J. C., Smith, V. L., and Walker, J. M. (1988). Theory and individual behavior of first-price auctions. *Journal of Risky Uncertainty*, 1(1), 61–99.
Crone, E. A., Somsen, R. J. M., van Beek, B., and van der Molen, M. (2004). Heart rate and skin conductance analysis of antecedents and consequences of decision making. Psychophysiology, 41(4), 531–540.
Dawson, M. E., Schell, A. M., and Filion, D. L. (2007). The electrodermal system. In J. T. Cacioppo, L. G. Tassinary, and G. G. Bernston (Eds.), *Handbook of psychophysiology* (pp. 159–181). Cambridge: Cambridge Univ. Press.
Engelbrecht-Wiggans, R. (1989). The Effect of Regret on Optimal Bidding in Auctions. *Management Science*, 35(6), 685–692.
Engelbrecht-Wiggans, R., and Katok, E. (2007). Regret in Auctions: Theory and Evidence. *Economic Theory*, 33(1), 81–101.
Engelbrecht-Wiggans, R., and Katok, E. (2008). Regret and Feedback Information in First-Price Sealed-Bid Auctions. *Management Science*, 54(4), 808–819.
Engelbrecht-Wiggans, R., and Katok, E. (2009). A Direct Test of Risk Aversion and Regret in First Price Sealed-Bid Auctions. *Decision Analysis*, 6(2), 75–86.
Filiz-Ozbay, E., and Ozbay, E. Y. (2007). Auctions with Anticipated Regret: Theory and Experiment. *The American Economic Review*, 97(4), 1407–1418.
Fischbacher, U. (2007). z-Tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics*, (10)2, 171–178.
Fowles, D. C., Christie, M. J., Edelberg, R., Grings, W. W., Lykken, D. T., and Venables, P. H. (1981). Publication recommendations for electrodermal measurements. *Psychophysiology*, 18(3), 232–239.
Gilovich, T., and Medvec, V. H. (1995). The experience of regret: What, when, and why. *Psychological Review*, 102(6), 379–395.
Greiner, B. (2003). An Online Recruitment System for Economic Experiments. In K. Kremer and V. Macho (Eds.), *Forschung und wissenschafltiches Rechnen* (pp. 79–93). Göttingen.
Humphrey, S. J. (2004). Feedback-conditional regret theory and testing regret aversion in risky choice. *Journal of Economic Psychology*, 25(6), 839–857.
Ivanova-Stenzel, R., and Salmon, T. C. (2004). Bidder preferences among auction institutions. *Economic Inquiry*, 42(2), 223–236.
Kagel, J. H. (1995). Auctions: A survey if experimental research. In J. H. Kagel and A. E. Roth (Eds.), *The handbook of experimental economics*. Princeton, NJ: Princeton University Press.
Krishna, V. (2002). *Auction theory*. San Diego, California: Acad. Press.
Levinson, D. J. (1978). *The seasons of a man's life*. New York: A. Knopf.
Milgrom, P. R. (2004). *Putting auction theory to work*. Churchill lectures in economics. Cambridge: Cambridge Univ. Press.
Roth, A. E. (2002). The economist as Engineer: Game theory, experimentation, and computation as tools for design economics. *Econometria*, 70(4), 1341–1378.
Schmidt, S., and Walach, H. (2000). Electrodermal Activity (EDA): State-of-the-art measurement and techniques for parapsychological purposes. *The Journal of Parapsychology*, 64, 139–163.
Smith, V. L. (1976). Experimental Economics: Induced value theory. *The America Economic Review*, 66(2), 274–279.
Venables, P. H., and Christie (1980), M. J. Electrodermal activity. In I. Martin (Ed.), *Techniques in Psychophysiology*. Wiley.
Vickrey, W. (1961). Counterspeculation, auctions, and competitive sealed tenders. *The Journal of Finance*, 16(1), 8–37.
Weinhardt, C., Holtmann, C., and Neumann, D. (2003). Market engineering. *Wirtschaftsinformatik, 45*(6), 635–640.