Measuring Emotions in Electronic Auctions

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To my mother.

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Abstract

Auctions are nowadays a popular and frequently employed market mechanism in electronic markets. In economic literature, the success of electronic auctions has been largely attributed to the reduction of transaction costs, the large number of potential buyers, and the independence of time and space. However, an additional explanation for the success of electronic markets, and in particular Internet consumer auctions, is the hedonic or emotional value bidders derive from auction participation. The emotionality bidders experience in Internet auctions confronts a market engineer of electronic markets with two important challenges, regarding both the auction mechanism design and the user interface design. First, how can an auction system induce emotionality and, thus, attract excitement oriented consumers? Second, what is the impact of emotionality on bidding behavior? In order to approach both challenges, a market engineer needs to be able to actually measure emotions in electronic auctions.

This thesis develops a structured methodology that allows to systematically analyze emotions in electronic auctions. It provides a unified framework for emotional bidding in electronic auctions, which comprises the bidders' processes of cognitive reasoning and emotional processing. Moreover, a methodology for measuring physiological correlates of human emotional processing in economic experiments is proposed: physioeconomics. Physioeconomics extends existing methods of experimental economics by measuring autonomic nervous system activity using well-established psychophysiological methodology in order to gain a profound understanding of human economic decision-making. Based on the framework for emotional bidding and the methodology of physioeconomics, this thesis describes how emotions and their impact can be measured in electronic ascending auctions, and provides a proof-of-concept study.

Moreover, an experiment was conducted in order to analyze the impact of clock speeds on the bidders' emotional processing and behavior in Dutch auctions. Several previous experimental studies have discovered that the sellers' revenues in Dutch auctions depend on the speed at which the standing price is decreased: Slow Dutch auctions generally yield higher revenues than fast Dutch auctions. This effect is commonly explained by the conjecture that participants experience a "utility of suspense" which is stronger in fast Dutch auctions. The experiment in this thesis provides physiological evidence for a utility of suspense in Dutch auctions, further characterizes the elicited emotional state bidders experience, and investigates how this emotional state is reflected in bidding behavior. Furthermore, characteristic patterns of bidders' emotional processing in Dutch auctions are identified. It is shown (1) that inducing a bidder with an independent private valuation directly influences her level of arousal, and (2) that the heart rate of the winning bidder momentarily decreases about two seconds before she places her bid.

Contents

Chapter 1.

Motivation and Introduction

Auctions are nowadays a popular and frequently employed market mechanism in electronic markets. In particular Internet auctions for consumers have turned out to be "one of the greatest success stories of web-based services" (Ariely and Simonson, 2003). At the end of 2008, alone the market leader *eBay.com* alone reported a total number of 86.3 million active users worldwide, net revenues of $5.6 billion US, and a gross merchandise volume of nearly $60 billion US (eBay Inc., 2009).

In economic literature, the success of Internet auctions has been largely attributed to the reduction of transaction costs, the large number of potential buyers, and the independence of time and space (Ockenfels et al., 2006). However, these characteristics also apply to retail sites as *amazon.com* or *staples.com*. Further, the popularity of Internet auctions seems somewhat counterintuitive from a consumer perspective. Several field studies have confirmed that on average, auctions yield higher prices compared to fixed price offers on retail sites (e.g. Lucking-Reiley, 1999; Lee and Malmendier, 2010). In a field study, Ariely and Simonson (2003) even report that 98.8% of the observed auctions yield higher prices than commodities on retail sites with bidders paying on average 15.3% more. While a part of this phenomenon can be explained by search and waiting costs (Carare and Rothkopf, 2005), Lee and Malmendier (2010) report in another field study that 42% of the analyzed auctions yield higher prices than simultaneously listed fixed price offers on the very same computer screen. Taking the shipping costs into account, even 73% of the observed auctions result in higher total costs.

1.1. Emotions as a Quality Characteristic of Internet Consumer Auctions

However, the question arises, why a substantial part of Internet consumers is willing to pay more on auction sites than on retail sites? An additional explanation for the success of Internet auctions is the *hedonic* or *emotional* value that bidders derive from auction participation (e.g. Möllenberg, 2004; Stern et al., 2008). Whereas utilitarian value refers to the utility gained from obtaining the desired commodity, the hedonic value is gained from perceived entertainment and emotional worth of auction participation.

In this regard, Lee et al. (2009) identify "thrill of bidding, excitement of winning, stimulation of beating competitors, and enjoyment of finding rare or unusual items" as sources of hedonic value. Following this reasoning, Internet auctions may be more appealing to consumers, because they are simply more exciting. This characteristic clearly distinguishes auctions from fixed price offers and may even be understood as a quality characteristic of Internet auctions. Bapna et al. (2001) argue that consumers have to decide whether to purchase with an unexciting fixed price mechanism or to experience the "bazaar-like competitive atmosphere" of online auctions.

Marketing departments of Internet auction platforms have long understood that emotions play an important role in attracting consumers. Referring to the competitive nature of auctions, eBay launched an advertisement campaign in 2007 titled "shop victoriously" stating that "it's better when you win it" (eBay.com, 2007). In the corresponding television commercials, bidding in an eBay auction is compared to sport events such as football matches or dog races. In Germany, eBay even simply advertises directly the immediate emotions bidders experience upon winning an auction with "Jippiiieh!" or blunt "make shopping exciting" in Australia. Similarly, the platform *swoopo.com* advertises with "pulse up, price down." This refers to the actual physiological arousal bidders can experience on their platform. Another indicator for the emotionality in auctions and their "game-like action and bidding frenzy characteristic" (Stafford and Stern, 2002) is the terminology bidders apply for describing the course of action. Contrary to retail websites, bidders do not just buy commodities, they *win* or *lose* them. Correspondingly, Ariely and Simonson (2003) find in an Internet survey that 76.8% of the respondents perceive other bidders as "competitors" and refer to auction outcomes as "winning" and "losing."

The general development outlined above can be interpreted as a paradigm shift to "entertainment shopping" or "auctainment" (Glänzer and Schäfers, 2001). Hedonic values of Internet auction participation gain increasing importance. Salient evidence for this paradigm shift are emerging sites, as for example *swoopo.com*, *1-2-3.tv*, and *dubli.com*. These sites aim at attracting consumers with new (exciting) auction mechanisms and explicitly advertise themselves as "entertainment shopping" and "fun shopping" platforms, respectively. By the end of 2009, the platform *swoopo.com* alone reported more than 2.5 million registered users worldwide and an average of ten thousand products sold per month (Stone, 2009).

With respect to the competition between market platforms, it will therefore be increasingly important for market places to distinguish themselves by *how* products are sold. In particular in consumer markets, emotionless and unexciting market models will hardly have the potential to draw the attention of (new) customers and eventually end up as losers in this highly competitive business segment.

1.2. Engineering Emotionality in Auctions

Electronic market design is far from being a trivial task (Neumann, 2007). 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). This thesis concentrates in particular on auctions in which one seller auctions off a single unit of a commodity, i.e. single-unit auctions.

Highlighting the significance of sophisticated market design, Weinhardt et al. (2003) introduce an engineering approach for the design of electronic markets: *market engineering*. The authors define market engineering as a "structured, systematic, and theoretically founded procedure of analyzing, designing, introducing, and also quality assuring of electronic markets as well as their legal framework regarding simultaneously the market microstructure, infrastructure, and business strategy" (Weinhardt et al., 2003). The key elements of the structured methodology market engineering are depicted in the market engineering framework in Figure 1.1.

Based on the market structure and subject to environmental conditions, the agent be-

havior determines the market outcome and, thus, the allocation of the transaction object. The success of electronic market design crucially depends on a profound understanding of the element *agent behavior*, i.e. the behavior of market participants interacting in the market. In this respect, Engelbrecht-Wiggans and Katok (2007) note: "Since the quality of the resulting auction designs 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. In the context of this thesis, the focus lies in particular on the behavior of human individuals in electronic auctions.

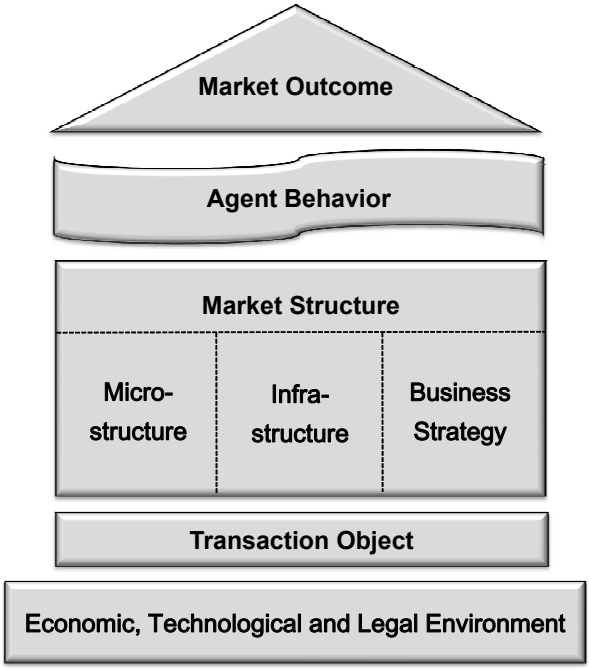


Figure 1.1.: Market Engineering Framework

A distinguished strand of the literature analyzes auctions theoretically with highly sophisticated analytical models (e.g. Vickrey, 1961; Krishna, 2002). Typically, those studies assume bidders to be sufficiently sophisticated to derive an optimal bidding strategy based on their expected monetary payoff. While these models are undoubtedly an important contribution to the design and understanding of electronic auctions, they seldomly include hedonic values of auction participation.[1] However, results from the

[1]See, for instance, Katok and Kwasnica (2008) and Ehrhart et al. (2008) for analytical approaches which comprise non-monetary utilities and behavioral biases, respectively.

laboratory and the field indicate that emotions induced during the dynamic process of auctions have an impact on bidding behavior and, subsequently, on auction outcome and seller revenue (e.g. Ehrhart et al., 2008; Lee and Malmendier, 2010). For instance, Ding et al. (2005) note that "emotions are an integral component of a bidder's decision state and bidding strategy." One phenomenon frequently observed in traditional and Internet auctions, which is often referred to an increased emotionality, is "auction fever" (e.g. Ku et al., 2005; Ehrhart et al., 2008). Under the influence of auction fever, so Murnighan (2002), bidders' "adrenaline starts to rush, their emotions block their ability to think clearly, and they end up bidding much more than they ever envisioned."

The emotionality bidders experience in Internet auctions presents the market engineer of an Internet consumer auction system with two important challenges, regarding both the auction mechanism design and the user interface design. First, how can the auction system *induce* emotionality and, thus, attract excitement oriented consumers? As described above, emotions are, for a substantial part of the bidders, an important incentive for participating in Internet consumer auctions. Second, what is the *impact* of emotionality on bidding behavior, and subsequently, on the auction outcome and seller revenue? In order to approach both challenges, a market engineer needs to be able to actually *measure* emotions in electronic auctions.

1.3. Research Questions and Structure

The main goal of this thesis is to develop a structured methodology that allows to systematically analyze emotions in electronic auctions and their impact on human bidding behavior. The remainder of this thesis is structured as follows.

Chapter 2 and Chapter 3 introduce the fundamental elements of this structured methodology. In order to systematically analyze emotions in electronic auctions, the market engineer needs a profound understanding of the dynamic interactions between cognitive reasoning and emotional processing of human bidding behavior. Therefore, Chapter 2 focuses on Research Question 1 and proposes a unified framework for emotional bidding in auctions.[2]

[2]Chapter 2 is based on joint research with Caroline Jähnig, Jan Krämer, Stefan Seifert, and Christof Weinhardt (cf. Adam et al., 2010).

Research Question 1: *How do cognitive reasoning and emotional processing interact in deriving market decisions?*

This framework focuses particularly on the interaction of cognitive reasoning and emotional processing of human bidders in electronic auctions. Further, Chapter 2 provides a detailed literature review regarding single facets of the proposed emotional bidding framework and derives a definition for the phenomenon of auction fever. The framework for emotional bidding conjectures a fundamental role of emotions on human bidding behavior and human decision-making in general. In order to evaluate this conjecture, one needs to accurately measure human emotional processing. This objective is reflected in Research Question 2.

Research Question 2: *How can economic laboratory experiments be augmented to allow for physiological measurements as proxies for emotional processing?*

Chapter 3 focuses on Research Question 2 and proposes a methodology for measuring physiological correlates of human emotional processing in economic experiments: *physioeconomics*.[3] Physioeconomics extends existing methods of experimental economics by measuring autonomic nervous system activity, using well-established psychophysiological methodology, in order to gain a profound understanding of the dynamic process of human economic decision-making. This chapter will outline methodological implications when applying psychophysiological methodologies to experimental economics and review psychological literature regarding economic decision-making.

Based on the foundations of Chapter 2 and Chapter 3, the following chapters outline how physioeconomics and the unified framework for emotional bidding can be used to investigate emotions and their impact on bidding behavior. In particular with respect to auction fever in electronic ascending auctions, Chapter 4 focuses on Research Question 3.

Research Question 3: *Is the newly developed physioeconomic methodology suitable to measure emotional processing in electronic auctions?*

[3] Chapter 3 and Chapter 4 are based on joint research with Matthias Gamer and Christof Weinhardt (cf. Adam et al., 2009). Part of this research is also published in Adam et al. (2009).

Chapter 4 introduces a basic framework for physioeconomic analyzes of electronic ascending auctions, which complies with the methodological requirements discussed in Chapter 3. Variations of the framework outline how different elicitors of auction fever can be investigated both in isolation as well as in combination. While auction fever literature frequently conjectures an interaction between physiological arousal and bidding behavior (Malhotra et al., 2008), physioeconomics allows for actually *measuring* this interaction. The chapter concludes with a proof-of-concept study.

Chapter 5 then focuses specifically on emotions in Dutch auctions, i.e. descending auctions.[4] Several previous experimental studies have discovered that the sellers' revenues in Dutch auctions depend on the speed at which the standing price is decreased: Slow Dutch auctions generally yield higher seller revenues than fast Dutch auctions (e.g. Carare and Rothkopf, 2005; Katok and Kwasnica, 2008). This effect is commonly explained by the fact that auction participants experience a "utility of suspense" (Cox et al., 1983), which is stronger in fast Dutch auctions. Chapter 5 presents a physioeconomic laboratory experiment, which focuses on Research Question 4.

> **Research Question 4:** *Can the methodology of physioeconomics provide physiological evidence for a utility of suspense in Dutch auctions?*

Further, Chapter 5 identifies characteristic patterns of emotional processing, which occur in the dynamic process of Dutch auctions. In particular, I will show that artificially induced values influence a bidder's current emotional state: bidders who receive a high product valuation also experience a higher degree of arousal in comparison to receive a low product valuation. Therefore, the methodology of physioeconomic cannot only contribute to supporting and stress-testing *existing* economic models of human bidding behavior. Physioeconomics can also help to gain a deeper understanding of bidder's emotional processing and, subsequently, may even contribute to creating *new* theories of human bidding behavior.

Finally, Chapter 6 summarizes the findings of this thesis and discusses their significance for electronic market design. Further, I will identify avenues for future physioeconomic research regarding emotionality in electronic auctions and discusses methodological approaches.

[4] Chapter 5 is based on joint research with Jan Krämer and Christof Weinhardt (cf. Adam et al., 2010).

Chapter 2.

Interaction of Cognitive Reasoning and Emotional Processing in Auctions

The main focus of this thesis is to develop a structured methodology that allows to systematically analyze emotions in electronic auctions and their impact on human bidding behavior. This chapter provides the first element of such a methodology by introducing a unified framework for emotional bidding in electronic auctions. Thus, the chapter addresses in particular the below mentioned Research Question 1. The framework focuses specifically on the interactions between cognitive reasoning and emotional processing of human bidders in electronic auctions.

> **Research Question 1:** *How do cognitive reasoning and emotional processing interact in deriving market decisions?*

2.1. A Unified Framework for Emotional Bidding in Electronic Auctions

2.1.1. Framework Definition

Traditional approaches of auction theory neglect the influence of emotions. In order to coherently approach the interaction between cognitive reasoning and emotional processing, this section proposes a unified framework for emotional bidding in electronic

auctions. The framework is depicted in Figure 2.1.

The upper part of the framework describes the traditional perspective of auction theory. Auction theory typically describes auctions as non-cooperative games with incomplete information (Bayesian games). A fundamental assumption is that bidders are sufficiently sophisticated to derive a bidding strategy, which maximizes their expected monetary payoff (e.g. McAfee and McMillan, 1987a; Krishna, 2002). A strategy is defined as a set of rules, which tells a decision-maker which action to choose at each stage of the game, given her information set (Rasmusen, 2007). In terms of auctions, a bidding strategy tells a bidder when to place a bid, for what amount, and whether to participate in the auction at all. Often, a particular auction mechanism implicates one or more equilibria, which each consist of a set of bidding strategies. The bidding strategy of each bidder results in one or more auction events, which ultimately result in an auction outcome.

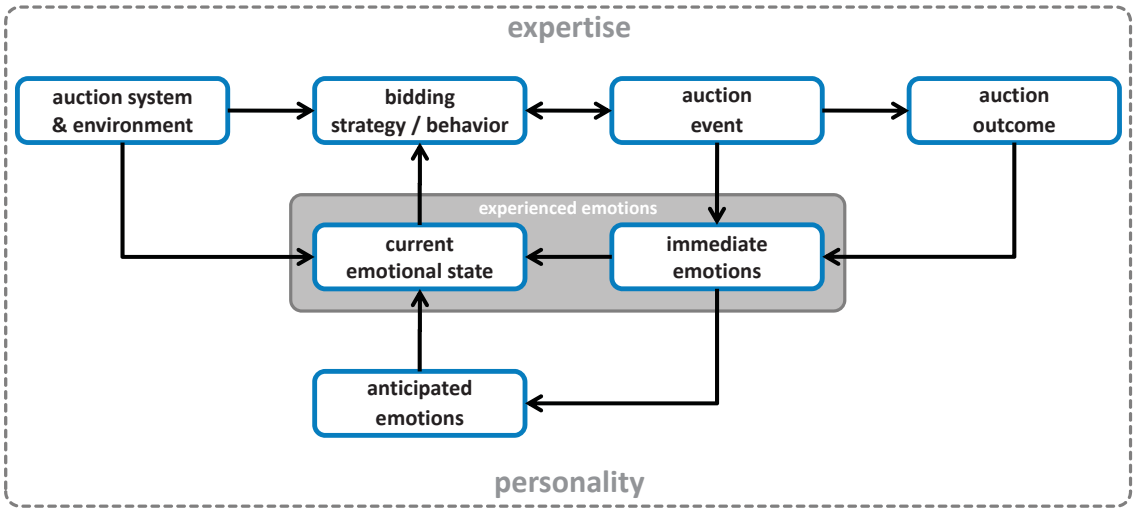


Figure 2.1.: Unified Framework for Emotional Bidding in Electronic Auctions

The framework is based on the conjecture that the bidders' emotional processing interacts with the process of cognitive reasoning asserted above. More specifically, the lower part of Figure 2.1 illustrates the interactions between the auction mechanism, bidding behavior, auction events, and emotional processing. In this thesis, the term emotion[1] is defined as:

[1]With respect to the term emotion, Fehr and Russel (1984) denote: "Everyone knows what an emotion is, until asked to give a definition. Then, it seems, no one knows." As a matter of fact, a large body of psychological literature defines, depending on the particular context, emotions and feelings from

Definition (Emotion)**.** *An emotion is a subjectively experienced state that can be described qualitatively and is accompanied by changes in feeling, physiology, and expression.*

As pointed out by Loewenstein (2000), emotions can be divided into anticipated and experienced emotions. Anticipated emotions describe expected emotional processing in response to a salient future event, e.g. the end of an auction and the anticipated win or loss. In contrast, experienced emotions describe the actual emotional processing, which comprises both *immediate emotions* in response to a single stimulus (Loewenstein, 2000) and ongoing current emotional states (Ding et al., 2005).

In the context of auctions, immediate emotions are triggered by auction events and the auction outcome. Auction events comprise, for instance, the placement of new bids, entry of new bidders, becoming the current high bidder, or being outbidden. The auction outcome induces immediate emotions such as "joy of winning" and "frustration of losing" (Delgado et al., 2008). The processing of immediate emotions can be anticipated by bidders throughout the process of an auction. The set of possible immediate emotions is limited by the auction system[2]. Therefore, some auction mechanisms pronounce emotionality stronger than others. For instance, some auction mechanisms only allow to place a single sealed-bid. These auctions are often referred to as *static* auctions. In contrast, *dynamic* auctions allow bidders for placing multiple bids and observe the behavior of other bidders. As argued by Gimpel (2007), auction fever is, in particular, a phenomenon of dynamic auctions. Again, the auction system limits the set of possible immediate emotions. Therefore, also the set of possible anticipated emotions is limited by the auction system.[3]

The terms immediate and anticipated emotion refer to momentary *(phasic)* responses to a single stimulus. In contrast, a bidder's current emotional state refers to her ongoing *(tonic)* emotional processing. As outlined by Ariely and Simonson (2003), the current emotional state of a bidder is influenced by the "frequency and magnitude of anticipated

various perspectives (cf. Panksepp, 1982; Ortony and Turner, 1990). The definition applied in this thesis addresses a rather *general* understanding of emotions in psychological literature (Gerrig and Zimbardo, 2007). Furthermore, Chapter 3 illustrates a *psychophysiological* perspective on emotions.

[2]In this thesis, an *auction system* is well-defined through the auction mechanism design and the user interface design. However, as outlined by Weinhardt et al. (2003), the design of an auction system may also comprise the business structure and further aspects of the technical infrastructure.

[3]For instance, some auctions allow bidders to experience regret upon learning the auction outcome. This emotional processing can be anticipated during the auction process (cf. Chapter 2.3).

post-auction feelings." For instance, it can increase a bidder's tonic level of arousal, if she frequently anticipates the joy of winning or the frustration of losing. However, anticipated and immediate emotions with respect to auction events other than the auction outcome also have an impact on a bidder's current emotional state. Examples of such salient events are to become the current high bidder in an auction and to be outbidden (Ehrhart et al., 2008). However, as indicated in the framework for emotional bidding, the current emotional state can also directly be affected by the employed auction system. For instance, Malhotra et al. (2008) denote that "a ticking clock [...] can overwhelm people with the desire to win," indicating that a high degree of time pressure in auctions can directly increase bidders' levels of arousal.

Finally, it is important to note that both the development of an optimal bidding strategy as well as the emotional processing both depend on a bidder's individual personality and expertise. The personality comprises psychological concepts like personality traits (e.g. McCrae and Costa, 1999), as well as (rather) economic concepts like the individual risk preference and product valuation. Further, bidders may have different levels of both *product domain expertise* and *online auction expertise* (e.g. Ariely and Simonson, 2003).

2.1.2. Auction Fever

Auction fever is a phenomenon which is frequently observed in traditional and in Internet auctions and is usually associated with an increased emotionality. The controversy over auction fever is probably as old as auctions. Apparently, legal scholars in ancient Rome already debated whether auctions would be void if the winner was infected by "bidder's heat" (Malmendier, 2002). Generally, the term auction fever, sometimes also referred to as *bidding fever* (Malmendier and Szeidl, 2008), *bidders' heat* (Malmendier, 2002), *bidding frenzy* (Häubl and Popkowski Leszczyc, 2004), or *bidding war* (Johns and Zaichkowsky, 2003), is used to describe objectively irrational decision-making in auctions. However, there is no consensus on a uniform definition of auction fever in the literature at this stage. Definitions range from overbidding an analytically optimal bidding strategy to mere descriptions of an intense emotional state. An overview of selected auction fever definitions is provided in Table 2.1.

A key element of many definitions is overbidding, which takes the observation that market participants sometimes place bids in excess of their preset bidding limits into account. While the assumption that bidders set themselves a bidding limit *ex ante* seems

Table 2.1.: Selected Auction Fever Definitions from the Literature

Author(s)	Published	Auction fever descriptions and definitions
Prince (1999)	Monograph	"When the competition swings into high gear, emotion really comes into play [...]. In the beginning, you might feel it as an affront, almost offensive, when someone else bids on something you want [...]. But you decide you wont back down. Come hell or high water, you're going to stand triumphant."
Ku (2000)	Kellogg Journal of Organization Behavior	"Auction fever, by its very name, is not a completely cognitive phenomenon. Individuals who are caught up in auction fever do not think strategically and methodically; instead, they are emotionally stimulated."
		"Auction Fever is viewed as bidding over one's preselected limit and is often accompanied by increased arousal."
Malhotra and Murnighan (2000)	Working Paper	"We suggest that the auction fever of folk wisdom is due to these two elements (competition and time pressure) and that they result in a state of competitive arousal that causes bidders to lose sight of their limits and bid past them."
Murnighan (2002)	Journal of Management Education	"Long-held folk wisdom on auctions suggests that people occasionally get caught up in auction fever; that is, their adrenaline starts to rush, their emotions block their ability to think clearly, and they end up bidding much more than they ever envisioned."
Gilkeson and Reynolds (2003)	Psychology and Marketing	"[...] when the number of bidders increases, bidders can get caught up in the bidding or develop auction fever, and ultimately bid more than they had originally intended."
Johns and Zaichkowsky (2003)	Psychology and Marketing	"The thought of competition also increases arousal in consumers and may lead to bidders being swept up in a bidding war they never intended."
Häubl and Popkowski Leszczyc (2004)	Advances in Consumer Research	"[...] bidders may experience a mental state, which we refer to as bidding frenzy, that is characterized by a high level of arousal or excitement, a sense of competition, and a strong desire to win."
		"[...] we hypothesize that, all else being equal, greater levels of bidding frenzy will cause consumers to value an auctioned product more highly."
Dholakia (2005)	Marketing Theory	"[...] 'bidding frenzy', in other words, getting caught up in the excitement of the auction and bidding multiple times on the same item, often overpaying for it [...]"
Ku et al. (2005)	Organizational Behavior and Human Decision Processes	"auction fever - the emotionally charged and frantic behavior of auction participants that can result in overbidding"
Walley and Fortin (2005)	Journal of Business Research	"[...] consumers become involved in the price-setting process and they can experience the thrill of winning a product, potentially a bargain, as opposed to the typically relatively tedious notion of buying it."
Abele et al. (2006)	Group Decision and Negotiation Conference Proceedings	"Auction fever is usually defined as a 'disease' that induces bidders to bid over their preselected bidding limit."
Ockenfels et al. (2006)	Book chapter	"In general, auction fever is thought to be an excited and competitive state-of-mind, in which the thrill of competing against other bidders increases a bidders' willingness to pay in an auction, beyond what the bidder would be willing to pay in a posted-price setting."
Gimpel (2007)	Monograph	"Auction fever or bidding fever means that bidders get caught by the dynamics of an auction and outbid their initial upper limit price"
		"Auction fever can roughly be defined as bidders outbidding their initial reservation price in an auction where this cannot be explained by information gathered during the auction."
Hou (2007)	Journal of Electronic Commerce Research	"With auction fever, bidders become caught up by the competitive nature of auctions with a low starting bid and bid more than their true valuations."
Lee and Malmendier (2010)	Working Paper	"During the heat of the auction, bidder i perceives an additional payoff π_i if she acquires the object in the auction. Once the auction is over, the player realizes that $\pi_i = 0$, i.e. that the utility from obtaining the same object at a fixed price is identical."
Cui et al. (2008)	Electronic Markets	"[...] empirical findings on the online behaviour of bidders have suggested that many of them bid in excess of their pre-set limits, which is called 'bidding fever'."
Delgado et al. (2008)	Science	"The fear of losing the social competition inherent in an auction may lead people to pay too high a price for the good for sale."
Ehrhart et al. (2008)	Working Paper	"[...] we see auction fever as a phenomenon, whose appearance can be influenced by the auction format and that induces bidders to bid higher in some format than in others where it does not appear or occurs less severely."
Malmendier and Szeidl (2008)	Working Paper	"[...] auction participants sometimes bid too much, due to psychological mechanisms such as bidding fever [...]"
Haruvy and Popkowski Leszczyc (2009)	Decision Analysis	"Frenzy refers to a mental state induced by the dynamic interaction among bidders in an ascending bid auction and [is] characterized by a high level of excitement, a strong sense of competition, and an intense desire to win"

in line with classical auction theory, the question as to whether *if* and *how* this limit is set remains. In a rather game theoretical approach, overbidding can be defined with respect to an optimal bidding strategy, which often assumes bidders to be risk-neutral (e.g. Cooper and Fang, 2008; Delgado et al., 2008). However, bidders may be "insufficiently sophisticated to discern the equilibrium-point strategy" (Vickrey, 1961). Further, it is a well-known fact that subjects do not behave in a risk-neutral way (e.g. Holt and Laury, 2002) and often neither know the number of competing bidders (e.g. Heshmat, 1996) nor the probability distribution of their valuations. In a more behavioral approach, one can argue that bidders may set themselves a limit by evaluating the commodity subjectively and then heuristically deriving a corresponding bidding strategy (Ariely and Simonson, 2003).[4] Smith (1990) argues that bidders may even be uncertain regarding their own product valuation and Lucking-Reiley (1999) notes that this uncertainty inherently increases in Internet auctions, where the bidders' information regarding product quality and seller reliability is rather limited and biased. In an Internet survey, Ku et al. (2005) find that 82% of the survey respondents set themselves a limit prior to bidding. Similarly, in Section 5.4, I will present the results of a self-report questionnaire regarding a Dutch auction experiment, in which subjects strongly agree to setting themselves a bidding limit before the auction starts.

The definition of overbidding in the context of auction fever is particularly difficult in field studies, in which fixed-price offers listed on retail sites are often chosen as reference prices (e.g. Ariely and Simonson, 2003; Lee and Malmendier, 2010). While the literature reports higher prices in Internet auctions in comparison to fixed-price offers, it remains unclear whether these high prices can be fully explained with auction fever. Partially, this overbidding may also be explained by rational behavior when taking into account additional parameters. First, as Carare and Rothkopf (2005) pointed out, it can in fact maximize a bidders expected utility to accept a higher price in a slow Dutch auction in order to avoid waiting and transactions costs. Second, bidders may not be aware of cheaper offers on retail sites or want to avoid the search costs for finding the cheaper price.

A second element often associated with auction fever is increased emotionality experienced by bidders. In the literature, this emotional state is usually characterized by a

[4]Note that developing this bidding strategy is also subject to the cognitive abilities of each bidder, her risk preferences, and her general personality.

high level of arousal, increased excitement, and a strong desire to win or not to lose, respectively. Auction dynamics, along with anticipated feelings and perceived competition, are frequently listed as elicitors of this state. This intense emotional state can "block [bidders'] ability to think clearly" (Murnighan, 2002), which results in an excess of the preselected bidding limit and ultimately higher final prices. Abele et al. (2006) even characterize this process as a "disease," referring to the literal meaning of the term auction fever. With respect to the conceptual framework for emotional bidding proposed in Section 2.1.1, I define auction fever as:

> **Definition** (Auction Fever)**.** *Auction fever is defined as an intense current emotional state elicited in the course of one or more auctions that distorts a bidder's preselected bidding strategy.*

This definition not only comprises overbidding in ascending auctions, but also underbidding in Dutch auctions, repeated bidding, and other changes in the preselected bidding strategy. While some definitions understand excitement as a sufficient condition for auction fever (e.g. Ku et al., 2005), the definition above identifies both excitement and a change in the bidding strategy as necessary conditions. As outlined before, overbidding alone can also be explained, to a certain extent, by bounded rationality as well as transaction, waiting, and search costs.

The remaining sections of this chapter each focus on one specific aspect of the framework for emotional bidding. Based upon the derived definition of auction fever, Section 2.2 provides a literature overview regarding prominent inducers of auction fever. In contrast, Section 2.3 focuses on the processing of immediate and anticipated emotions. Section 2.4 outlines the impact of heterogeneities among bidders, in particular regarding their personality and expertise.

2.2. Inducers of Auction Fever

In the context of the framework for emotional bidding, this section focuses on how the process of an auction can affect a bidder's current emotional state. In particular, I focus on the phenomenon of auction fever.

As pointed out in the last section, auction fever is an intense current emotional state elicited in the course of one or more auctions that distorts a bidder's preselected bidding

strategy. In the context of auctions, the literature identifies three major factors that can trigger an intense current emotional state: perceived competition, previous investment, and perceived ownership. Further, in electronic auctions, the experience of emotions is mediated through the interaction with the auction system. Therefore, the design of the auction system plays an important role as well. The three major factors and their interactions will be discussed in this section.

However, a bidder's current emotional state is subject to anticipated emotions regarding salient future events as well. Anticipated and immediate emotions are discussed in Section 2.3.

2.2.1. Perceived Competition

The degree of *perceived competition*, subjectively experienced by bidders, is frequently characterized as one of the main inducers of auction fever. Malhotra et al. (2008) and Ku et al. (2005) refer to the triggered emotional state as "competitive arousal" and identify *time pressure*, *rivalry*, and *social facilitation* as its main driving forces.

Salient evidence for the perceived competition in auctions is the terminology which bidders use to describe the course of action. Contrary to retail websites, bidders do not just buy commodities, they *win* or *lose* them. In an Internet survey, Ariely and Simonson (2003) find that 76.8% of the survey respondents perceive other bidders as "competitors" and refer to auction outcomes as "winning" and "losing." Therefore, auction participants seem to be very sensitive concerning the presence of other bidders. This terminology is also systematically used by marketing departments of Internet auction platforms. For instance, in 2007, the industry leader eBay launched an advertisement campagin titled "shop victoriously" stating that "it's better when you win it" (eBay.com, 2007). In the corresponding television commercials, bidding in an eBay auction is compared to sport events, such as football matches or dog races. This general development can be interpreted as a paradigm shift to "entertainment shopping" or "auctainment" (Glänzer and Schäfers, 2001).

Time Pressure

Time pressure is one of the main factors that drive auction fever (e.g. Ku et al., 2005). Generally, time pressure is known for fueling arousal and increasing decision-makers'

willingness to take risk (Maule et al., 2000). Particularly in auctions, bidders often have to take quick decisions and respond to market events within a limited period of time. With respect to time pressure, Ku (2000) denotes: "bidders are highly aroused and unable to think clearly, and since decisions need to be made quickly, bidders keep bidding." In an eBay field study, Roth and Ockenfels (2002) show that in hard close auctions, i.e. auctions with a fixed ending time and date, a large part of final bids is placed within the last 5 minutes. Thus, while the actual auction is conducted over a time period of up to 10 days, the final price is often determined in the last few minutes, leaving bidders only very limited time to respond to bids of their competitors. Haruvy and Popkowski Leszczyc (2009) analyze empirical field data from a local auction site. The authors report that short auctions lead on average to higher jump bidding, i.e. more aggressive bidding, and eventually to higher prices.

Contrary to hard close auctions, the ending times of soft close auctions can be extended by bidding activity. Ku et al. (2008) analyze the impact of arousal in auctions by manipulating time pressure and stakes in a soft close auction. In particular, the authors investigate bidding behavior in a *dollar auction* with two bidders competing in each auction. In a dollar auction, the highest bidder pays her own bid and receives the commodity for sale. However, the second highest bidder also has to pay her own bid but does not obtain the commodity (cf. Shubik, 1971). Both time pressure and stakes are either set to a low or to a high level. The authors report that significantly more bids are submitted in high stakes auctions in comparison to low stakes auctions, while time pressure did not directly affect bidding. However, the self-report levels of arousal are generally higher in high time pressure auctions.

In the context of *Dutch auctions*, time pressure may be induced by high clock speeds. In a Dutch auction, an initial high standing price is consecutively decreased by a decrement δ after each time interval τ until one of the bidders claims the good by accepting the current standing price. The clock speed θ is defined as the quotient of δ and τ, i.e. $\theta = \delta/\tau$. When the clock speed is increased, bidders have less time to accept the current standing price and are forced to take quick decisions. In order to analyze the impact of clock speeds on bidding behavior, Katok and Kwasnica (2008) conduct a laboratory experiment and show that fast clock speeds yield lower prices in Dutch auctions than slow clock speeds. Thus, bidders tend to wait on average more price decrements when the clock speed is fast. This effect is commonly explained by the fact that auction par-

ticipants experience a "utility of suspense" (Cox et al., 1983), which is stronger in fast auctions. Chapter 5 discusses an experiment which provides physiological evidence for utility of suspense in Dutch auctions.

Social Facilitation

Another factor leading to perceived competition is social facilitation (Malhotra et al., 2008). The term social facilitation refers to the impact of the sheer presence of other individuals upon human behavior. Social facilitation literature distinguishes between two major paradigms: *audience effects* and *co-action effects* (cf. Zajonc, 1965).

Audience effects designate the influence passive spectators have on human behavior. In the context of auctions, audience effects are elicited by individuals who observe the course of bidding but are not actively participating. For instance, this may be an audience watching a charity auction or the media attention on spectrum license auctions. Co-action effects designate the influence the presence of other individuals has, who are engaged in the same activity (cf. Zajonc, 1965). In the context of auctions, co-action effects are elicited by the presence of other bidders, who are currently participating in the same auction or waiting for another auction. In a live auction, for instance, these individuals may be bidders who are bidding on the same item or just observing the current auction, waiting for a specific item following up. Social facilitation is leveraged by the spotlight effect. The spotlight effect describes the phenomenon that individuals tend to overestimate the attention gained from the audience, believing that "the social spotlight shines more brightly on them than it really does" (Gilovich et al., 2000). Particularly in the final stages of an auction, when only few active bidders remain, the perception of being in the spotlight may become more intense than it actually is.

Social facilitation seems to be less prominent in Internet auctions than in live auctions. Malhotra et al. (2008) attribute this to the higher degree of privacy in Internet auctions and denote that the "spotlight is dimmer" in this environment. In a field study, Ku et al. (2005) report lower revenues in Internet auctions in comparison to simultaneously conducted live auctions for the same commodity - fiberglass cows auctioned off for charities. The authors partially explain these results with an increased spotlight and media attention in the live auctions. The auction site *1-2-3.tv* is an example of how the spotlight in Internet auctions can be increased. This platform consecutively conducts multi-unit uniform price Dutch auctions on the Internet, which are simultaneously broadcasted

on Austrian and German national television. The bidders can either submit their bids online or via telephone. When a bidder places a bid, this bid will be listed along with the bidder's pseudonym on television. This feature is also specifically addressed in the platform's advertisement campaign. Presumably, simultaneously broadcasting the auctions on television does not only increase the number of active and passive observers, but also bidders' awareness of the audience.

Rivalry

It is important to highlight that audience and co-action effects already occur without strategic interaction. Accordingly, social facilitation only refers to the sheer presence of other individuals, i.e. the awareness of being observed by passive observers and other bidders. In contrast, the concept of rivalry addresses the fact that the commodities for sale in an auction are rivalrous. A good is considered as rivalrous if its consumption fully eliminates any utility other individuals may derive from it (cf. Cornes and Sandler, 1986; Romer, 1990). Rivalry is an inherent characteristic of live and of Internet auctions, as "each bidder competes against others who want the same item" (Stern and Stafford, 2006).[5] Therefore, the presence of other bidders induces not only co-action effects, but also rivalry.

The literature identifies rivalry as another important factor leading to perceived competition. Ockenfels et al. (2006) argue that the "thrill of competing against other bidders" can cause an excited and competitive state of mind. Heyman et al. (2004) refer to this phenomenon as the "opponent effect" and Delgado et al. (2008) argue that actually the fear of losing the "social competition," inherent in auctions, is responsible for overbidding. The major influencing factors for rivalry identified in the literature will be discussed in the following paragraphs.

Number of bidders. In his seminal paper, Vickrey (1961) shows that a larger number of bidders decreases the expected payoff for each bidder. For instance, in first-price auctions the optimal degree of bid shading decreases when the number of bidders increases. Therefore, the degree of rivalry increases *ceteris paribus* along with the number of bidders in an auction.[6]

[5] Similarly, bidders compete for a limited stock of identical items in multi-unit auctions (e.g. *1-2-3.tv*).

[6] It is important to note, however, that the number of bidders also increases audience and co-action effects.

Heyman et al. (2004) manipulate the degree of rivalry by increasing the number of bidders. In a survey based experiment, individuals have to imagine taking part in a sealed-bid auction. The authors report higher (hypothetical) bids when bidders observe more bidders who take part in the same auction. In a follow up laboratory experiment, Heyman et al. keep the number of competing bidders constant and manipulate the bidding behavior of the competitors. While bidders believe to bid against other human bidders, they actually bid against computerized agents, which either bid more or less aggressive. The authors report significantly higher bids when bidders face more aggressive bidders. Additionally, Heyman et al. conduct an eBay field study and find that the number of active bidders correlates positively with final bids. The authors concentrate on auctions for which they exactly know the final bid and not only the second highest bid. Häubl and Popkowski Leszczyc (2004) conduct a laboratory experiment, in which participants bid against computerized agents, in order to manipulate the frequency of competitors' bids and the perceived number of bidders.[7] Häubl and Popkowski Leszczyc (2004) confirm the results of Heyman et al. (2004) and conclude that higher rivalry leads to higher final prices.

In real auctions, in which the number of bidders is endogenous, the number of bidders is directly affected by the *starting price* of an auction. Ku et al. (2006) analyze how low starting prices attract an entry of new bidders and affect final prices. Based on eBay field data and survey experiments, the authors find that low starting prices attract more bidders and thereby result in higher final prices. Walley and Fortin (2005) confirm in their controlled field experiment that lower starting prices increase the number of bidders and eventually final prices. Ariely and Simonson (2003) also confirm the results of Ku et al. (2006), stating that low starting prices attract more bidders, with data from a controlled field experiment on eBay. However, and in contrast to Ku et al. (2006), Ariely and Simonson (2003) find that these auctions yield on average less bids and lower final prices. The authors argue that this can be explained by an *anchoring effect*: starting prices may serve as a value signal for bidders, with higher starting prices indicating a higher product value.

Therefore, low starting prices have at least *two opposing effects* on final prices. On the one hand, low starting prices decrease entry barriers and, therefore, attract more bidders:

[7] Similar to Heyman et al. (2004), Häubl and Popkowski Leszczyc (2004) deceive the subjects. The bidders are told that they are bidding against other human individuals, while they are actually bidding against computerized agents.

anyone who is interested in obtaining the commodity for sale can enter an eBay auction with a starting price of one dollar. Further, placing a bid with a low starting price is associated with a low degree of commitment. Entering an auction does not necessarily result in obtaining the good, but opens the possibility of receiving the commodity for a low price.[8] On the other hand, low starting prices can serve as an anchor for bidders, i.e. as a signal for the true value of the auctioned commodity.

Moreover, the number of bidders can also be directly affected by the *duration* of an auction. Lucking-Reiley et al. (2007) analyzes eBay auctions of collectible United States one-cent coins and finds that longer auction durations increase the number of bidders and final prices. Haruvy and Popkowski Leszczyc (2009) show in their controlled field experiment on eBay that three day auctions yield a larger number of bidders, and also larger final bids, compared to one day auctions. However, the authors also conduct a controlled field experiment on a local auction site and find that auction duration does not affect the number of bidders and that longer auctions can even result in lower final prices. Hou (2007) analyzes field data from eBay China and eBay US. The author reports that the duration of an auction has no significant effect on final prices. The author argues that the duration of an auction has only a positive impact on the number of bidders, if the degree of the commodity's scarcity is not too low. According to Hou (2007), there is no effect of auction duration on the number of bidders, if bidders have "more options at any point of time."

In summary, the experimental evidence for a potential linkage between final prices and the number of bidders is mixed. This indicates that other factors come into play as, for example, product characteristics and anchor effects.

Interdependent utilities. Rivalry can also become more intense when a bidder's utility does not only depend on her own individual monetary gains and losses, but also on the utilities of other bidders. This concept of utility is usually referred to as "interdependent utilities" (e.g. Schall, 1972; Bault et al., 2008). For instance, subjects may develop personal rivalries with other individuals and perceive feelings of envy or gloating (Smith et al., 1996). In the context of auctions, the literature has identified, in particular, "spitefulness" and (non-monetary) "joy of winning" as sources for such interdependencies.

[8] See Section 3.3 for how repeated bidding can lead to an escalation of commitment.

A bidder is spiteful, if she derives an additional negative utility in case her opponent wins an auction, which depends on the monetary profit of the competitor (cf. Morgan et al., 2003). For instance, firms may gain a competitive disadvantage from losing an auction, which eventually results in monetary losses (e.g. Brandt et al., 2007). Morgan et al. (2003) show that symmetric equilibrium bidding becomes more aggressive in various auctions, if bidders are spiteful. Therefore, if an agent's utility depends on the outcomes of other agents, it can be a (rational) best response to place higher bids. In contrast, a bidder experiences a non-monetary joy of winning if she derives an additional positive utility from the "uniqueness of being first" in the social competition of an auction (Ku et al., 2005). Morgan et al. (2003) refer to this non-monetary component of the joy of winning as the "love of winning."[9]

Bidders' utility functions, which exhibit such interdependencies, can result in "head-to-head battles" (Ku et al., 2008) among a small (sub-)group of bidders. In a survey among bidders participating in live auctions, Johns and Zaichkowsky (2003) observe a U-shaped dependency between the number of bidders and the degree of rivalry. In auctions with only two active bidders, the authors state that "the bidding war was more personal." However, when an auction attracts a large number of active bidders, there is a "race to bid on and win the item." Murnighan (2002) observes an extreme case of how a head-to-head battle between two bidders can result in gross overbidding. The author conducts dollar auctions (cf. Shubik, 1971) in his management classes and observes how two individuals get caught up in a "bidding war," with the winner paying almost 2000 dollars for a 20 dollar bill. Ku et al. (2005) argue that rivalry is particularly intense when only two bidders compete in a single auction. Based on data from a laboratory experiment, the authors report that bidders experience higher levels of self-report arousal and place higher bids in high rivalry treatments, i.e. when they face one single opponent in comparison to eight opponents. The authors conclude that rivalry and arousal seem to be higher with few rather than with many bidders. Following this argumentation, there may also be an interaction between the degree of utility interdependencies and the number of bidders.

From an economic perspective, the concept of rivalry does not make a distinction between human competitors and computerized competitors. However, the decision-makers' arousal and behavior change when human counterparts are involved. Based on data from

[9]Section 4.2 focuses specifically on the "joy of winning" in auctions.

a laboratory experiment, Häubl and Popkowski Leszczyc (2004) argue that for the experience of auction fever, it is a necessary condition "that an auction participant competes directly with other human bidders." In particular, utility interdependencies based on personal rivalries can develop only among human bidders. For instance, Bosman and Riedl (2004) describe such dynamics between human decision-makers as "emotional spillover effects between subjects," which comprise feelings of anger and envy.[10] Van't Wout et al. (2006) analyze how human decision-makers respond to unfair offers by human or computerized counterparts in the ultimatum game. The authors show that decision-makers' physiological responses are stronger and the rejection rate is higher in case the unfair offers are made by a human counterpart. In another laboratory experiment including physiological measurements, Bault et al. (2008) show that the participants' behavior and physiological processing is already affected by the mere presence of another human agent, although there is, from a game theoretical perspective, no strategic interaction. In their theory of interdependent utilities, the authors identify the feelings involved as "envy" and "gloating." The results of Bault et al. (2008) may also serve as an indicator that co-action effects comprise an increase of physiological arousal.

2.2.2. Previous Investments

Previous investments have been identified in the literature as another elicitor for auction fever. The underlying concept is commonly referred to as the "sunk cost fallacy" (e.g. Arkes and Blumer, 1985; Friedman et al., 2007) or "escalation of commitment" (e.g. Staw, 1976; Ariely and Simonson, 2003). These terms describe the observation that a human decision-maker usually places too much emphasis on recouping previous investments for which she feels personally responsible. Following economic theory, a decision-maker should ignore sunk costs associated with previous investments and only consider future costs and benefits.

Staw and Ross (1989) describe escalation of commitment as "situations in which losses have resulted from an original course of action, but where there is the possibility of turning the situation around by investing further time, money, or effort." In the context of auctions, bidders invest in particular auction fees (Ivanova-Stenzel and Salmon, 2004b),

[10] Engelbrecht-Wiggans and Katok (2007) conjecture with respect to spitefulness: "However, such theories [of spitefulness] require inter-personal comparisons and, therefore, cannot explain similar behavior by subjects who were bidding against computerized rather than human competitors."

search costs (Ariely and Simonson, 2003), transaction costs (Carare and Rothkopf, 2005), and waiting costs (Carare and Rothkopf, 2005). These investments all become sunk costs in the course of the auction and can be converted into a payoff if the auction is won.

The Multi-Stage Process of Bidding

In a fixed-priced market, a consumer only faces the decision to accept or decline a given price. However, taking part in an auction comprises several stages of decision-making. For instance, Ariely and Simonson (2003) outline three major phases of hard close English proxy auctions: choice of entry, the middle phase, and the end phase. First, each bidder has to decide individually whether it is rational for her to take part in the auction. Second, bidders place bids and observe bids placed by other bidders. Third, close to the fixed ending of an auction, bidders have to take quick decisions under time pressure, as a large part of bidding activity is usually observed in this phase. As the phenomenon of escalation of commitment is only possible within a situation of repeated decision-making with personal responsibility, the multi-stage process, inherent in auctions, provides the actual basis for escalation of commitment.

This is particularly applicable for auctions in which bidding is not restricted to placing a single sealed-bid. Cox et al. (1982) argue that it is as a matter of fact the "real-time" element that distinguishes sealed-bid auctions from other auctions, such as English auctions or the English proxy auction employed on eBay.[11] In ascending auctions, this real-time element allows bidders to repeatedly place bids and observe the bidding behavior of their rivals. In order to clearly distinguish between sealed-bid auctions and auctions with a multi-stage process after auction entry, the terms *static* and *dynamic* auction, respectively, are used in the following. Ariely and Simonson (2003) note that the multi-stage process of dynamic auctions requires consumers to be "highly involved," i.e. commit themselves when participating in a dynamic auction.

From a consumer perspective, entering a dynamic ascending auction seems to involve only a small degree of commitment, as it does not necessarily result in obtaining the good, but opens the possibility of receiving the commodity at a low price. However, by placing a bid in such an auction, a bidder commits herself to an amount of money she has to pay in the case of winning the auction. This commitment, in combination with

[11] Seifert (2006) outlines that the English auction and the English proxy auction employed on eBay are theoretically equivalent.

the general uncertainty about a bidder's willingness to pay (e.g. Lucking-Reiley, 1999), can later on serve as a self-justification for placing another bid: if the bidder is already willing to pay an amount x, why not a little bit more? This self-justification bias has been identified in the literature as the major reason for escalation of commitment (e.g. Staw and Ross, 1989). Park et al. (2008) analyze escalation of commitment in consumer auctions by collecting survey data from online bidders. The authors show that sunk costs and self-justification have a major impact on the willingness to continue bidding.

However, there is a debate going on whether this cognitive impairment alone is sufficient to fully explain the phenomenon of escalation of commitment or whether it also comprises increased levels of arousal and, thus, a change in the bidder's current emotional state. For instance, Ku et al. (2005) report that high sunk costs lead to increased self-report levels of arousal and higher bidding activity. The authors conduct a survey experiment. Students are asked to imagine themselves taking part in an Internet auction, in which they had already invested low, medium, or high search efforts, i.e. sunk search costs. In another paper, Ku et al. (2008) argue that if bidding itself is arousing, this can "feed a vicious cycle of bidding and overbidding."

As discussed in Section 2.2.1, the starting price and the duration of an auction have an impact on the number of bidders and, thus, on perceived competition. However, these factors also influence the commitment bidders incur in the course of an auction. Placing a bid in an auction with a high starting price involves a higher initial commitment and, therefore, a higher reference point for self-justification. As argued before, a high starting price can serve as a quality signal, as bidders often do not know their willingness to pay (Ariely and Simonson, 2003). A longer auction duration involves higher waiting costs and, therefore, increases a bidder's commitment. Accordingly, the starting price and the duration of an auction have an impact on both perceived competition and previous investments. A low starting price increases the number of bidders, while it simultaneously decreases a bidders' initial commitment. A long auction duration increases the number of bidders and also increases sunk costs in terms of waiting time.

Auction Fees

In addition to the indirect costs that originate from waiting, bidding, and search effort, some auction sites entail direct monetary costs on bidders by charging auction fees, e.g. entry and bidding fees. While entry fees are charged for the right to actually participate

in an auction, bidding fees are charged for every single bid a bidder submits.

Meyer (1993) analyzes the effect of entry fees in a laboratory experiment. The author reports that 59% of the participants did not consider the entry fee as sunk costs. 93% of these bidders increased their bids in order to "increase their chances of winning the auction." However, Ivanova-Stenzel and Salmon (2004b) show that bidders avoid auctions with entry fees and are even willing to give up expected surplus in order to do so. The authors argue that entry fees particularly deter bidder entry in case an auction site faces competition with other providers. This may also explain the observation that currently no major consumer auction site charges entry fees.

While entry fees are only seldomly observed in consumer auctions, bidding fees, however, have turned out to be a quite successful business model. One of the most prominent sites in this context is the platform *swoopo.com*.[12] The platform operates an ascending auction with fixed price increments. Each auction starts from zero dollars and bidders can place bids in fixed increments of 12¢. Jump bids are not possible and the auction ends when no bids are submitted within a predefined period of time (soft close). After the end of the auction, the highest bidder obtains the commodity and has to pay the amount of her bid.[13] In order to place a bid, however, a bidder has to pay a bidding fee of 60¢. Therefore, placing a bid on Swoopo involves a comparatively high degree of commitment.

Particularly with respect to the debate as to whether escalation of commitment is a purely cognitive phenomenon or whether it also comprises arousal, it is interesting to observe that Swoopo advertises with "pulse up, price down" (swoopo.de, 2009) and promotes itself as an "entertainment shopping" platform (swoopo.com, 2009).

The Dollar Auction

Shubik (1971) introduces the dollar auction as a stylized model of an auction which elicits an increased commitment. In the original setting, a dollar bill is auctioned off at an initial starting price of 5¢. The first bid has to be 5¢. From then on, bidders can only bid in increments of 5¢, i.e. jump bidding is not permitted. The auction ends when no one bids for a predefined period of time (soft close). After the end of the

[12] Swoopo has started off under the name "telebid" in Germany. Today, the company Swoopo operates auction sites in Austria, Canada, Germany, Spain, the UK, and the US.

[13] In contrast to the dollar auction, the second highest bidder does not have to pay her own bid.

auction, the highest bidder obtains the commodity and has to pay the amount of her bid. However, the second highest bidder also has to pay her bid, without obtaining the commodity. With this twist, placing a bid in a dollar auction is associated with a higher degree of commitment. Bidders face the possibility of paying their bid without receiving anything in return. Therefore, this auction is frequently utilized to analyze escalation of commitment in auctions (e.g. Murnighan, 2002; Ku et al., 2006).

Teger (1980) analyzes the dollar auction in a series of laboratory and classroom experiments. The author finds that almost half of the auctions receive final bids which exceed the value of the auctioned item.[14] In these auctions, the author observes head-to-head bidding: as soon as the current highest bid reaches the value of the auctioned bill, all but two bidders drop out of the bidding. According to Teger (1980), these bidders have "too much invested to quit." Ku et al. (2008) analyze escalation of commitment by varying the stakes in a dollar auction. While holding the relative amounts in experimental monetary units (MU) constant, the authors manipulate the conversion rate between MUs and real money. Ku et al. (2008) show that bidders place higher bids in case conversion rates are high, i.e. when placing a bid is associated with a higher degree of commitment.

Ku (2008) analyzes whether bidders are able to learn out of escalation situations and improve their decision-making behavior. In the study, participants experience regret associated with escalation of commitment in an anagram task. One week later, the same individuals participate in a dollar auction. Ku (2008) found that post-escalation regret in the first task reduces subsequent escalation in the dollar auction task, with more regret predicting less escalation. In a follow up survey experiment, the author shows that even just imagining regret in an escalation situation can result in less bidding activity in the dollar auction. Therefore, experiencing regret in one task may help auction participants to refrain from auction fever in a subsequent bidding task.

Although the dollar auction is frequently used to analyze escalation behavior in auctions, the generalizability of results is limited with regard to several aspects. First, it remains unclear which pattern of behavior in a dollar auction can actually be interpreted as *irrational*, as there is no theoretical benchmark.[15] Second, in case that there are more than two bidders participating in a dollar auction, the own bid is not necessarily sunk.

[14] Note that the exact value of the auctioned bill is known to all bidders before the auction starts.

[15] As long as the bid increment is smaller than the value of the auctioned bill, there is no optimal equilibrium bidding strategy in the dollar auction. However, note that Murnighan (2002) also observes bidding increments of $50 for a $20 bill.

Third, the dollar auction is a rather stylized auction model which is hardly employed outside of the laboratory. It seems more appropriate to focus on auction mechanisms that are implemented in real markets. Therefore, future research should rather focus on confounding effects between perceived ownership and previous investments for auctions which are in fact used in the field.

2.2.3. Perceived Ownership

Apart from perceived competition and previous investments, the literature has identified *perceived ownership* as another elicitor for auction fever. The term perceived ownership refers to the conjecture that being the high bidder in an ascending auction can make a bidder "feel like already owning the item" (Ehrhart et al., 2008) and, thus, can provoke a shift of the bidder's reference point. The term reference point describes a decision-maker's *status quo*, from which she measures gains and losses (Kahneman and Tversky, 1979).

Pseudo-Endowment and Attachment Effect

Thaler (1980) introduces the term "endowment effect" for the observation that a human decision-maker usually values a commodity more if it is part of her individual endowment, i.e. if she owns the item. Kahneman et al. (1990) argue that this phenomenon is contradictory to the neoclassical Coase theorem, which states that as long as "market transactions are costless," the allocation of resources is independent of property rights (Coase, 1960). The authors analyze the endowment effect by conducting an experiment, in which coffee mugs are randomly assigned to one half of the participants (sellers), while the other participants (buyers) receive no coffee mugs. Sellers and buyers can then exchange the coffee mugs in a double-sided auction. The authors report that the average price a seller is willing to accept (WTA) for a coffee mug is significantly larger than the average price a buyer is willing to pay (WTP). Kahneman et al. (1990) argue that the endowment effect can be explained with the prospect theory of Kahneman and Tversky (1979) and a shift of the decision-maker's reference point: while buying an item is regarded as a gain, selling the same item is regarded as a loss. Following this reasoning, buyers and sellers have different reference points in their decision-making. As losses are experienced stronger than gains, the WTA is larger than the WTP.

However, the endowment effect described by Thaler (1980) only focuses on actual ownership. In contrast, the terms "pseudo-endowment effect" and "quasi-endowment effect" refer to situations in which an individual develops a psychological ownership of an item, although there is actually no real ownership.[16] For instance, in the context of auctions, no bidder owns the commodity before the auction has finished. However, the current high bidder in an ascending auction can get more attached to an item, as the item becomes "a part of his or her psychological endowment" (Ariely and Simonson, 2003). Similar to the endowment effect, this psychological ownership can induce a shift of the bidder's reference point and, in combination with loss aversion, increase her valuation for the commodity.

A concept closely related to the pseudo-endowment effect is the "attachment effect" (Köszegi and Rabin, 2006). Köszegi and Rabin (2006) argue that the reference point of a decision-maker is affected by her subjective "probabilistic beliefs" about the outcome of a situation. In the context of auctions, the attachment effect refers to the observation that the current high bidder in an auction can perceive an "increase in the expected [subjective] probability of winning" the auction (Ehrhart et al., 2008). In contrast, the pseudo-endowment effect refers to an increased attachment with an item due to psychological ownership. Therefore, as argued by Ehrhart et al. (2008), both effects comprise a reference point shift, which is originated in perceived ownership - psychological or probabilistic.

While perceived ownership has been identified in the literature as an elicitor for auction fever (e.g. Heyman et al., 2004; Ehrhart et al., 2008), pseudo-endowment and attachment effects are concepts which are not directly related to an intense emotional state. However, following the definition of Section 2.1, an intense emotional state is an inherent characteristic of auction fever. At this stage, the conjecture that perceived competition also induces such a current emotional state turns out to be an open research issue. One could argue, however, that an increased emotional attachment with the item increases a bidder's personal involvement and, thus, arousal. Further, becoming the high bidder in an auction presumably induces an immediate emotion of joy, which affects the current emotional state.

[16] The terms *pseudo-endowment effect* and *quasi-endowment effect* are used interchangeably in the literature. In the following, only the term pseudo-endowment effect will be used.

Perceived Ownership in Auctions

As argued before, the current high bidder in an ascending auction can perceive ownership of the commodity. Wolf et al. (2005a) analyze this perceived ownership in a series of survey auction experiments. The survey participants are asked to imagine being the high bidder in an eBay auction, in which a single numbered certificate for a portable music device, in particular an Apple iPod, is auctioned off. One group of the participants is informed that they have been outbidden. Then, they are given the opportunity of placing a subsequent bid. The other group gets the information that the auction has to be canceled, but that they can place a bid on another, identical certificate with a different number instead. The authors report that the outbidden bidders place higher (hypothetical) bids than those bidders who could only place a bid on another certificate. Wolf et al. explain these results with the pseudo-endowment effect and argue that bidders develop a "desire to win a specific item."[17]

Ehrhart et al. (2008) conduct a laboratory experiment and show that bidders place higher bids in a Japanese auction in case the auctioneer declares a high bidder. The authors argue that those bidders who are the high bidders in an auction develop a perceived ownership of the commodity. Further, Ehrhart et al. observe even higher bids, if bidders have a direct influence on becoming the high bidder: auctions in which bidders can become the high bidder by placing bids faster than other bidders have higher final prices than auctions in which the high bidder is selected randomly. The authors explain this observation by a "source-dependence effect" (Loewenstein and Issacharoff, 1994) and argue that bidders obtain the status of being high bidder due to a "better performance" in the bidding task. The source-dependence effect describes the observation that subjects value goods more if "those objects were obtained through exemplary performance" in comparison to receiving the objects by chance (Loewenstein and Issacharoff, 1994).

[17] However, parts of these results may also be explained by learning about the value of the iPod, as the authors do not control for valuations. Generally, hypothetical auction scenarios in survey studies have fundamental drawbacks. In this regard, Falk and Heckman (2009) note: "Whereas surveys can generate large and representative data sets that provide statistical power, experiments allow the elicitation of preferences and attitudes in a controlled and incentive-compatible way because participants have to make choices with real money at stake."

Auction Duration and Perceived Ownership

Ariely and Simonson (2003) conjecture that perceived ownership is positively affected by the high bidder duration, i.e. by the period of time a single bidder is the high bidder in an ascending auction. The authors argue that the pseudo-endowment effect is "more pronounced," if an individual bidder "had the highest bid for a longer period." Heyman et al. (2004) analyze the interaction of high bidder duration and perceived ownership in a survey experiment regarding a hypothetical auction scenario. Survey participants are asked to imagine being the high bidder in an auction for a long (5 days) or short (1 day) duration and then face the event of being outbidden. Subsequently, they can submit another bid. The authors observe significantly larger (hypothetical) bids in case bidders have been the high bidder for a longer period of time. In a second study, the authors confirm the results of the survey in a laboratory experiment. Again, a longer duration of perceived ownership results in higher bids. Wolf et al. (2005b) conduct a field study with data collected from eBay Motors auctions. The authors report that both the duration of auction participation and the high bidder duration significantly affect the probability of re-bidding, i.e. placing a subsequent bid after being outbidden.

Bramsen (2008a) conducts a field study based on Danish furniture auctions and observes a logarithmic dependency between the high bidder duration and the probability to rebid. Additionally, the author interprets the distance between a bidder's maximum bid and the current price as a proxy for her "subjective probability to win." Similar to the high bidder duration, the author observes a logarithmic dependency between the distance and the probability to rebid. Bramsen (2008a) highlights that this effect is an "entirely additional component" that cannot be explained by the high bidder duration. In the spirit of Köszegi and Rabin (2006), the proxy of subjective probability can be interpreted as an indicator for an "attachment effect."

Wolf et al. (2008) analyze how physical contact with the auctioned commodity affects bidding behavior independent of high bidder duration and auction duration. The authors conduct a laboratory experiment, in which coffee mugs are sold to participants in English and first-price sealed-bid auctions. Participants have either 10 (short) or 30 (long) seconds to examine the coffee mugs with their hands prior to the auction. In both auction formats, the authors observe higher bids if bidders had more time to examine the coffee mugs. Wolf et al. conclude that perceived ownership can already be elicited by a "relatively short period of time of tactile exposure."

2.2.4. System Design

Sections 2.2.1 through 2.2.3 outlined the three major factors that have been identified in the literature as triggers for a current emotional state of auction fever: perceived competition, previous investments, and perceived ownership. However, particularly in electronic auctions, the experience of emotions and, thus, the elicitation of auction fever is mediated through the interaction of the bidders with the auction system. The design of an auction system comprises the user interface design and the auction mechanism design.[18]

User Interface Design

In electronic auctions, the interaction of a bidder with the auction system is well-defined through the user interface. Although some bidders use software agents to avoid a direct interaction with the user interface and place bids in the last few seconds of an auction, an overwhelming majority of bidders interacts with the auction system through the user interface (cf. Roth, 2002).

Kolitz (2007) analyzes how the user interface design of an auction system affects bidding behavior and final prices. The author conducts a laboratory experiment in which the same auction mechanism is implemented with two different user interface implementations. Kolitz reports stronger bidding activity and higher final prices if new auction events can be observed instantly, without a manual refresh of the current display. The author explains this result by the fact that a fast reacting user interface can mediate the emergence of an intense emotional state and eventually induce auction fever. As a matter of fact, many Internet auction sites automatically update their user interface when new auction events occur. These fast reacting user interfaces can induce a stronger involvement of participants with the auction and, therefore, increase arousal.

Specifically, elements affecting the degree of perceived competition are frequently employed on Internet auction sites. Malmendier and Szeidl (2008) note that "eBay often use[s] salient warning messages informing the bidder that he has been outbid, which can strengthen bidding fever." Further, platforms usually display the current number of bids placed in the auction and the number of active bidders (e.g. *ebay.com*, 2009;

[18] As outlined before, the design of an auction system may also comprise the business structure and further aspects of the technical infrastructure (Weinhardt et al., 2003). However, in this thesis, an *auction system* is well-defined through the auction mechanism design and the user interface design.

1-2-3.tv, 2009). Some platforms additionally display the pseudonyms of active bidders (e.g. *swoopo.com*, 2009).[19] Displaying the number of bidders and their pseudonyms directly increases bidders' awareness of other bidders in an auction and, therefore, leverages co-actor effects and rivalry. It is important to recall, however, that in some auction mechanisms the number of bidders also directly affects a bidders optimal bidding strategy (e.g. Vickrey, 1961; McAfee and McMillan, 1987a). In contrast, other design elements exclusively address bidders' emotionality. Salient examples are, particularly, ticking clocks that display the remaining time in an auction. In the last few seconds of an auction, the platform *swoopo.com* even displays the time in red characters and the information "Just a few seconds to go!" is flashed. This design facet seems to specifically pronounce the time pressure inherent in auctions, which has been discussed as another influencing factor of perceived competition.

In a field study, Stern and Stafford (2006) show that the number of pictures in an eBay auction increases the number of first day bids and subsequently final prices. The authors argue that the "presence of more pictures captures initial attention and engenders positive attitudes to the item." Even more so, pictures may increase psychological attachment with the item and, thus, foster the pseudo-endowment effect. Wolf et al. (2008) show that bidders get more psychologically attached with an item if they can examine it properly. At the same time, the presence of pictures also serves as a quality signal and reduces quality uncertainty.

Auction Mechanism Design

A large body of economic literature analyzes how changes in the market mechanism affect bidders' optimal bidding strategy (e.g. McAfee and McMillan, 1987a; Krishna, 2002). However, there has only been little research on how different auction mechanisms are emotionally processed by bidders.

Smith and Dickhaut (2005) conduct a laboratory experiment and compare bidders' physiological processing as well as their bidding behavior in Dutch auctions with those in Japanese auctions.[20] In particular, the authors compare heart rate data in these two auction mechanisms. Smith and Dickhaut conclude that the Japanese auction, as a

[19] Interestingly, eBay changed its policy in this regard and no longer displays the complete pseudonym of a bidder due to anonymity reasons. To the contrary, the Internet auction site *1-2-3.tv* even broadcasts the pseudonyms of its bidders on national television.

[20] The authors use the term "English clock auction" for a Japanese auction.

collection of all relevant stimuli, induces less emotional arousal than the Dutch auction. However, the authors do not address which *specific* features of the Dutch auction are responsible for the reported increased emotionality. The literature conjectures that bidders derive a "utility of suspense" from participating in Dutch auctions (Cox et al., 1983; Katok and Kwasnica, 2008). In Chapter 5, I will provide physiological evidence for a utility of suspense in Dutch auctions.

Different auction mechanisms can generate different auction events, which in turn induce different immediate and anticipated emotions. For instance, some auctions allow for multiple rounds of bidding with one bidder being the current high bidder, while other auctions only allow bidders to place one single sealed-bid. As outlined in Sections 2.2.2 and 2.2.3, previous investments and perceived ownership are inherent characteristics of dynamic auctions, while they are less pronounced in static auctions. According to the definitions listed in Table 2.1, auction fever is a phenomenon which is particularly observed in dynamic auctions (e.g. Ockenfels et al., 2006; Haruvy and Popkowski Leszczyc, 2009).

The immediate emotions triggered in the process of an auction can be anticipated by bidders. For instance, the regret and joy associated with losing and winning an auction, respectively, are salient future emotions that can influence bidders' decision-making (e.g. Engelbrecht-Wiggans and Katok, 2008). These emotions will be discussed in detail in Section 2.3.

2.2.5. Conclusions

In the context of the framework for emotional bidding, this section focused on how the process of an auction can affect a bidder's current emotional state. In particular, I focus on the phenomenon of auction fever. The literature on auction fever has identified perceived competition, previous investments, and perceived ownership as the main influencing factors for a bidder's current emotional state. Selected literature on these factors, along with the particular focus and methodology, is listed in Table 2.2. As argued in Section 2.1, the outlined influencing factors can induce an intense current emotional state that distorts a bidder's preselected bidding strategy. This phenomenon is interpreted as auction fever. Summarizing results from the relevant literature, the following conclusions can be drawn:

1. *Perceived competition:* Competition is an inherent characteristic of auctions. The degree of perceived competition is particularly affected by time pressure, social facilitation, and rivalry (e.g. Malhotra et al., 2008). Time pressure can induce more aggressive bidding in ascending auctions (e.g. Haruvy and Popkowski Leszczyc, 2009). The presence of other bids and passive spectators can increase the perception of being in the spotlight and, therefore, cause bidders to place higher bids (e.g. Ku et al., 2005). Field studies have shown that low starting prices and long auction durations can increase the number of bidders and, thus, rivalry. Further, a (sub-)group of bidders may develop personal rivalries, which induce interdependencies between bidders' individual utility functions. This means, a bidder can derive an additional positive or negative utility from winning or losing an auction, respectively. However, the degree of these interdependencies seems to depend on the number of bidders. Particularly when there are only two active bidders in an auction, so called "head-to-head battles" can arise (cf. Johns and Zaichkowsky, 2003; Ku et al., 2005).

2. *Previous investments:* The terms *escalation of commitment* and *sunk cost fallacy* describe the observation that human decision-makers often put too much emphasis on recouping previous investments, for which they feel personally responsible, by investing further effort. The multi-stage bidding process is the actual basis for this effect in dynamic auctions. Various studies observe stronger bidding activity and higher final prices in consequence to accumulated sunk costs in the form of auction fees, search, transaction, and waiting costs. Particularly, high starting prices, auction fees, and long auction durations induce higher commitments.

3. *Perceived ownership:* Although no bidder actually owns the item before the end of an auction, being the high bidder in an ascending auction can make a bidder feel like already owning it. This perceived ownership can be evoked by an increased psychological attachment to the item (*pseudo-endowment effect*) and/or an increased probabilistic belief about winning the auction (*attachment effect*). Various studies have shown that a longer duration of being high bidder can increase the probability of placing subsequent bids. Ehrhart et al. (2008) show that this effect can be amplified, if bidders have a direct influence on becoming the high bidder by placing bids faster than other bidders.

4. *System design:* Particularly in electronic auctions, the elicitation of auction fever is mediated through the auction design, i.e. the user interface design and the auction mechanism design. Auction sites can increase perceived competition through user interface design elements. Photos of the commodity for sale can increase a bidder's psychological attachment with the item. Different auction mechanisms typically induce different auction events and, thus, emotionality. The phenomenon of auction fever seems to be a phenomenon particularly observed in dynamic auctions (e.g. Ockenfels et al., 2006).

It is important to note, however, that the outlined influencing factors of auction fever are not isolated components. On the contrary, they *interact* with each other! First, auction mechanism parameters, such as the starting price or the auction duration, can have opposing effects. For instance, a long auction duration in an ascending auction can increase the average high bidder duration and, thus, perceived ownership, while at the same time, the degree of time pressure decreases and previous investments in terms of waiting costs increase. As argued in Section 2.2.2, the starting price of an auction diametrically affects perceived competition and previous investments. Second, there is little research to what extent one influencing factor leverages the impact of another influencing factor. For instance, Heyman et al. (2004) qualitatively report that the pseudo-endowment effect is "stronger" in case the degree of perceived competition is high. In an eBay field study, Wolf et al. (2005b) report that the effect of high bidder duration and the number of bidders on final prices are multiplicative, while the effect of auction duration and the number of bidders are additive. I believe that the unified framework for emotional bidding in auctions can help to identify the interdependencies better and more concise. Moreover, in combination with the methodology of physioeconomics introduced in Chapter 3, these interdependencies can also be physiologically measured.

Product Characteristics. Ariely and Simonson (2003) argue that the interaction of the outlined influencing factors is subject to the specific characteristics of the auctioned item, e.g. "whether the product offered is such that the allure of its low starting price has the potential to generate emotional involvement." At this stage, there has been little research on how the phenomenon of auction fever depends on product characteristics. This research question is particularly important, however, because the literature on auction fever analyzes auctions ranging from retail products, such as electronic equipment,

Table 2.2.: Selected Literature on Elicitors of Current Emotional States in Auctions
(PC = perceived competition, PI = previous investment, PO = perceived ownership)
(TH = theory, LE = lab experiment, CFE = controlled field experiment, FS = field study, SV = survey, RV = review)

Author(s)	Published in	PC	PI	PO	TH	LE	CFE	FS	SV	RV
Teger (1980)	Monograph		X			X			X	
Thaler (1980)	Journal of Economic Behavior & Organization			X	X	X				
Meyer (1993)	The Quarterly Review of Economics and Finance		X		X	X				
Ku (2000)	Kellogg Journal of Organization Behavior	X				X				
Murnighan (2002)	Journal of Management Education	X	X			X				
Ariely and Simonson (2003)	Journal of Consumer Psychology	X	X				X	X	X	
Johns and Zaichkowsky (2003)	Psychology and Marketing	X				X		X	X	
Morgan et al. (2003)	Contributions to Economic Analysis & Policy	X			X					
Häubl and Popkowski Leszczyc (2004)	Advances in Consumer Research	X				X				
Heyman et al. (2004)	Journal of Interactive Marketing	X		X		X			X	
Ku et al. (2005)	Organizational Behavior and Human Decision Processes	X	X			X		X	X	
Walley and Fortin (2005)	Journal of Business Research	X					X			
Wolf et al. (2005a)	Working Paper			X					X	
Wolf et al. (2005b)	Working Paper			X				X		
Ku et al. (2006)	Journal of Personality and Social Psychology	X	X			X		X	X	
Hou (2007)	Journal of Electronic Commerce Research	X	X					X		
Katok and Kwasnica (2008)	Experimental Economics	X			X	X				
Bramsen (2008a)	Working Paper			X				X		
Ehrhart et al. (2008)	Working Paper			X	X	X				
Ku (2008)	Organizational Behavior and Human Decision Processes		X			X				
Ku et al. (2008)	Working Paper	X	X			X			X	
Malhotra et al. (2008)	Harvard Business Review	X								X
Park et al. (2008)	EMCIS Proceedings	X	X						X	
Wolf et al. (2008)	Judgement and Decision Making			X		X				
Haruvy and Popkowski Leszczyc (2009)	Decision Analysis	X					X			

to collectibles, such as one-cent coins and fiberglass cows (cf. Ku et al., 2005; Lucking-Reiley et al., 2007). It seems sensible to conjecture that particularly a product's value, scarcity, and public interest play an important role in this regard. First, if the value of the item is high, it affects bidder's individual involvement. For instance, Ku et al. (2008) show that bidding behavior is more aggressive if stakes are high. Second, a product's scarcity *ceteris paribus* affects rivalry among bidders. Hou (2007) argues that a long auction only positively affects the endogenous number of bidders, if scarcity is sufficiently high and bidders do not have "more options at any point of time." Lynn (1992) reports that an item becomes more desirable for consumers if it is scarce. Peters and Bodkin (2007) observe that eBay bidders derive "joy in finding rare or unusual items." Third, a high public interest can increase a bidder's prestige when obtaining the auctioned item, e.g. a charity auction or a unique collectible. Ku et al. (2005) observe charity auctions and conjecture that the intense media attention may also have "increased arousal and facilitated higher bidding." Lee and Malmendier (2010) report that the amount of overbidding in eBay auctions depends on the product category, with proportions of

overbidding ranging "between 30% and 60% for most categories."

Inducing a Current Emotional State. The literature discussed so far focuses on how characteristics of bidders, the auction mechanism, and the product can induce an intense emotional state in auctions. However, a change in a bidder's current emotional state may also be induced by a task completely unrelated to the bidding task. In this regard, the experimenter may also induce a specific current emotional state by means of videos (Rottenberg et al., 2007), pictures (Bradley and Lang, 2007), music (Eich et al., 2007), or tasks proceeding the actual experiment (Roberts et al., 2007). For instance, Ku (2008) conducts a survey experiment that comprises two stages. In the first stage, participants are asked to write a self-report on a competitive incident in the past, in which they either felt "aroused, stirred up, and excited" (high arousal) or "quiet, peaceful, and calm" (no arousal). In the second stage, subjects participate in an hypothetical auction scenario. The author shows that subjects in the high arousal treatments place significantly higher bids.

Methodological Discussion. The literature on auction fever comprises many examples of laboratory experiments in which participants are intentionally deceived in order "not to disturb the emergence of auction fever" (Ockenfels et al., 2006). In particular, participants are told that they bid against other human individuals, while they are actually competing against computerized agents (e.g. Häubl and Popkowski Leszczyc, 2004; Ku et al., 2008). While deception of participants has turned out to be common practice in experimental psychology, it violates established paradigms of experimental economics (cf. Guala, 2005). With respect to auction fever experiments, Ockenfels et al. (2006) criticize that it remains unclear to what extent participants "will actually believe any part of the information they are given," if the subject pool has been exposed to deception in experiments before. Other studies focus on surveys in which bidders place hypothetical bids in an artificial auction scenario (e.g. Heyman et al., 2004; Ku, 2008). Again, this is not in line with established paradigms of experimental economics. In particular, the induced value theory states that subjects need to be incentivized through a proper reward medium, e.g. money, in order to observe economic decision-making behavior that is actually related to the focus of investigation (cf. Smith, 1976).

2.3. Immediate and Anticipated Emotions

Section 2.2 discussed how the characteristics of the auction system, the bidders, and the product can induce an intense emotional state of auction fever. This section focuses specifically on immediate emotions in response to a single auction event and on the anticipation of future emotional processing. As outlined in the framework for emotional bidding in Section 2.1.1, the elicitation of an intense emotional state is also subject to immediate and anticipated emotions experienced in the course of an auction. Particularly the "frequency and magnitude of anticipated post-auction feelings" can have a major impact on bidding decisions (Ariely and Simonson, 2003). The literature has focused specifically on the single most anticipated event in single-unit auctions - the *auction outcome*.

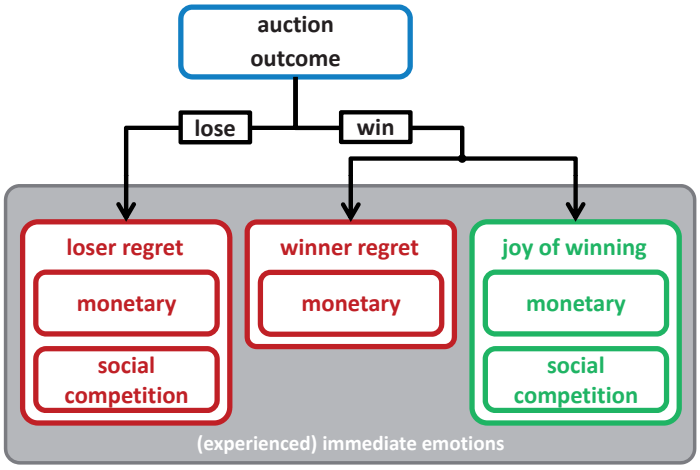


Figure 2.2.: Immediate Emotions Induced by Auction Outcome

In a single-unit auction, the auction outcome reveals which bidder obtains the commodity for sale and how much she has to pay for it. This bidder is referred to as the "winner" and all other bidders as the "losers" of an auction. Figure 2.2 schematically depicts the main immediate emotions a bidder may experience in consequence to the revelation of the auction outcome.

If the bidder *wins* an auction, she may experience a "joy of winning" (e.g. Goeree and Offerman, 2003). This joy does not only comprise her utility from monetary payoffs, but also the utility from winning the social competition inherent in an auction. This non-monetary component of the joy of winning is also referred to as "love of winning"

(e.g. Morgan et al., 2003; Kogan and Morgan, 2009). However, the winner of an auction may at the same time suffer from "winner regret." For instance, in a first-price sealed-bid auction, the winner of an auction may still have won the auction by placing a lower bid and, thus, won the auction with a higher monetary payoff (e.g. Engelbrecht-Wiggans, 1989). Even more so, she may also experience winner regret in an auction in which she gained a negative monetary payoff.[21]

In contrast, if the bidder *loses* an auction, she can experience "loser regret" with regard to the missed opportunity of achieving a monetary payoff and because of losing the social competition (e.g. Filiz-Ozbay and Ozbay, 2007).[22] The following subsections will discuss these three immediate emotions along with results from the literature.

2.3.1. Winner and Loser Regret

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 (2004a) 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. In terms of the 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*.[23] Crone et al. (2004) show that those individuals, who have a stronger emotional processing of secondary inducers, take on average more advantageous decisions.

[21] The literature on winner regret does not consider regret from winning the social competition. This emotion seems counterintuitive, as the love of winning is generally assumed to be non negative.

[22] Joy of winning and loser regret are sometimes also referred to as "excitement of winning" and "frustration of losing," respectively (e.g. Ding et al., 2005; Peters and Bodkin, 2007). Ding et al. (2005) argue that "anticipated regret is similar to [the] concept of anticipated frustration."

[23] The somatic marker hypothesis of Bechara and Damasio (2005) states that advantageous decision-making is only possible in consequence of a prior accurate emotional processing of primary and secondary inducers (cf. Section 3.4.1).

Engelbrecht-Wiggans (1989) introduces a model of post-auction regret for first-price sealed-bid (FPSB) auctions. In 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 can experience winner regret if she is told the amount of the second highest bid upon winning. Engelbrecht-Wiggans refers to this feeling as "money left on the table" regret, because *ex post* the winner of a FPSB auction could have gained a higher profit by shading her bid.[24] In contrast, the loser of an auction can suffer from loser regret if she is told the amount of the highest bid upon losing. Engelbrecht-Wiggans refers to this feeling as "missed opportunities" 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 on the highest and second highest bid, they can anticipate winner and loser regret during decision-making and reflect this concern in their bidding strategy. Engelbrecht-Wiggans analytically shows that a bidder's utility maximizing bidding strategy is independent of regret, if she puts equal weights on winner and loser regret. However, bidders place higher (lower) bids in equilibrium, if they put more weight on loser (winner) regret.

Vickrey (1961) introduces a risk neutral Nash equilibrium (RNNE) bidding strategy, for which a bidder maximizes her expected payoff in FPSB auctions. However, it is a well-established result of experimental economics that human individuals place higher bids than the RNNE bidding strategy of Vickrey suggests (cf. Kagel, 1995). In order to explain this observation, Cox et al. (1988) introduce a model of constant relative risk averse (CRRA) bidders. Following the argumentation of Engelbrecht-Wiggans (1989), however, bidding above the RNNE can also be explained with anticipated loser regret. Kagel (1995) argue 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, Engelbrecht-Wiggans and Katok (2007) show that regret theory can also explain contradictory results of various studies, which cannot be explained with risk aversion.

[24] Recall that in a FPSB auction, the highest bidder receives the commodity for the amount of her bid. As long as her bid is slightly higher than that of the second highest bidder, she still wins the auction. Therefore, it can *ex post* be a better strategy to place a lower bid. In other words, "what seems the best action *ex ante* may not turn out to be the best one *ex post*" (Filiz-Ozbay and Ozbay, 2007).

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 decided 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 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, the authors introduce a *both regret* treatment, in which the highest as well as the second highest bid are revealed. Engelbrecht-Wiggans and Katok also 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 both regret treatment. 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."

Sujarittanonta and Cramton (2009) analytically show that anticipated loser regret can also affect bidding behavior in an ascending clock auction. In particular, two pricing rules are compared, for which auction theory actually predicts equivalent seller revenues: lowest accepted bid (LAB) and highest rejected bid (HRB). While profit maximizing bidders truthfully bid their valuation in the HRB auctions, the LAB auction induces them to shade their bids in equilibrium. Therefore, bidders "face the risk of losing at profitable prices" in LAB auctions. Sujarittanonta and Cramton (2009) conclude that

revenues are higher in LAB auctions if the "fear of losing is sufficiently strong."[25] In order to test these theoretical predictions, Cramton et al. (2009) conduct a laboratory experiment. In line with the theoretical predictions of Sujarittanonta and Cramton (2009), Cramton et al. (2009) also find support for the theory of loser regret and observe higher revenues in LAB auctions in comparison to HRB auctions. The authors conclude that subjects shade their bids less rigid than auction theory predicts, because they "anticipate the regret of losing at a profitable price."

It is important to note, however, that the studies discussed in this section so far all model regret exclusively as a function of the additional monetary payoff an *ex post* optimal bidding strategy would have achieved (Engelbrecht-Wiggans, 1989). In other words, this particular concept of regret does not comprise aversive feelings of losing the social competition.[26] In contrast, Delgado et al. (2008) take these social aspects in a neuroeconomic experiment into account. The authors analyze two different scenarios: a lottery and a FPSB auction with one human competitor. Delgado et al. find that losing a FPSB auction induces a similar activation of brain regions as known from actual monetary losses. This, however, is not the case in the almost identical lottery setting.[27] The authors conclude that the "fear of losing the social competition" is responsible for overbidding in FPSB auctions and that the "the anticipation of the unpleasant state associated with loss" leads participants to increase their bids. In terms of regret, this can be interpreted as anticipated loser regret regarding the social competition.

2.3.2. Joy of Winning

The expected utility from winning an auction is the actual reason for bidders to participate. The immediate emotion triggered by the event of winning an auction and receiving a positive monetary payoff is referred to as "joy of winning" (e.g. Goeree and Offerman, 2003). Traditionally, the utility gained from winning an auction depends only

[25] In line with the argumentation above, Sujarittanonta and Cramton (2009) use the terms "fear of losing" and "anticipated loser regret" interchangeably.

[26] Engelbrecht-Wiggans and Katok (2008) deliberately exclude effects related to the social competition by letting bidders compete against computerized agents. In contrast to the auction fever literature discussed in Section 2.2, subjects are explicitly informed that they compete against computers.

[27] A brain region referred to as "striatum" is the focus of the investigation. The authors report a decrease in BOLD (blood oxygen level dependency) signal in the case of losing an auction, but not when receiving no payoff in a lottery. However, there is an increase if the bidder wins an auction or if she receives a payoff in a lottery.

on monetary payoffs (cf. Vickrey, 1961). However, bidders may also derive a utility from winning the social competition of an auction that is "over and beyond any monetary payoffs" (Cooper and Fang, 2008). Fliessbach et al. (2007) argue that "outperforming someone else" can induce a joy of winning in addition to mere monetary reward. This non-monetary component is also referred to as "love of winning" (e.g. Morgan et al., 2003; Kogan and Morgan, 2009). In the following, the term joy of winning will be used to refer to its non-monetary component.

There are contradictory results in the literature regarding the impact of anticipated joy of winning. Cooper and Fang (2008) conduct a laboratory experiment in order to analyze how the anticipation of joy of winning affects bidding behavior in a second-price sealed-bid (SPSB) auction. Although Vickrey (1961) has shown that bidders have a weakly dominant strategy in a SPSB auction to truthfully bid their individual valuation for the item, it is a common observation in experimental economics that up to 60% of the bidders place bids which exceed their valuation (cf. Kagel and Levin, 1993). Cooper and Fang report that one main explanation for such overbidding is bounded rationality, as bidders learn how to avoid costly overbidding over time. According to the authors, another part of overbidding can be explained with interdependent utilities associated with joy of winning and spite. In another study, Andreoni et al. (2007) find that anticipated joy of winning is only responsible for at most 10% of the observed overbidding. Goeree and Offerman (2003) find no support for the theory of anticipated joy of winning in their experiment and explain their results with loss aversion. Delgado et al. (2008) argue that it is actually anticipated loser regret and not anticipated joy of winning that is responsible for overbidding. Based on neurological data, the authors show that there is virtually no difference between winning a lottery or a FPSB auction as regards emotional processing.

It is important to note, however, that the literature on joy of winning (1) mainly focuses on static auctions and that (2) the results of these studies are based on experiments in a neutral laboratory environment. It may be worthwhile analyzing whether the joy of winning is stronger in dynamic auctions and in the case of personal rivalries among bidders. Further, the literature on auction fever frequently conjectures that love of winning, and its anticipation, is strongly intertwined with auction fever (e.g. Häubl and Popkowski Leszczyc, 2004; Walley and Fortin, 2005; Haruvy and Popkowski Leszczyc, 2009). As outlined above, however, auction fever is particularly observed in *dynamic*

auctions (e.g. Gimpel, 2007; Haruvy and Popkowski Leszczyc, 2009).

2.3.3. Conclusions

In the context of the framework for emotional bidding, this section focused on the major immediate emotions a bidder can experience upon learning the auction outcome.[28] Selected literature on immediate and anticipated emotions in auctions, along with the particular focus and methodology, is listed in Table 2.3. Summarizing results from the literature, the following conclusions can be drawn:

1. *Winner and loser regret:* Regret is an aversive emotion an individual experiences upon realizing *ex post* that she could have taken a better decision in the past. In auctions, bidders can experience in particular loser regret, i.e. by realizing upon losing that one could have won the auction at a profitable price, and winner regret, i.e. by realizing upon winning that one could have achieved an even higher profit. In case bidders anticipate loser regret, they tend to raise their bids. In case they anticipate winner regret, they shade their bids. While anticipated loser regret can instantly be observed in bidding behavior, this is not the case for winner regret. Engelbrecht-Wiggans and Katok (2008) conjecture that the anticipation of winner regret needs to be learned through experience.

2. *Joy of winning:* The joy of winning an auction comprises utility gained from both monetary profits as well as outperforming other bidders. However, there is only weak evidence in the literature that the anticipation of this non-monetary component of joy of winning is responsible for placing higher bids in static auctions. Delgado et al. (2008) report that the joy of winning a FPSB auction is virtually the same as winning a lottery. The authors argue that it is in fact anticipated loser regret that causes bidders to place higher bids. However, love of winning, i.e. the non-monetary component of joy of winning, may be strongly intertwined with auction fever, which is particularly observed in dynamic auctions (e.g. Gimpel, 2007; Haruvy and Popkowski Leszczyc, 2009).

[28] Moreover, Greenleaf (2004) demonstrates that not only the behavior of the bidders, but also the behavior of the *seller* is subject to processing of immediate and anticipated emotions. Based on a theoretical model and a laboratory experiment, the author shows that sellers reflect "anticipated regret and rejoicing" when setting a reserve price for an auction. However, this thesis focuses particularly on the emotions experienced by the bidders.

3. *Auction mechanism design:* The immediate emotions experienced upon winning or losing an auction also depend on the mechanism design of the auction. As described in Section 2.1.1, the auction system limits the set of possible immediate emotions. Therefore, such emotions can only be anticipated in certain auctions. Filiz-Ozbay and Ozbay (2007) argue that winner and loser regret cannot explain overbidding in SPSB auctions, as overbidding is a dominated strategy in this case. In ascending clock auctions, the experience of loser regret depends on the pricing rule (cf. Sujarittanonta and Cramton, 2009). Ivanova-Stenzel (2008) argues that "subjects prefer ascending auctions because there is never any regret in them."

As argued in the framework for emotional bidding in Section 2.1.1, the impact of immediate emotions is twofold. First, bidders can anticipate future immediate emotions and reflect this in their bidding strategy. Second, the processing of anticipated and immediate emotions also directly affects a bidder's current emotional state.

Table 2.3.: Selected Literature on Immediate and Anticipated Emotions
(TH = theory, LE = lab experiment, CFE = controlled field experiment, FS = field study, SV = survey, RV = review)

Author(s)	Published	Emotion	TH	LE	CFE	FS	SV	RV
Engelbrecht-Wiggans (1989)	Management Science	loser & winner regret	X					
Goeree and Offerman (2003)	European Economic Review	loser regret, joy of winning	X	X				
Bosman and Riedl (2004)	Working Paper	economic shock	X	X			X	
Greenleaf (2004)	Journal of Consumer Research	seller joy & regret	X					
Ding et al. (2005)	Management Science	loser regret, joy of winning	X	X			X	
Andreoni et al. (2007)	Games and Economic Behavior	joy of winning	X	X				
Filiz-Ozbay and Ozbay (2007)	American Economic Review	loser & winner regret	X	X			X	
Engelbrecht-Wiggans and Katok (2007)	Economic Theory	loser & winner regret	X	X				
Cooper and Fang (2008)	The Economic Journal	joy of winning	X	X				
Delgado et al. (2008)	Science	loser regret, joy of winning		X				
Engelbrecht-Wiggans and Katok (2008)	Management Science	loser & winner regret	X	X				
Cramton et al. (2009)	Working Paper	loser regret	X	X				
Engelbrecht-Wiggans and Katok (2009)	Decision Analysis	loser & winner regret	X					
Sujarittanonta and Cramton (2009)	Working Paper	loser regret	X					

Bosman and van Winden (2002) analyze how the emotional processing of a sudden "economic shock" affects a bidder's current emotional state. The emotional state is assessed with self report questionnaires. After a first sequence of auctions, the authors randomly induce either a positive economic shock, i.e. doubling the accumulated profit of a bidder, or a negative shock, i.e. dividing it by two. The authors report a direct influence of the economic shock on the emotional state. Further, Bosman and van Winden find that the "emotional state systematically influences bidding behavior." Those bidders who are in a negative emotional state increase their bids in the second auction series, whereas

the other bidders do not change their bidding behavior. The authors conclude that "a bad emotional state significantly increases the likelihood to bid more aggressively." In another study, Ding et al. (2005) investigate how winning or losing in one auction affects bidding behavior in the following auction. The authors derive an analytical model in which bidders revise their bidding strategy "each time as his/her emotional state changes due to the outcome of previous bidding." This model is then tested in a laboratory experiment. Consistent with the model, Ding et al. report that bidders tend to change their bidding strategy after each auction. If a subject lost the previous auction, she gets more excited about winning the current auction. In contrast, if a subject won the previous auction, she gets more frustrated about losing the current auction. The authors conclude that "emotions are an integral component of a bidder's decision state and bidding strategy."

At this stage, the literature focuses particularly on immediate emotions induced by the auction outcome. However, especially in dynamic auctions, there are several auction events other than the auction outcome that can also trigger immediate emotions. As outlined in Section 2.1, the event of becoming the current high bidder and the event of being outbidden have been identified to be essential with regard to inducing an intense emotional state, which is comprised in the effects of pseudo-endowment and escalating commitment. Therefore, the study of immediate and anticipated emotions regarding auction events and their interaction with a bidder's current emotional state seem worthwhile for future research.

2.4. Bidder Heterogeneity

Sections 2.2 and 2.3 discussed how emotions can *generally* affect bidding behavior in the framework for emotional bidding, without taking into account heterogeneities among bidders. However, as outlined in the framework for emotional bidding in Section 2.1.1, the elaboration of a bidding strategy and the emotional processing of an auction are also subject to a bidder's individual characteristics. Therefore, this section specifically addresses how a bidder's personality and expertise can affect her bidding behavior and emotional processing.

2.4.1. Sensitivity to Heterogeneities Among Bidders

It is a common assumption in auction literature that bidders are homogeneous and have the cognitive abilities to derive an optimal bidding strategy (e.g. McAfee and McMillan, 1987a).[29] In contrast, already Vickrey (1961) argues that some of the bidders may be "insufficiently sophisticated to discern the equilibrium-point strategy." Highlighting the importance of heterogeneities among bidders, Cox et al. (1982) state that "freeing bidding theory from dependence on identical bidders assumption is an important generalization."[30]

Auctions are particularly sensitive to heterogeneities among consumers, as they "systematically pick those buyers as winners" who have a tendency to overbid (Lee and Malmendier, 2010). Therefore, if a small (sub)group of bidders is particularly liable for auction fever, their behavior is *disproportionally* pronounced in the auction outcome. With respect to this special characteristic, Malmendier and Szeidl (2008) describe auctions as "tool[s] to search for fools." The authors theoretically analyze how a comparatively small number of "fools," i.e. agents with a behavioral bias to overbid, affect the auction outcome. The other agents are assumed to be "rational agents," i.e. agents who place bids according to a given optimal bidding strategy. The authors analytically show that already a small number of behavioral agents can have a large impact on the auction outcome. For instance, under the assumption that there are 20% fools in the general population and 10 bidders in an auction, the "share of overbid auctions with at least two fools is 62%." Further, the authors argue that the impact of behavioral agents also depends on the particular auction mechanism. While second-price auctions need at least two such agents to observe overbidding, only one of them is needed in first-price auctions.

Based on these theoretical considerations, Lee and Malmendier (2010) analyze field data from eBay auctions and fixed price offers for a popular board game. The authors define overbidding in auctions as placing bids beyond fixed price offers, which are simultaneously listed on the same computer screen. Overbidding is observed in 42% of the auctions, taking into account the differences in shipping costs this proportion even is

[29] In this respect, Falk and Heckman (2009) note: "The evidence that people are different clashes sharply with the widely used 'representative agent' model that assumes that agents are homogeneous or can be represented as if they are homogeneous."

[30] It is important to note, however, that abandoning the "assumption of homogeneity among bidders" can turn out to be an "intractable" problem in theoretical models (Vickrey, 1961).

73%. In contrast, the share of bidders who overbid is only 17%.[31] The authors conclude that due to the "nature of auctions," the presence of this comparatively small number of bidders has a "disproportionate influence" on final auction prices.

Malmendier and Szeidl (2008) highlight that this amplification effect of auctions is not restricted to a particular behavioral bias, i.e. the underlying psychological phenomenon for overbidding. The important aspect is that auctions are *particularly sensitive* to such biases. Such behavioral biases are subject to a bidder's individual personality and expertise, which will be discussed in the following subsections.

2.4.2. Personality

In the context of Internet auctions, the literature identifies different personality categories of auction participants. For instance, Weinhardt and Schmidt (2001) distinguish the "serious shopper," the "collector," and the "bargain hunter" as the main categories of online auction consumers. Lee et al. (2008) categorize bidders into "impulse buyers," "variety seekers," "risk-averse economists," and "auction lovers." This terminology indicates a wide spectrum of auction participants, ranging from price sensitive customers to sensation seeking bidders.

Möllenberg (2004) conducts an Internet survey among eBay auction participants. Each subject is either categorized as an "auctainer" or a "smart bidder." An *auctainer* is characterized as an experiential-oriented customer, who is attracted by emotional stimuli and tends to aggressive bidding. In contrast, a *smart bidder* is a result-oriented customer, who is attracted primarily by cognitive stimuli and strictly adheres to preselected bidding limits. Altogether, 48% of the bidders are categorized as auctainers and 52% as smart bidders. Therefore, a substantial part of auction participants is attracted by emotional aspects of Internet auctions. In another survey study, Lee et al. (2009) investigate how consumer characteristics are related to their utilitarian and hedonic values of online auctions. While utilitarian value refers to the utility gained from obtaining the desired commodity, hedonic value is gained from "perceived entertainment and emotional worth" of auction participation. The authors find that hedonic value is positively affected by compulsive buying behavior and variety seeking, while it is negatively af-

[31] Note that overbidding is defined in this case relative to the fixed price offer. However, a bidder's preselected bidding limit may be well below this fixed price and, therefore, the actual fraction of overbidders may be even higher.

fected by price sensitivity. Lee et al. conclude that "thrill of bidding, excitement of winning, stimulation of beating competitors, and enjoyment of finding rare or unusual items" play an important role as to why these consumers participate in auctions.

While these studies only focuses on bidders who are already customers of Internet auction sites, Stafford and Stern (2002) outline which consumer characteristics determine auction participation. The authors conclude that in particular acceptance of technology, affinity with computers, and "involvement" in auctions affect the propensity to bid in Internet auctions. Involvement describes the emotional aspects of auctions, for instance the "game-like action and bidding frenzy characteristic" (Stafford and Stern, 2002). Similarly, Stern et al. (2008) identify "impulsiveness" as a personality dimension, which is attracted by hedonic value of Internet auctions.

Peters and Bodkin (2007) analyze whether emotionality in auctions can even lead to an addiction. The authors conduct one-on-one interviews with eBay customers and define habitual use, negative consequences, psychological distress, and dependency as characteristics of an online auction addiction. In particular, elements associated with auction fever, i.e. perceived competition, previous investments, and pseudo-endowment, are described to be the cause of an intense emotional state of psychological distress. Further, immediate emotions elicited by the auction outcome play an important role as well. Peters and Bodkin conjecture that "the highs of winning and the lows of losing may lead to [...] a dependency on online auctions." The authors observe that 12% of the interviewees exhibit all four characteristics and that a large proportion exhibits at least one. Although this result is difficult to generalize, addictive behavior in combination with the amplificiation effect of auctions may explain a part of the observed overbidding on eBay.

Bapna et al. (2001) and Bapna et al. (2003) categorize bidders based on their objectively observable bidding behavior into "evaluators," "opportunists," and "participators." This categorization is further refined in Bapna et al. (2004). In a field study, the authors analyze bidding behavior in multi-unit discriminatory price auctions on *Onsale.com* by assessing three objective parameters of each bidder: time of entry (TOE), time of exit (TOX), and number of bids (NOB).[32] "Early evaluators," "middle evaluators," and "opportunists" are bidders who only place a single bid in the early, middle, or late stages of an auction. Those bidders categorized as "sip-and-dippers" strategically place one bid

[32]This particular mechanism is also referred to as "Yankee auction."

at the beginning and another bid at the end of an auction. In contrast, "participators" place multiple bids in all stages of an auction. Bapna et al. conjecture that these bidders "gain satisfaction from the bidding and participation process" and, thus, are also motivated by emotional components of bidding. Analyzing behavior of bidders on eBay, Hayne et al. (2003) categorize bidders in a quite similar way: early, in-between, and late bidders only place a single bid. In contrast, "probe bidders" place consecutive incremental bids in order to eventually reveal the maximum bid of the proxy agent. "Sentry bidders" quickly place additional bids every time they are outbid. Hayne et al. (2003) argue that "making consecutive incremental bids is irrational" in eBay proxy auctions. With 25% probe bidders and 9% sentry bidders, the proportion of such bidding activity is substantial.

Other studies focus on cultural, regional, and gender differences among bidders. For instance, Hou (2007) compares bidding behavior on eBay China and eBay US. The authors report that a high starting price "helps building bidding momentum" on eBay China, which is not the case on eBay US. Further, the authors report that experienced bidders, as assessed through feedback score, pay lower prices on eBay US, while there is no such effect on eBay China. In another eBay field study, Black (2005) analyzes bidding behavior of different regions in the US. The author reports higher bidding activity in rural in comparison to urban areas, and that females are more likely to place bids on eBay than males.[33] At this stage, however, the actual cause for differences in bidding behavior remains generally unclear in studies on cultural, regional, and gender heterogeneities.

Personality heterogeneities are also observed in laboratory experiments. For instance, Andreoni et al. (2007) report in a laboratory study that some subjects overbid due to joy of winning, while others are motivated by spite, and again another group is affected by bounded rationality. Therefore, subjects can have different interdependencies in their utility functions. Cooper and Fang (2008) observe that some subjects decide "almost completely in line with the standard theoretical predictions," while other subjects consistently overbid. The authors conclude that "bidder heterogeneity is playing an important role" in their data and that "some subjects are more rational than others."

[33] With respect to gender differences, Black (2005) conjectures: "many women like to shop, and the excitement of the auction may replace the satisfactions of the brick-and-mortar shopping experience."

2.4.3. Expertise

Bidders can also be categorized according to their level of expertise. Ariely and Simonson (2003) distinguish in particular between "product domain expertise" and "online auction expertise." Product domain expertise positively affects the "evaluation of the auction items" and, thus, reduces uncertainty regarding the item's value. In contrast, online auction expertise refers to the experience a bidder has with auctions and the abilities to derive a bidding strategy.

On average, experienced bidders seem to be less prone for auction fever, as these bidders have a tendency to place only a single bid in dynamic ascending auctions.[34] Murnighan (2002) conjectures that "with luck, experience, and insight, people can avoid [such] mistakes." For instance, Bramsen (2008a) observes that on average the pseudo-endowment effect seems to diminish for experienced bidders. In a field study, Wilcox (2000) reports that more experienced bidders on eBay are more likely to snipe and less likely to submit multiple bids. Similarly, Gilkeson and Reynolds (2003) and Borle et al. (2006) observe a tendency of experienced eBay bidders to place single bids at the end of auctions. These studies define experience as the net number of positive and negative feedback provided by eBay. While this proxy only accounts for auctions a bidder has actually won, Wang and Hu (2009) also take into account the number of all auctions a bidder actively participated in, including those she did not win. The authors conclude that "winning experiences [...] can be counterproductive." To the contrary, bidders actually learn to refrain from placing multiple bids from the losing experiences, i.e. those auctions that are not reflected in the feedback score. Therefore, the immediate emotions induced from losing an auction seem to play an important role in a bidder's learning process.

Most of the papers discussed in this literature review address consumer auctions. This leads to the question of how important emotions actually are for *professional* traders in business auctions. Johns and Zaichkowsky (2003) conjecture that "it may be psychologically easier for bidders at a business-oriented auction to drop out of the bidding," because these bidders are less emotionally involved in the auction process.[35] The sociologist Charles W. Smith (1990) observes that the "high predictability of prices and

[34] Recall that one characteristic of auction fever is that bidders place multiple bids in dynamic ascending auctions.

[35] Johns and Zaichkowsky (2003) observe that many bidders in art auctions "actually send an agent to buy for them due to the emotional involvement and competitive nature of the sale."

lack of personal involvement" at business auctions sometimes seems to cause bidders to "fall asleep." In a laboratory experiment, Sokol-Hessner et al. (2008) show that decision behavior and emotional processing can even be changed if subjects are told to "think like a trader." The authors observe that subjects behave less loss averse and have limited physiological responses to actual losses in the context of lottery decisions. Sokol-Hessner et al. conclude that "taking a perspective similar to that of a trader can alter choice and arousal responses related to loss aversion." In a controlled field experiment comprising physiological measurements, Lo and Repin (2002) observe that physiological responses to market events depend on the expertise of the trader. In particular, the authors find that senior traders show a different pattern of emotional arousal than junior traders.

2.4.4. Conclusions

The last sections discussed how heterogeneities among bidders can affect their individual bidding behavior. In particular, a bidder's personality and expertise have been identified to be of importance.

Table 2.4.: Selected Literature on Bidder Heterogeneity and Emotional Bidding
(TH = theory, LE = lab experiment, CFE = controlled field experiment, FS = field study, SV = survey, RV = review)

Author(s)	Published	TH	LE	CFE	FS	SV	RV
Wilcox (2000)	Marketing Letters				X		
Bapna et al. (2001)	Communications of the ACM				X		
Stafford and Stern (2002)	International Journal of Electronic Commerce					X	
Bapna et al. (2003)	Information Systems Research				X		
Gilkeson and Reynolds (2003)	Psychology and Marketing				X		
Bapna et al. (2004)	MIS Quarterly				X		
Möllenberg (2004)	Electronic Markets					X	
Black (2005)	SAM Advanced Management Journal				X		
Borle et al. (2006)	Statistical Science				X		
Hou (2007)	Journal of Electronic Commerce Research					X	
Peters and Bodkin (2007)	Journal of Retailing and Consumer Services					X	
Bapna et al. (2008)	Decision Support Systems				X		
Malmendier and Szeidl (2008)	Working Paper	X			X		
Lee et al. (2008)	Journal of Customer Behaviour						
Stern et al. (2008)	Psychology and Marketing					X	
Lee et al. (2009)	Journal of Retailing and Consumer Services				X		
Lee and Malmendier (2010)	American Economic Review	X			X		

Selected literature on bidder heterogeneity in auctions, along with the particular methodology is listed in Table 2.4. Summarizing results from the literature, the following conclusions can be drawn:

1. *Sensitivity:* Auctions are particularly sensitive to heterogeneities among bidders, as they systematically select those bidders as winners who have a tendency for

overbidding. This amplification effect leverages behavioral biases among bidders and disproportionally pronounces the behavior of even a small group of bidders (cf. Malmendier and Szeidl, 2008; Lee and Malmendier, 2010).

2. *Personality:* There is a wide personality spectrum with regard to Internet auction participants, ranging from price sensitive customers to sensation seeking bidders. For a substantial part of bidders, e.g. "auctainers," "participators," the hedonic values derived from auction participation are an important reason to attend Internet auctions. As pointed out by Bapna et al. (2004), such bidders also tend to perform bidding behavior similar to auction fever. Further studies identify differences in bidding behavior related to a bidder's culture, region, and gender. At this stage, however, the actual reason for such differences in behavior remains unclear.

3. *Expertise:* On average, bidding behavior becomes more sophisticated with growing experience. Particularly, those auctions a bidder did not win are an important experience for learning. As a consequence, experienced bidders also tend to be less prone to auction fever (e.g. Bramsen, 2008a). Further, physiological processing and decision behavior can already change if subjects take the perspective of a professional trader. In particular, those subjects who are told to "think like a trader" behave less loss averse and their physiological response to actual losses is smaller (Sokol-Hessner et al., 2008). At this stage, however, the literature concerning emotionality in auctions focuses particularly on consumer auctions. Therefore, emotional processing of professional bidders, seems to be an interesting avenue for future research.

2.5. Conclusion

This chapter proposed a unified framework for emotional bidding in electronic auctions. The framework serves as a first element of a structured methodology for systematically analyzing emotions in electronic auctions and their impact on human bidding behavior. Furthermore, the chapter provides detailed literature reviews regarding specific parts of the framework.

First, I discuss literature regarding the main inducers of auction fever: *perceived competition*, *previous investments*, and *perceived ownership*. Thereby, a new definition of

auction fever is derived from the framework for emotional bidding. I define auction fever as an intense current emotional state elicited in the course of one or more auctions that distorts a bidder's preselected bidding strategy. Second, I focus on immediate and anticipated emotions bidders can experience in auctions. In particular, bidders can experience *joy of winning*, *loser regret*, and *winner regret* with respect to the auction outcome. The set of possible immediate and anticipated emotions in a specific auction is *limited* by the respective auction system. Third, the impact of heterogeneities among bidders is discussed with focus on their personality and expertise. Auctions systematically pick those bidders as winners, who have an behavioral bias for overbidding. Therefore, the impact of such biases is disproportionally pronounced in auctions (cf. Malmendier and Szeidl, 2008; Lee and Malmendier, 2010).

The proposed framework allows to systematically analyze the interactions between its single elements. For instance, future research can focus on how changes in the auction system are reflected in immediate and anticipated emotions the bidders experience. In order to actually *measure* this emotional processing, Chapter 3 proposes the methodology *physioeconomics*. More specifically, I will outline how physiological proxies of human emotional processing can be measured in economic experiments. Thereby, physioeconomics serves as the second element of a structured methodology for systematically analyzing emotions in electronic auctions and their impact on human bidding behavior.

Chapter 3.

Measuring Emotions in Economic Experiments

How do emotions affect human decision-making behavior and how can the study of emotions help economists to better understand decisions of human individuals? In his forecast on the future of economics, Thaler (2000) claims that the well-known and perfectly rational "homo economicus will become more emotional," indicating that economists will devote more attention to the study of emotions and include emotional factors in their models of decision-making.

While economic theory provides a highly elaborate methodology for analyzing organizational behavior and complex macroeconomic interrelations, economic models, though highly sophisticated and rich, often fail to capture the complexity of individual (human) decision-making. Economic models tend to understand decision-making as a single rational maximization of expected utility, rather than as a dynamic process involving both cognitive reasoning and emotional processing.[1] Camerer (2003b) argues that "most economic theories minimize the influence of human emotions" and Sanfey et al. (2003) even claims that economic models "idealize the decision-maker as a perfectly rational cognitive machine." While the assumption of a perfectly rational decision-maker seems sensible for organizational entities, it does not hold for explaining individual behavior of human agents (Lee et al., 2009).

[1] In contrast, Camerer (2003a) provides a thorough review of behavioral game theory, including analytical models which comprise emotional elements.

3.1. Experimental Economics

The methodology of experimental economics provides experimenters with a well-established procedure to analyze economic decision-making of human individuals in the laboratory.[2] Thereby, it is a complementary approach to economic theory, as it allows to systematically analyze the predictions of economic models in a controlled environment. As proposed by Smith (1976, 1982), an economic experiment comprises a standardized *economic environment*, on which the experimenter establishes a controlled *microeconomic institution*.

Economic Environment. The standardized economic environment comprises a set of well-established rules (paradigms) for experimenters. By adhering to these rules, the experimenter ensures (1) that the observed behavior is directly related to the established microeconomic institution and (2) that her experiment is conducted in an environment, which is identical to those of other experiments. Therefore, these rules are essential to guarantee control and replicability in economic experiments. In particular, it is a major paradigm of experimental economics that subjects must not be deceived.[3] Another important paradigm is the induced value theory by Smith (1976).[4]

> *"Control is the essence of experimental methodology, and in experimental exchange studies it is important that one be able to state that, as between two experiments, individual values (e.g. demand or supply) either do or do not differ in a specified way. Such control can be achieved by using a reward structure to induce prescribed monetary value on actions."* (Smith, 1976)

The induced value theory states that subjects of economic experiments need to be incentivized through a proper *reward medium*, e.g. money, in order to observe human decision-making behavior, which is actually related to the focus of investigation. According to Smith (1976), the reward medium has to meet three requirements: *monotonicity*,

[2] For thorough overviews on the methodology of experimental economics, please refer to Davis and Holt (1993), Kagel (1995), and Guala (2005).

[3] With respect to deceiving participants in economic experiments, Davis and Holt (1993) criticize: "Moreover, even if subjects fail to detect deception within a session, it will jeopardize future experiments if the subjects ever find out they were deceived and report this information to their friends."

[4] The focus on human decision-making in microeconomic institutions, the non deception of participants, and the performance depending payment are the main factors that distinguish the methodology of experimental economics from the methodology of experimental psychology (e.g. Rabin, 1998; Hertwig and Ortmann, 2001).

salience, and *dominance*. First, monotonicity means that a subject prefers more of the reward medium over less. Second, there has to be a salient relation between the subject's actions and her reward, which is implemented in the reward structure of the microeconomic institution. Third, changes in a subject's utility have to come predominantly from gains and losses concerning the reward medium. Usually, the experimenter choses real money as the reward medium.

Microeconomic Institution. Based on the standardized economic environment, the experimenter establishes a controlled microeconomic institution. The microeconomic institution is the actual focus of a *specific* experiment. It comprises a set of rules, which describe how subjects can interact with each other and how their individual payoffs are computed. One such institution, for instance, is an electronic auction. The rules of an auction describe when and how bidders can place their bids, who obtains the commodity for sale, how much each bidder has to pay, etc.

Together, the standardized economic environment and the microeconomic institution define a *microeconomic system* (Smith, 1982). Over the past decades, the investigation of such microeconomic systems in economic experiments has turned out to be an insightful source of economic research (Falk and Heckman, 2009). Most important, the methodology of experimental economics allows to observe "real" human behavior in a controlled environment.[5]

> *"In this sense, 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."* (Falk and Heckman, 2009)

The focus of this chapter is to extend the methodology of experimental economics in order to gain a deeper insight regarding the emotional aspects of human decision-making in microeconomic institutions. More specifically, I will discuss physiological measurements as proxies for emotional processing for their use in economic experiments.

[5] With respect to realistic human behavior, Plott (1982) notes: "While laboratory processes are simple in comparison to naturally occurring processes, they are real processes, in the sense that real people participate for real and substantial profits and follow real rules in doing so. It is precisely because they are real that they are interesting."

3.2. Physioeconomics

This chapter starts from the intuition that decision-making is both a cognitive and affective *process* rather than a single, indivisible maximization of utility. This dynamic process comprises strategic considerations of the agents concerning the maximization of their expected payoff on the one hand; these aspects are the main focus of game theory today and are fairly well understood. On the other hand, however, there is an inevitable influence of affective or emotional factors that also have an impact on the decision-making process (e.g. Elster, 1998; Loewenstein, 2000). Bechara and Damasio (2005) even argue that taking advantageous decisions is only possible in consequence of a prior accurate emotional processing.

> **Research Question 2:** *How can economic laboratory experiments be augmented to allow for physiological measurements as proxies for emotional processing?*

In order to provide another element for the aim of systematically analyzing emotions in electronic auctions and their impact on human bidding behavior, this chapter focuses specifically on Research Question 2, i.e. on the question of how physiological correlates of human emotional processing can be utilized to measure emotions and their impact in economic decision-making. More specifically, I propose a structured methodology denoted as *physioeconomics*.

> **Definition** (Physioeconomics)**.** *Physioeconomics extends existing methods of experimental economics by measuring autonomic nervous system activity using well-established psychophysiological methodology, in order to gain a profound understanding of the dynamic process of human economic decision-making.*

While experimental economics provides a highly reliable and sophisticated methodology for analyzing economic behavior in the laboratory, research in the field of psychophysiology focuses on the complex interrelationship of physiological states, perceptual, cognitive, or emotional processes, and human behavior. This chapter suggests that the appropriate adaptation of psychophysiological parameters, e.g. skin conductance and heart rate, to traditional methods of experimental economics can contribute

to a better understanding of human decision-making. In contrast to the mere use of questionnaires and interviews, which often have to deal with the problem of subjectivity and social-desirability bias, the analysis of physiological parameters offers the intriguing opportunity to complementary examine objective parameters that show robust correlations to emotional processes of human agents. In contrast to the field of neuroeconomics, physioeconomics focuses on activation of the autonomic nervous system (ANS) only, as this can be achieved with a comparatively low amount of measurement overhead and, thus, allows for collecting empirical data for much larger samples. Moreover, this allows for analyzing emotional processing in strategic interaction of two or more deciders in a wider range of experimental environments.

The remainder of this chapter is structured as follows. Section 3.3 takes a closer look at the methodology of psychophysiology and evaluates physiological parameters for their adequate use in experimental economics. Section 3.4 provides an overview on experiments in the laboratory and the field which already apply physiological parameters with a focus on economic decision-making. Section 3.5 discusses methodological implications for the experimental environment when applying physiological parameters. Section 3.6 concludes.

3.3. Evaluation of Physiological Parameters for Economic Experiments

3.3.1. Emotions, Feelings, and Somatic States

In order to measure the impact of emotions on human behavior in electronic auctions, it is crucial to properly define what emotions and feelings actually are, as these terms are often used interchangeably in the literature. Unfortunately, elaborating a general definition of the term emotion turns out to be a complex task, which can lead to the impression that there "seem to be as many definitions as investigators" (Bradley, 2000). As a matter of fact, an immense body of psychological literature defines, depending on the particular context, emotions and feelings from various perspectives (cf. Panksepp, 1982; Ortony and Turner, 1990). Reflecting a rather *general* understanding of emotions in psychological literature, the term emotion is defined in this thesis as: "a subjectively experienced state that can be described qualitatively and is accompanied by changes in

feeling, physiology, and expression" (cf. Section 2.1.1). Thus, a subjectively experienced feeling is only a part of the broader concept of emotion, which also comprises objectively observable changes, e.g. in physiology. As described in Chapter 2, emotions can be further distinguished into immediate emotions, anticipated emotions, and the ongoing current emotional state.

This chapter concentrates specifically on the physiological aspects of emotions. Therefore, it follows a more *psychophysiological* perspective and also takes into account the definitions of Bechara and Damasio (2005). Psychophysiology is both a psychological, as well as a physiological discipline and, therefore, an interdisciplinary field of research. Based on the assumption that human perception, thought, emotion, and action are embodied and embedded phenomena (cf. Cacioppo et al., 2007b), its major focus is to gain a profound understanding of the dynamic interaction of human behavior, physiological processes, and perceived feelings.

Bechara and Damasio (2005) define an emotion as "a collection of changes in the body and brain states triggered by a dedicated brain system [...] relative to a particular object or event." Thereby, the authors focus in particular on the physiological aspects of emotions, which are also reflected in the general definition of emotion applied in this thesis (cf. Section 2.1.1). The specific object or event which can cause an emotion is defined as an "emotionally competent stimulus." In the context of electronic auctions, a stimulus translates into the term *auction event*.[6] Such an auction event are for instance the start and the end of an auction or the event of being outbidden by another participant. In contrast to the physiological term emotion, Bechara and Damasio (2005) define a feeling as a rather psychological construct: "The ensemble of signals as mapped in somatosensory regions of the brain itself provide the essential ingredients for what is ultimately perceived as a feeling, a phenomenon perceptible to the individual in whom they are enacted." Finally, the emotion caused by the stimulus triggers responses to the body that are "proper enacted in a body (somatic) state" involving "physiological modifications." These modifications comprise for instance changes in heart rate and skin conductivity. The observed physiological parameters, e.g. skin conductance and heart rate, are either under control of the sympathetic, the parasympathetic, or both branches of the ANS, and therefore cannot directly be influenced by free will (cf. Cacioppo et al., 2007b). In the following, some of these physiological parameters typically used in psychophysiology

[6] See the framework for emotional bidding in Chapter 2.1.1.

will be discussed and evaluated for their use in physioeconomic experiments.

3.3.2. Physiological Parameters

A large body of psychophysiological research relies on the interpretation of measures that reflect the activity of the autonomic nervous system (ANS). This system that normally acts outside conscious awareness is necessary for adjusting visceral functions to match environmental demands. It can be roughly partitioned into the sympathetic and the parasympathetic (vagal) nervous system that typically function in opposition to each other. The sympathetic nervous system activates the organism for "fight or flight," while the parasympathetic nervous system promotes digestion and recreation. Although both branches of the ANS typically have antagonistic effects on a number of internal organs, they seem to be regulated rather independently (cf. Berntson et al., 1991). Thus, the whole system acts in functional synergy and sympathetic as well as parasympathetic activity can be modulated by adjusting environmental conditions.

Skin Conductance. Skin conductance is one of the most frequently used measures in psychophysiological research. It reflects sympathetic activity and corresponds to the electrical conductivity of the human skin, which in turn is driven by sudomotor activity of eccrine sweat glands. The density of these glands is highest at palmar and plantar sites and it is therefore recommended to use these areas for measurement (cf. Fowles et al., 1981). Figure 3.1 depicts common measurement sites for skin conductivity in psychophysiological literature. Particularly the thenar and hypothenar eminences of the non-dominant hand are frequently used for measurement.[7] The skin conductance signal can be decomposed into tonic and phasic components with the former reflecting the general arousal level of the examinee (skin conductance level, SCL), i.e. the ongoing current emotional state, and the latter representing short bursts of sympathetic activity (Wallin, 1981), which are usually elicited by an external or internal stimulation (cf. Boucsein, 1992; Dawson et al., 2007), i.e. immediate or anticipated emotions. These monophasic skin conductance responses (SCR) typically occur 1 to 3 seconds after a discrete event, but they can also be observed in absence of an identifiable stimulus (non-specific SCR). Especially the amplitude of SCRs, commonly denoted as SCR.amp,

[7] The Society for Psychophysiological Research (SPR) has published internationally well-established guidelines for electrodermal measurements in Fowles et al. (1981).

seems to be a valid index of personal significance and arousal (Lang et al., 1993). Thus, biologically relevant stimuli such as the own name typically elicit larger SCRs than irrelevant information (Ben-Shakhar et al., 1975).

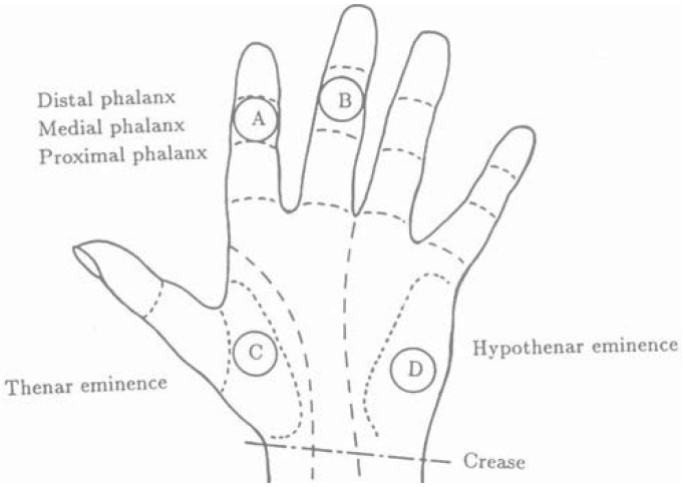


Figure 3.1.: Skin Conductance Measurement Sites of the Human Hand
(As depicted in Venables and Christie, 1980)

Cardiovascular Activity. The cardiovascular system has also been in the central focus of psychophysiological research during the last decades.[8] It comprises the heart and the vasculature which distributes the blood to all tissues of the body. The electric activity of the heart can easily be measured by means of an electrocardiogram (ECG). For most research questions, it is sufficient to quantify heart rate by measuring the time between successive R-waves in the ECG (cf. Jennings et al., 1981). This measure is modulated by both, the sympathetic and parasympathetic branch of the autonomic nervous system. However, the vagal system exerts a much wider range of control over cardiac chronotropy and it responds faster to external events (Berntson et al., 2007). Similar to the electrodermal activity, heart rate can either be averaged across longer periods of time to reflect tonic arousal, or changes in heart rate following discrete events can be quantified by measuring slight variations in successive heart periods (Velden and Wölk, 1987). This latter phasic measure was shown to be correlated with the valence of external events. Thus, negative events typically elicit a heart rate decrease

[8] Publication guidelines of the SPR for measurement of cardiovascular activity are published in Jennings et al. (1981).

whereas positive events are more likely to be accompanied by heart rate accelerations (e.g. Bault et al., 2008; Lang et al., 1993). Again, tonic emotional processing refers to a subjects ongoing current emotional state, while phasic responses relate to immediate and anticipated emotions.

Pupil Diameter. Another proxy for ANS activity is the absolute change in pupil diameter in response to a stimulus. Pupil width is regulated by two groups of smooth muscles: sphincter pupillae and dilator pupillae. These muscles are innervated by the vagal and the sympathetic nervous system, respectively. Post-stimulus dilatation, however, was found to be highly correlated with skin conductance responses. Thus, pupil changes varying with perceived arousal largely reflect sympathetic activation (Bradley et al., 2008). As pupil width is very sensitive to changes in luminance, it is important to control for a uniform average luminance of the user interface. Pupil size is typically recorded with an eye-tracking-system that additionally allows for measuring which part of information is perceived by the subject at what time. Therefore, such devices can be very useful in psychophysiological research as they allow for measuring cognitive aspects of stimulus evaluation (eye movements) in addition to autonomic responses.

Artifact Detection. Other measures that are routinely recorded in psychophysiological research are respiratory and musculature activity. With respect to the framework of physioeconomics, however, these measures are not directly relevant for inferring ANS activity. These parameters are particularly used in clinical psychophysiology and reveal only few information regarding a subjects emotional processing compared to the other parameters (Cacioppo et al., 2007a). It might be useful, however, to record such responses in order to identify artifacts in other channels, that are associated with abnormal breathing patterns or body movements.

3.3.3. Evaluation for Physioeconomics

The physiological parameters discussed so far particularly allow for identifying two dimensions of emotional processing: arousal and valence (cf. Lang et al., 1993). Thus, skin conductance level and the amplitude of skin conductance responses are sensitive indexes for the general level of arousal and the degree of arousal associated with a single stimulus, respectively. Phasic heart rate, on the other hand, allows for evaluating the perceived

valence of a certain stimulus with negative stimuli typically eliciting decelatory responses and positive stimuli relative heart rate accelerations. Pupil responses are less suitable for economic experiments for at least two reasons. First, such a measurement always has to face the problem of controlling the average degree of luminance. In contrast to picture analysis (e.g. Bradley et al., 2008), the average luminance of the user interface in experimental economics changes continuously when new information is being displayed. A stringent control of display luminance is, thus, difficult. Second, pupil responses are highly correlated with skin conductance responses and are, therehence, redundant to some degree.

Therefore, this chapter proposes to particularly focus on skin conductance and heart rate changes in physioeconomic experiments, as these measures first allow for simultaneously assessing arousal and valence of emotional processing. Second, these physiological changes occur in the very moment of human information processing and decision-making. Third, it is possible to utilize such physiological responses in economic decision-making comprising strategic interaction of two or more participants. With a clear experimental structure and complementary questionnaires, the perceived feelings, e.g. joy or anger, associated with a single emotion can be further isolated.

3.4. Emotions in Economic Decision-Making

This section provides a literature overview on experiments in the laboratory and the field which already apply physiological measurements and have a focus on economic decision-making. It will first concentrate on decision-making comprising no strategic interaction, and then continue with decision-making in strategic interaction of two or more individuals.

3.4.1. Decision-Making without Strategic Interaction

One of the most prominent experiments combining economic decision-making with the measurement of physiological parameters is the *Iowa gambling task* by Bechara et al. (1997). In the Iowa gambling task a single decision-maker is given four decks of cards, from which she continuously has to draw cards without knowing how many cards have to be drawn until the game ends. Each card results either in a gain or a loss for the decision-maker. While decks A and B are disadvantageous in the long run and lead to an

overall loss, the advantageous decks C and D lead to an overall gain. In a clinical study, Bechara et al. (1997) report that normal participants, i.e. subjects without any diagnosed brain damage, had higher SCRs prior to selecting from disadvantageous in comparison to advantageous decks even before the participants had reported a "hunch" which decks might be better. Even in this "pre-hunch" period, the regular participants decided more often for the advantageous decks. To the contrary, patients with bilateral damage of the ventromedial part of the prefrontal cortex did not show higher SCRs when deciding for disadvantageous decks. Even more striking, the patients who correctly described which were the good and bad decks still chose disadvantageously. Based on the results of the Iowa gambling task experiment, Bechara and Damasio (2005) proposed in their *somatic marker hypothesis* that advantageous decision-making is only possible in consequence of a prior accurate emotional processing. Therefore, emotions are beneficial for decision-making if they are integral to the task, but may be disruptive if they are unrelated to the task. Crone et al. (2004) analyze differences in emotional processing of healthy individuals playing the Iowa gambling task by categorizing them *ex post* in three performance groups: *bad*, *moderate*, and *good*. The authors demonstrate that there are no differences in emotional processing of participants in response to immediate punishment (primary inducer). However, Crone et al. (2004) show that bad performers turn out to have significantly lower SCRs generated by secondary inducers (i.e. thoughts regarding future losses in the moment of decision-making) than good performers. Again, the authors find that an accurate emotional processing seems to be essential for advantageous decision-making.

Bault et al. (2008) analyze the influence of social ranking on decision-making. In their experiment, participants have to continuously choose between two lotteries with different levels of risk. In the *two player* setting, participants can observe the choice and result of one other player, while in the *one player* setting, participants decide without observing the behavior of another participant. Skin conductance and heart rate of the participants, as well as a self-report scale indicating their subjective feeling from extremely negative to extremely positive were recorded. In comparison to *regret* (losses) and *relief* (gains) in the one player setting, Bault et al. (2008) report overall stronger SCRs when experiencing *envy* and *gloating*, i.e. the feeling associated with a loss when the other wins and vice versa. To the contrary, the authors report lower SCRs when participants experience *shared-regret* and *shared-relief*. Most interestingly, participants' behavior seems to be

affected by emotional experience, as their behavior turns out to be more risk averse in later trials when playing with a risk loving counterpart and less risk averse when playing with a highly risk averse counterpart - although, from a game theoretic perspective, there clearly is no strategic interaction. Bault et al. (2008) conclude that human deciders have "interdependent utilities."[9] This means that a subject's utility does not only depend on her own gains and losses, but also on the utilities of other bidders (e.g. Schall, 1972). Analyzing the subjective and objective parameters of arousal, Bault et al. (2008) report a high correlation between self-reported arousal in the questionnaire and physiological SCRs.

In another laboratory experiment on lottery choice, Sokol-Hessner et al. (2008) analyze how decision-making behavior and emotional processing change, when subjects are told to "think like a trader." The authors observe that subjects tend to behave less loss averse on average. Even more interesting, SCRs in response to actual losses are on average smaller under this condition. The authors conclude that the mere cognitive act of taking the perspective of a professional trader can alter choice and physiological response related to loss aversion. Sokol-Hessner et al. categorize those subjects who are capable to perform this mental transfer as "emotion regulators." The theory of emotion regulation states that human deciders have some degree of control over their affective state and consequently amplify or attenuate the emotional impact of a stimulus (e.g. Gross, 1998; Ochsner et al., 2004).

Although the precise functional role of autonomic responses in information processing and decision-making is still debated (Bechara et al., 2005; Maia and McCelland, 2004), it has been repeatedly shown that SCRs systematically vary with the outcome of a choice even before feedback is given (e.g. Bechara et al., 1997; Biermann et al., 2005). These results demonstrate that autonomic responses are modulated by economic decisions and are thus capable to reveal a deeper insight into human information processing in such situations.

3.4.2. Strategic Interaction of Two Individuals

Another economic experiment applying physiological parameters is based on the *power-to-take* game (cf. Bosman and van Winden, 2002). In the power-to-take game two

[9] Section 2.2.1 discusses interdependent utilities in the context of electronic auctions.

players, the *take authority* and the *responder*, are initially endowed with an equal amount of money. In the first stage, the take authority decides how much money, denoted as the take rate, she takes from the responder. In the second stage, the responder can decide to destroy any percentage of her own money. By doing so, she reduces her own payoff and the payoff of the take authority. Ben-Shakhar et al. (2007) analyze the power-to-take game while continuously recording the responders' SCL. Additionally, the authors assess the perceived arousal of participants by using self-report questionnaires. The authors report that those responders who had a stronger increase in arousal measured by SCL destroyed larger amounts of their initial endowment. Furthermore, they find a strong correlation between self-reported anger in the questionnaire and the physiological arousal level. Ben-Shakhar et al. (2007) also tested for effects of the measurement equipment on participants' behavior and found no such influence. Therefore, participants do not seem to change their economic decision-making when physiological responses are recorded.

In the ultimatum game two players, a proposer and a responder, have to agree on how to split up a given amount of money (cf. Güth et al., 1982). The proposer suggests how much money each of the two players receives and the responder can either accept or reject the offer. If the responder rejects, neither the proposer nor the responder will receive any money. Otherwise the money will be split in exactly the way the proposer suggested. Van't Wout et al. (2006) analyze responders' SCRs upon receiving offers and report higher SCRs for unfair offers in comparison to fair offers.[10] When playing against a computer counterpart though, this pattern of emotional response could not be observed. Further, the rejection rate of unfair offers by humans was significantly higher than for unfair offers generated by a computer. Additionally, van't Wout et al. (2006) show that higher SCR rates are associated with higher rejection rates, which again is not the case when facing a computer counterpart.[11] This correlation between physiological arousal and economic behavior fits to the above mentioned link between somatic states and decision-making (Bechara and Damasio, 2005) and indicates that emotions can serve as a sensitive predictor of economic behavior. In another ultimatum game experiment, Xiao and Houser (2005) give responders the opportunity of sending a textual message

[10] The authors define unfair offers as offers in which the amount of money is unequally split between the proposer and the responder.

[11] The emotional arousal observed by van't Wout et al. (2006) is very similar to the activation pattern of a brain region referred to as *anterior insula* as reported in a neuroeconomic experiment by Sanfey et al. (2003).

to the proposer when deciding on accepting or rejecting her offer. The authors refer to these messages as "emotion expression." Responders who are given the opportunity of emotion expression tend to accept unfair offers far more often than responders who are not. Thus, emotions do not only play an important role in economic decision-making, but may also be controlled or regulated by means of emotion expression.

In another study concerning the ultimatum game, Civai et al. (2010) compare subjects' behavior and emotional processing when either playing for themselves or for a third party. While the authors observe no change in rejection rates, SCRs in response to unfair offers are stronger when subjects are playing for themselves. Civai et al. (2010) conclude that emotions in fact "do play a role in the ultimatum game," but that "emotions are not always the key-mechanism underlying the responder's rejections." However, the authors highlight that these results "do not exclude that other emotional responses" may have come into place here, e.g. altruism or the feeling of being part of a group. Another explanation are carry over effects, as the study is based on a within-subject design.

3.4.3. Strategic Interaction in Markets

The influence of emotions on decision-making of financial traders is a highly controversial topic. In a controlled field experiment, Lo and Repin (2002) measure physiological parameters of professional security traders during live trading sessions. A large variety of physiological parameters is subject of their analysis: skin conductance, finger pulse amplitudes, heart rate, electromyographical[12] signals, respiration, and body temperature. The authors analyze the impact of market events, e.g. changes in the spread or the volatility, on the physiological parameters recorded. In their results, Lo and Repin (2002) report significant physiological responses to various market events. This indicates that the decision-making process of financial traders seems to be accompanied by emotions. Most interestingly, the authors find that physiological responses to market events depend on the expertise of the trader, i.e. senior traders show a different pattern of emotional arousal than junior traders.

Focusing on the design of (electronic) auctions, Smith and Dickhaut (2005) analyze the impact of different economic institutions on the arousal of market participants. In particular, they compare for each bidder the average heart rate while participating in a

[12]Electromyography is a technique to measure the electrical skeletal muscle activity.

sequence of Dutch and English auctions. The authors conclude that the English auction, as a collection of all relevant stimuli, induces less emotional arousal than the Dutch auction. However, the authors do not address which *specific* features of the Dutch auction are in fact responsible for the reported increased emotionality. Thus, as the design of electronic auctions has a significant impact of participants' emotional processing, there is a need for further research on the emotional impact of single facets of market design. Also focusing on the emotional facets of decision-making in auctions, Adam et al. (2008) analyze skin conductance and heart rate of bidders during common value Dutch auctions.[13] The authors discuss a framework of dynamic decision-making, linking the classical perspective of Vickrey (1961) to emotional components. In particular, the authors hypothesize that bidders *ex ante* cognitively set a price at which they intend to end the auction, but - as soon as this price is reached - the competitive environment creates a thrill of suspense, tempting the bidders to wait just a little bit longer in order to increase their nominal payoff. In their laboratory experiment comprising skin conductance measurement, Adam et al. (2008) find empirical support for this framework and report a significantly higher degree of arousal once the standing price has reached a certain level. Additionally, Smith and Dickhaut (2005) analyzed whether the fact that participants were attached to cardiovascular recording equipment had an an influence on their economic decision-making. Consistently with Ben-Shakhar et al. (2007), the authors did not find such an effect.

3.4.4. Conclusions

The economic experiments discussed in this section show the potential of psychophysiological parameters for experimental economics and, thus, for a structured methodology here denoted as *physioeconomics*. Selected literature along with the particular focus and methodology is listed in Table 3.1. Summarizing results from the literature, the following conclusions can be drawn:

1. Emotions play a significant role in economic decision-making and physiological parameters reflecting the activity of the autonomic nervous system are reliable proxies for assessing arousal and valence in the very moment these emotions occur.

[13] This is an experiment, which I conducted, but which is not part of this thesis.

Further, as Bechara and Damasio (2005) argue, a correct emotional processing can even be essential for taking advantageous decisions.

2. While questionnaires and interviews generally have to deal with the problem of subjectivity and social desirability bias, the complementary measurement of physiological parameters allows for observing objective proxies of deciders' emotional processing, in the very moment decisions are actually taken.

3. Decision-making induces a stronger degree of arousal when human counterparts are involved (cf. Bault et al., 2008; van't Wout et al., 2006). Physiological arousal as well as economic behavior is significantly different when human deciders face computerized agents. Therefore, when strategic interaction is the main focus of investigation, the experimental design should comprise human counterparts. The results of Bault et al. (2008) show that participants' behavior may even be affected by the presence of another human agent, when there is, from the a game theoretic perspective, no strategic interaction involved. One possible explanation for this observation is that human deciders have "interdependent utilities" (e.g. Schall, 1972).

4. Physiological arousal can in some cases even be predictive for human decision-making. Higher degrees of arousal often result in different patterns of behavior (e.g. van't Wout et al., 2006; Ben-Shakhar et al., 2007; Bechara and Damasio, 2005). As Crone et al. (2004) and Lo and Repin (2002) point out, physiological processing may also vary with the performance of individual deciders. The theory of emotion regulation suggests that human deciders can amplify or attenuate the impact of emotions and consequently change their behavior (Gross, 1998). Based on skin conductance measurements, Sokol-Hessner et al. (2008) show that some deciders are actually able to perform this mental transfer.

5. Smith and Dickhaut (2005) and Ben-Shakhar et al. (2007) have shown that the presence of recording devices itself does not affect participants' behavior. Therefore, physiological parameters can be recorded in economic experiments without affecting economic parameters.

However, in order to guarantee experimental control for replicable results, it is essential to stress the need for a structured and standardized methodology that is called

Table 3.1.: Selected Literature on Economic Decision-Making and Psychophysiological Parameters
(Inter. = strategic interaction, Env. = environment)
(EDA = electrodermal activity, HR = heart rate, Other = other parameters)

Author(s)	Published	Scenario	Inter.	Env.	EDA	HR	Other
Bechara et al. (1997)	Science	Iowa gambling task	no	lab	X		
Lo and Repin (2002)	Journal of Cognitive Neuroscience	financial market	market	field	X	X	X
Crone et al. (2004)	Psychphysiology	Iowa gambling task	no	lab	X		
Bechara and Damasio (2005)	Games & Economic Behaviour	Iowa gambling task	no	lab	X		
Smith and Dickhaut (2005)	Games & Economic Behaviour	auctions	market	lab		X	
van't Wout et al. (2006)	Experimental Brain Research	ultimatum game	two	lab	X		
Ben-Shakhar et al. (2007)	Journal of Economic Psychology	power-to-take game	two	lab	X		
Adam et al. (2008)	ECIS Conference Proceedings	Dutch auction	market	lab	X	X	
Bault et al. (2008)	PlosONE	lottery game	no	lab	X	X	
Sokol-Hessner et al. (2008)	PNAS	lottery game	no	lab	X		
Civai et al. (2010)	Cognition	ultimatum game	two	lab	X		

physioeconomics here. The studies presented so far show that the applied methodologies are not consistent at this early stage. Some experimenters deceive subjects (e.g. Bault et al., 2008), others do not (e.g. Ben-Shakhar et al., 2007; Lo and Repin, 2002). Sometimes participants are incentivized by a performance-based payment scheme, sometimes they participate for a fixed flat fee. These methodological differences are in large parts also attributed to the fact that with psychophysiology and experimental economics, two different disciplines with differing backgrounds come together when analyzing economic decision-making by taking into account physiological parameters. Therefore, the next section will outline implications for extending the methodology of experimental economics by the measurement of physiological parameters.

3.5. Methodological Implications

As physioeconomics is an extension of the methodology of experimental economics, a standardized economic and experimental environment is essential to guarantee *control* for replicable results. A standardized economic environment, as described in Section 3.1, is the basis on which the experimenter establishes a controlled microeconomic institution, which is the actual focus of a specific experiment. This economic environment comprises the non-deception of participants as well as a performance depending payment scheme.

The adequate and correct use of psychophysiological parameters in economic experiments imposes a variety of methodological implications for the experimental environment, in particular for the session structure and the environmental conditions of an experiment. In experimental economics, a *session* is defined as a "group of trials conducted

on the same day and the same set of subjects", with a *trial* being "an indivisible unit of observation" (Friedman and Sunder, 1994). A *period* is defined as a "self-contained unit of time for observation, e.g., a single auction." These methodological implications are now discussed along with a session framework for physioeconomic experiments.

3.5.1. Implications for the Session Structure

The methodological implications for the session structure are summarized in a physioeconomic session framework, which is depicted in Figure 3.2. The physioeconomic session framework comprises four phases: a *preparation phase*, a *decision-making phase*, a *perception phase*, and a *rest phase*. The following subsections each focus on one phase of the framework.

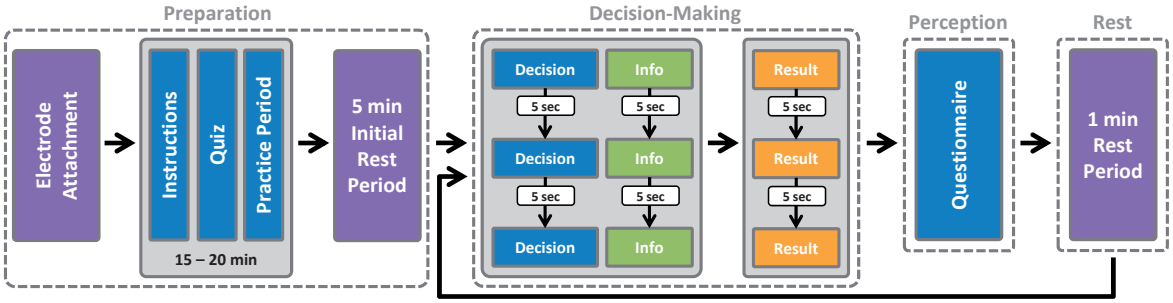


Figure 3.2.: Session Framework for Physioeconomic Experiments

(A) Preparation Phase

The first phase of a physioeconomic session is used for preparation. This phase comprises the electrode attachment, the reading of participant instructions, a quiz regarding the participant instructions, a practice period, and an initial rest period.

Electrode Attachment. The placement and attachment of the measurement electrodes should follow a standardized routine (e.g. Boucsein, 1992; Gramann and Schandry, 2009). Such a standardized routine does not only enhance the signal quality, but also ensures a similar treatment for all participants. The problem of signal quality is less serious for ECG measurement, as such measurement comprises a comparatively low signal amplification and the use of single-use electrodes. To the contrary, signal amplification

is much higher for skin conductance measurement, and such measurement is often conducted with reusable electrodes. To prepare the skin for measurement, Gramann and Schandry (2009) recommend to wash hands with warm water without soap.[14]

Instructions and Quiz. Some authors argue that physiological measurements cannot be conducted right after the measurement electrodes were attached to the participants, because electrodes are in general not ready for use right away. For instance, it is not guaranteed that the electrode paste used for SC measurement exactly matches the skin's ion concentration (Schmidt and Walach, 2000). Therefore, Boucsein (1992) recommends to attach the electrodes about 15 to 20 minutes before the beginning of measurement. Gramann and Schandry (2009) argue that this waiting time is particularly important if the temperature difference between the laboratory and the external environment is comparatively large. However, it is important to note that this procedure is by far not applied in all psychophysiological experiments. In order to efficiently utilize time while conducting the actual experiment, it seems sensible to use the recommended waiting time of 15 to 20 minutes to read aloud the participants instructions and let the subjects participate in a short comprehension quiz regarding the instructions. A comprehension quiz is common practice in experimental economics and contributes to ensure that the subjects understand the rules of the respective microeconomic institution. Furthermore, this waiting time can be used for a practice period.

Practice Period. In general, autonomic measures are very sensitive to novelty and bodily movements (Dawson et al., 2007). In order to reduce the impact of novelty, it is very important to introduce the decision-making situation to participants before actually measuring physiological parameters. This can either be achieved by introducing a practice period in the beginning, in which gains and losses are not considered, or by removing the first few decision periods from the data set.[15] As an additional benefit, introducing a practice decision period also contributes to an increased comprehension

[14] The soap can cause maceration of the skin, which in turn leads to a decrease of overall skin conductivity (cf. Boucsein, 1992). This can drastically distort skin conductance values if some subjects wash their hands with soap and others do not.

[15] Whether a practice round should be introduced or rather the first few rounds be cut off largely depends on the *focus* of the individual experimental design. In particular, wealth effects, strategical inferences, and learning effects can play an important role (e.g. Thaler and Johnson, 1990; Neilson, 1998; Guala, 2005).

regarding the rules of the experiment.

Initial Rest Period. Control and replicability are the essence of experimental economics. Therefore, as physiological parameters tend to have a high degree of inter-subject variability, it is important to introduce an initial rest period prior to the actual economic decision-making in physioeconomic experiments and thus control for an individual basic level of physiological arousal. For at least two reasons, it seems sensible to explicitly inform participants that this rest period is necessary for calibrating the physiological measurement for each participant. First, it is an important paradigm of experimental economics to provide subjects a trusted environment that is enriched with information. Second, subjects can then conclusively be asked to use this rest period to relax. This is particularly important, because cognitive tasks can have substantial effects on the physiological parameters and can, therefore, distort the baseline assessment.

Usually, an initial rest period of *5 minutes* is used in psychophysiological literature (cf. Vossel and Zimmer, 1990; Schmidt and Walach, 2000). Therefore, it seems sensible to comply with this 5 minute initial rest period in physioeconomic experiments. The individually assessed basic level of arousal can then be used in order to reference the level of arousal during economic decision-making, e.g. the tonic SCL and heart rate.[16]

(B) Decision-Making Phase

After the preparation phase, participants take part in a first period of economic decision-making. A period of decision-making is followed by either another period of decision-making, a perception period, or a rest period. Depending on the focus of investigation, decisions as well as information and results are displayed in timed intervals. Figure 3.2 depicts the decision-making phase in a rather conceptual fashion. In contrast, Section 4.1 discusses one particular instance for the case of ascending auctions. Section 5.3.3 outlines another instance for the case of Dutch auctions.

In order to reduce the impact of bodily movements on the recorded physiological parameters, user interaction with the experimental software has to be minimized. In particular, keyboard inputs should be avoided wherever possible and replaced with simple mouse inputs. If keyboard inputs are not needed at all, it can be considered to

[16] As proposed by Vossel and Zimmer (1990), the initial rest period can also be used to asses the individual frequency of non-specific SCRs and categorize subjects into electrodermally "stabile" or "labile" participants.

completely avoid them during the experiment. Vossel and Zimmer (1998) recommend to provide participants with a soft pad for their non-dominant hand to further reduce bodily movements and measurement artifacts. The amount of information displayed to subjects has be minimized as well. I propose to display results, e.g. prices and payoffs, and other information, which is subject of investigation, in timed intervals of at least 5 seconds (cf. Sanfey et al., 2003). By doing that, the experimenter allows for identifying the stimulus responsible for a single physiological response. This would not be possible if all information was presented simultaneously or in too short intervals of time.

(C) Perception Phase

Physiological measurements allow for identifying a subject's general level of arousal, as well as the intensity of single emotional responses and, to a certain extent, the valence of emotional processing (cf. Section 3.3.2). However, they do not allow to further specify which feelings a subject ultimately perceives. In order to identify specific *feelings*, e.g. joy and anger, the experimenter can control the set of possible feelings by a sophisticated experimental design and successive revelation of information. Furthermore, the physiological measurements can be enriched with complementary questionnaires. Such questionnaires can be conducted (1) after each period of decision-making or (2) after all periods of decision-making have finished. However, it is important to recall that questionnaires always have to deal with subjectivity and social desirability bias.

Research in psychology provides several standardized questionnaires to (subjectively) identify specific feelings and their intensity. Prominent examples of such questionnaires are the the *affect grid* (Russel et al., 1989) and the *self-assessment-manikin* (SAM) (Bradley and Lang, 1994). Furthermore, the experimenter can design own questionnaires, which specifically focus on her individual experiment. For instance, the degree of perceived competition in an auction can be assessed on a Likert scale. However, it is important to note that a perception questionnaire in between two periods of economic decision-making can also have an impact on the behavior of the subjects and their emotional processing. For instance, the experiment described in Chapter 5 comprises perception questions regarding a bidder's behavior. Therefore, in this particular experiment, the questionnaire is conducted after all auctions have finished.

(D) Rest Phase

If a change of the subject's (tonic) current emotional state during decision-making is focus of the investigation, each period of economic decision-making should be followed by a rest period of at least 1 minute. This rest period is necessary in order to evaluate the degree of physiological arousal during one single decision-making period, because it allows for the physiological parameters to return to an individual baseline of arousal.

3.5.2. Implications for the Control of Environmental Conditions

The measurement of physiological parameters and their interpretation strongly require to monitor and control environmental conditions, i.e. room temperature, relative humidity, and background noise. In general, these environmental conditions should be kept as constant as possible (cf. Dawson et al., 2007).

Temperature and Relative Humidity

Boucsein (1992) recommends to keep temperature in the thermoneutral zone of 25–26 °C (77–78.8 °F). Schmidt and Walach (2000) report a use of 23–24 °C (73.4–75.2 °F) in psychophysiological experiments, while Vossel and Zimmer (1998) recommend a temperature between 21 and 23 °C (69.8–73.4 °F). For relative humidity, both Schmidt and Walach (2000) as well as Vossel and Zimmer (1998) recommend to ensure a level of 45–55%. Further, even seasonal changes (Venables and Mitchell, 1996) and the time of day (Hot et al., 1999) can significantly influence SC measurement. Therefore, I propose to conduct physioeconomic experiments within a period of 2–3 weeks, control for the time of day throughout the different treatments, keep a temperature of approximately 23 °C (73.4 °F) and a relative humidity of approximately 50% throughout all sessions. These environmental conditions should also be reported along with the experimental results.

Background Noise

Background noise during the experiment should be avoided, as any perceived noise can potentially cause a physiological response (cf. Berntson et al., 2007; Dawson et al., 2007). Further, even the sound of mouse-clicks elicited by other participants of the

experiment can cause a physiological as well as a behavioral response. As a matter of fact, the author observed a change in behavior during trial Dutch auction experiments when subjects could hear the mouse-clicks of other participants. In particular, when one group finished a Dutch auction, the subjects of the other group heard the mouse-clicks and finished their auction within milliseconds, too. This behavior could not be observed when subjects were equipped with ear-muffs.

However, this problem does usually not arise in psychophysiological or neuroeconomic experiments so far, as these studies typically only measure one subject at a time, while the *strategic interaction* analyzed in physioeconomic experiments inherently imposes simultaneous measurement of at least two subjects. Further, if subjects can hear mouse-clicks of other participants, their decision-making turns from simultaneous to *quasi*-simultaneous. This imposes another problem, as Abele and Ehrhart (2005) have shown that participants behave economically different when deciding simultaneously or only quasi-simultaneously. Therefore, in order to avoid the problems of measurement artifacts and changes in economic decision-making, subjects of physioeconomic experiments should be equipped with ear-muffs or seated in separated soundproof cabins.

Time Synchronization and Data Protection

Finally, physioeconomic experiments require additional software and data protection plans. In particular, the experimental software should provide a sophisticated logging mechanism and all subject and measurement computers should be continuously time synchronized. For instance, the experimental software environments z-Tree (Fischbacher, 2007) and meet2trade (Weinhardt et al., 2006) provide this kind of functionality.[17] As physiological data is regarded as sensitive in many countries, all physiological data should be recorded and processed anonymously. Participants should be sufficiently informed about the physiological parameters recorded as well as about the fact that their data is processed anonymously.

[17]For further information on the z-Tree and meet2trade experimental software environments, please refer to `http://www.iew.uzh.ch/ztree` and `http://www.meet2trade.com/`, respectively.

3.6. Discussion

In this chapter, a structured methodology denoted as *physioeconomics* for analyzing the dynamic process of decision-making in electronic auctions was proposed. In particular, methodological implications were outlined for extending the traditional methodology of experimental economics by measuring autonomic nervous system activity using well-established psychophysiological methodology. Neuroeconomics analyzes economic decisions without or with limited strategic interaction using brain imaging technology. In contrast, physioeconomics focuses on activation of the autonomic nervous system (ANS) only, as this can be achieved with a comparatively low amount of measurement overhead and thus allows for collecting empirical data for much larger samples. Therefore, physioeconomics is particularly well suitable for analyzing decision-making in strategic interaction, e.g. auctions and negotiations. Further, Lo and Repin (2002) show that physioeconomic experiments also allow for collecting empirical data in controlled field experiments. Since brain imaging technologies are much more sophisticated in terms of identifying distinct brain regions involved in decision-making, I understand neuroeconomics and physioeconomics as *complements* and not as substitutes.

Adequately interpreting skin conductivity and cardiovascular activity allows for assessing emotional valence and arousal in response to a single information event (stimulus). With respect to the framework for emotional bidding proposed in Chapter 2.1.1, these physiological parameters provide proxies for a bidder's *(tonic)* ongoing current emotional state, as well as her *(phasic)* immediate and anticipated emotions. However, it is important to note that recording physiological measures alone is not sufficient in order to accurately identify specific perceived feelings. This can only be achieved with a clear experimental structure (e.g. Bault et al., 2008) and the complementary use of self-report questionnaires (e.g. Ben-Shakhar et al., 2007).

Most of the literature analyzing economic decision-making using physiological measures so far does not fully comply with the paradigms of experimental economics. This seems to be largely attributed to the respective focus of investigation. In psychological experiments, economic decision-making itself may only play an inferior role. However, when economic decision-making is the main focus of analysis, for instance in order to enrich or stress-test economic models, I propose to fully comply with the well-established methodological paradigms of experimental economics, foremost the induced value theory

and non-deception of participants (cf. Smith, 1982; Kagel, 1995). I discussed physiological measures along with their methodological implications and proposed a session framework for accurately applying these measures in economic experiments.

Finally, I strongly believe that physioeconomics as well as neuroeconomics will contribute to improve our understanding of economic decision-making. However, speaking in the words of Thaler (2000), the traditional homo economicus is not dead, he will only "become more emotional." Therefore, from an economic perspective, applying physiological measures as well as brain imaging technologies will always have to primarily focus on how to eventually contribute to enriching or stress-testing existing economic models of decision-making. This goal can only be achieved by utilizing well-established paradigms of experimental economics.

Based on the framework for emotional bidding in auctions and the methodology of physioeconomics, Chapter 4 will now focus on how the phenomenon of auction fever can be systematically investigated in electronic ascending auctions. Chapter 5 then focuses specifically on emotions in Dutch auctions, i.e. descending auctions, and seeks to provide physiological evidence for a "utility of suspense" (Cox et al., 1983).

Chapter 4.

Measuring Emotions in Electronic Ascending Auctions

This chapter introduces a physioeconomic framework for systematically analyzing bidders' emotional processing in ascending auctions. As outlined in Chapter 2, even slight variations in the auction design may result in large disparities in the bidding behavior, and, subsequently, in auction outcome and seller revenue. Therefore, this chapter concentrates on the research question of how the role of emotions in human bidding behavior can be systematically investigated with the methodology of physioeconomics in electronic ascending auctions (cf. Research Question 3). In particular, based on the unified framework for emotional bidding introduced in Chapter 2, the phenomenon of auction fever and its elicitors are focus of the analysis.

> **Research Question 3:** *Is the newly developed physioeconomic methodology suitable to measure emotional processing in electronic auctions?*

The remainder of this chapter is structured as follows. Section 4.1 introduces a framework for physioeconomic ascending auction experiments. In order to systematically investigate single elicitors of auction fever, variations of the framework are discussed in Section 4.2. Based on the proposed experimental framework, Section 4.3 presents a proof-of-concept study that analyzes the impact of time pressure on bidders' arousal and behavior. Section 4.4 concludes and discusses lessons learned from the proof-of-concept study.

4.1. A Basic Ascending Auction Framework for Physioeconomics

Chapter 2 defines *auction fever* as an intense current emotional state elicited in the course of one or more auctions that distorts a bidder's preselected bidding strategy. In order to better understand phenomena such as auction fever and systematically analyze diverse variations in the design of ascending auctions, and their impact on bidders' emotional processing and bidding behavior, an experimental framework for physioeconomic auction experiments will now be discussed. This auction framework is an instance of the decision-making phase of the physioeconomic session framework discussed in Section 3.5.1. While Chapter 3 discusses general methodological implications for physioeconomic experiments and provides a general session framework, this chapter focuses specifically on systematically measuring emotions in electronic ascending auctions.

The auction framework is based on an ascending auction which is frequently referred to as the *Japanese auction* (e.g. Klemperer, 1999; Lavi and Nisan, 2005). In a Japanese auction, the auctioneer starts the auction at a reservation price (which is usually set to zero), and then gradually raises the standing price p_{st} (Klemperer, 1999).[1] At each increment of p_{st}, each bidder has to decide whether she intends to leave the auction or not. Once a bidder decides to drop out of the auction process, she cannot rejoin again later. In the single-unit case, which is the main focus of this thesis, the auction ends when only one bidder remains in the auction. This bidder acquires the commodity for the standing price at which the last but one bidder left the auction.

In the proposed auction framework, which is depicted in Figure 4.1, the Japanese auction is extended by dividing the auction process into a sequence of consecutive price stages and introducing a fixed price increment δ for each price stage. Further, every price stage is followed by an optional information stage in which the information set[2] of each bidder can be updated. For instance, this information stage can be used to proclaim the current high bidder, or the number of participants who did not drop out of the bidding

[1] As pointed out by the sociologist Charles W. Smith, the term *Japanese auction* is sometimes ambiguously also used to describe an ascending auctions in which bids are submitted publicly and simultaneously, allowing other bidders to rapidly adjust their bids in response (Smith, 1990).

[2] The term *information set* is frequently used in game theory. The information set of a player comprises all relevant information she has regarding the state of the game she is playing. Rasmusen (2007) define an information set as "as the set of different nodes in the game tree that he knows might be the actual node, but between which he cannot distinguish by direct observation."

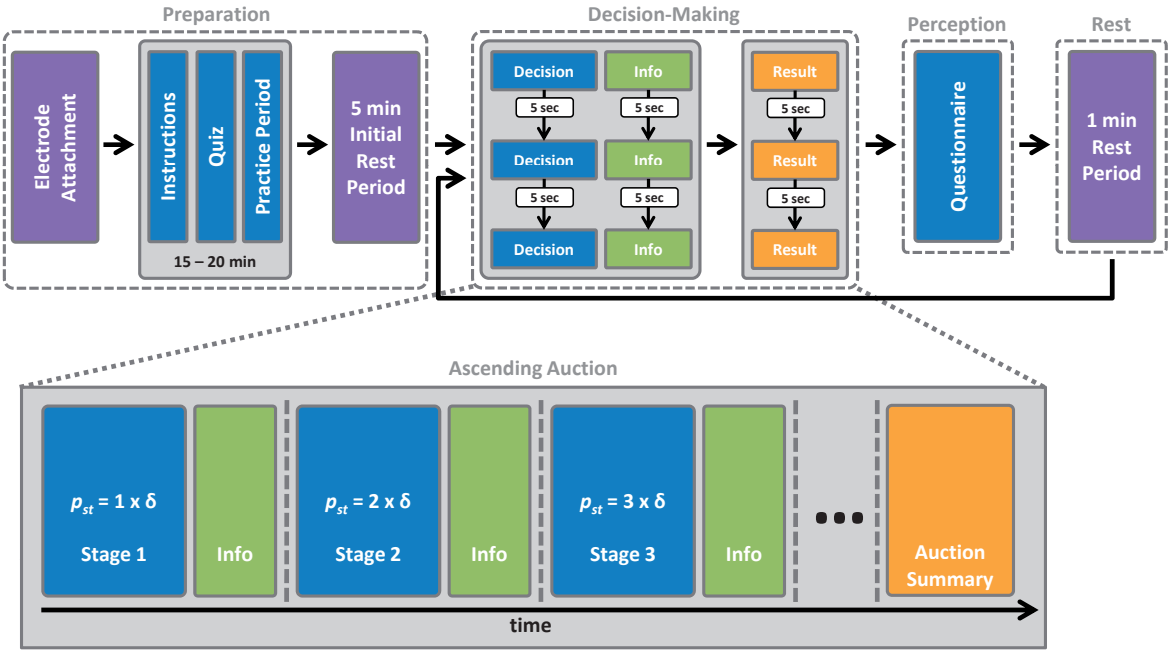


Figure 4.1.: Auction Framework for Physioeconomic Experiments

process yet. Additionally, and in contrast to the Japanese auction, each bidder has to explicitly decide in every single stage to stay in the auction or to drop out. As depicted in Figure 4.1, the auction framework is an instance of the decision-making phase of the physioeconomic session framework discussed in Section 3.5.1. In the auction summary stage, bidders are consecutively informed about the auction outcome.[3]

Dividing the auction process into a sequence of consecutive price and information stages allows for individually analyzing changes in physiological measures in response to single auction events, because the experimenter is able to control the number of simultaneous stimuli perceived by the bidders. With these timed information events, single facets of bidders' emotional processing can be analyzed separately. This applies in particular for immediate emotions triggered by *auction events*. This kind of bidding behavior analysis cannot be conducted for proxy-auction platforms such as *eBay.com*. In a proxy-auction, almost all bidding activity is observed in the very last minute of an auction (e.g. Roth, 2002; Ariely et al., 2005). Therefore, physiological responses to single auction events, e.g. being outbidden, cannot be analyzed, as time intervals between these events are too short. Further, as bidders only have to decide whether to stay in the

[3]Recall that the auction outcome can trigger immediate emotions as "joy of winning," "winner regret," and "loser regret."

auction or drop out in the proposed auction framework, measurement artifacts caused by bodily movements due to keyboard inputs are largely avoided.

Finally, the impact of changes in the auction mechanism on immediate emotions can be analyzed, which are triggered by the *auction outcome*. In this vein, the intensity of a bidder's "joy of winning" or "loser regret" can be measured depending on auction design parameters. For instance, the "joy of winning" may be stronger for an auction which was perceived more competitive by the bidders. The presented basic auction framework allows for a series of auction design parameters, which will be discussed in the context of auction fever in the following section.

4.2. Auction Framework Variations

The main focus of this chapter is to provide a framework that allows for systematically analyzing and measuring the phenomenon of auction fever in electronic ascending auctions. As outlined in Section 2.2, the literature identifies three major factors that can trigger an intense current emotional state: *perceived competition*, *previous investment*, and *perceived ownership*. The following subsections will outline how these three factors can be manipulated in the ascending auction framework for physioeconomics.

4.2.1. Perceived Competition

First, the impact of *time pressure* on bidders' physiological arousal and bidding behavior can be analyzed by introducing one of the following decision time rules:

1. **Time Pressure In (TPI):** Bidders only have a limited decision time τ for their decision in each stage. If a bidder does not decide within that decision time, this will be interpreted as if she declared to *accept* the current standing price and *stay in* the auction.

2. **Time Pressure Out (TPO):** Again, bidders only have a limited decision time τ for their decision in each stage. Moreover, if a bidder does not decide within that decision time, this will be interpreted as if she declared to *not accept* the current standing price and *drop out* of the auction.

3. **No Time Pressure (NTP):** In this setting, there are no time restrictions imposed on the bidders to take their decision. Therefore, bidders *actively* have to decide to stay in the auction or to drop out.

Ku et al. (2005) and Malhotra et al. (2008) identify time pressure, along with rivalry and social facilitation, as one of the main driving forces for *perceived competition* and, thus, as an elicitor for auction fever. Time pressure, so Malhotra et al. (2008), "can overwhelm people with the desire to win." While the intensity of time pressure can be varied by adjusting the decision time τ, the two different ways of interpreting the case of a bidder not deciding within τ allow for analyzing how often bidders accept the default, or conversely, *actively* decide for themselves.

While time pressure can be investigated with the decision time rule, the influence of rivalry and social facilitation can be analyzed by varying the size of bidders' individual information sets.[4] While in the basic auction framework the information set of a bidder is limited to the information that the auction is still ongoing and whether, depending on the high bidder rule, she is currently the high bidder or not, the information set can be extended by the following elements:

1. **Number of Bidders (NoB):** The number of bidders who participate in the auction.

2. **Bidder Count (BC):** The number of bidders who accepted the current standing price in this stage.

3. **Bidder Identity (BI):** The identity of bidders who accepted the current standing price in this stage. The bidder identity may for instance be announced by the use of pseudonyms.

4. **High Bidder Identity (HBI):** The identity of the high bidder in this stage. This element depends on the employed high bidder rule.

It is important to note here, however, that information on the number of bidders does not only affect the degree of perceived competition. For instance, Milgrom (2004, pp.

[4]Murnighan (2002) describes how intense the influence of rivalry and social facilitation can turn out to be in auctions conducted in small groups, in which bidders are very well known to each other.

195-200) analytically shows that, when bidders' valuations for the product are affiliated, the seller revenue is higher when bidders receive information about other bidders dropping out of the bidding processes.[5]

Further, with respect to social facilitation, the impact of audience effects can be investigated by gradually increasing the *spotlight*.[6] This can be accomplished, for instance, by letting an audience observe bidders' behavior through their anonymous screen names or even through video cameras.

4.2.2. Previous Investments

As outlined in Section 2.2.2, another elicitor for auction fever are accumulated *previous investments* and a phenomenon called *escalation of commitment* (cf. Ariely and Simonson, 2003). These terms describe the observation that a human decision-maker usually places too much emphasis on recouping previous investments for which she feels personally responsible. Following economic theory, a decision-maker should actually ignore sunk costs associated with previous investments and only consider future costs and benefits.

In the context of electronic auctions, bidders are lured into participation by low entry costs and a small degree of commitment: entering an auction does not necessarily result in obtaining the good, but opens the possibility of receiving the commodity for a low price. In order to increase the commitment associated with each bid and, thus, intensify the escalation situation, four different fee models are introduced as variations of the auction framework:

1. **Participation Fee (PF):** In every stage, each bidder has to pay a participation fee φ to stay in the auction.[7] If a bidder declares to leave the auction, the participation fees paid so far are lost. The auction ends if either only one bidder declares to stay in the auction, or all bidders declare to leave the auction. In the latter case, the winner is determined depending on the winner determination rule (see below). The classic Japanese auction is a special case of the participation fee auction with φ being set to zero.

[5] I would like to thank Stefan Seifert for this insightful comment.

[6] As outlined in Section 2.2.1, social facilitation can be distinguished into two major paradigms: *audience effects* and *co-action effects* (cf. Zajonc, 1965).

[7] For instance, the transactions and waiting costs incurred by auction participation can be interpreted as indirect participation fees.

2. **Bidding Fee[8] (BF):** In every stage, depending on the winner determination rule (see below), one of the bidders who accept the current standing price is chosen as high bidder and has to pay a bidding fee β. The bidder is then the current high bidder and wins the auction if no bidder accepts the price in the next stage. In contrast to the traditional Japanese auction and the participation fee auction, bidders may rejoin the auction process at any stage and the auction only ends if no bidder accepts the current standing price in a single stage.

3. **Entry Fee (EF):** In order to take part in an auction in the first place, a bidder has to pay an entry fee η prior to the first stage of bidding (cf. McAfee and McMillan, 1987b). If she refuses to pay the entry fee, she cannot participate in the auction.

4. **No Fee (NF):** Bidders do not have to pay a fee in the auction.

At this stage, there has been only little research regarding participation fees and bidding fess, and the experimental results on entry fees are mixed (cf. Section 2.2). Based on the physioeconomic ascending auction framework, future research should, therefore, take additional (emotional) aspects into account.

4.2.3. Perceived Ownership

In the literature, a phenomenon called the *pseudo-endowment* or *attachment effect* is often identified as another elicitor for auction fever (e.g. Heyman et al., 2004; Gimpel, 2007). These terms are usually used interchangeably[9] to describe the effect that sometimes a bidder, who is the current high bidder in an auction, feels like already owning the commodity and, therefore, does not want to lose it again. In order to analyze the bidding behavior associated with the pseudo-endowment effect, Ehrhart et al. (2008) propose three different high bidder rules, which are also applicable to the proposed physioeconomic auction framework:

1. **High Bidder First (HBF):** After each stage, the first bidder that declared to accept the current standing price is chosen as the current high bidder. If no bidder accepts the standing price in the next stage, this bidder wins the auction.

[8] The mechanism described here is very similar to the mechanism employed by the Internet auction platform *swoopo.com*.

[9] Ehrhart et al. (2008) points out that the pseudo-endowment effect and the attachment effect are caused by two different psychological phenomena which both result in a reference point change.

2. **High Bidder Random (HBR):** After each stage, one of the bidders accepting the current standing price is randomly declared as the current high bidder. If no bidder accepts the standing price in the next stage, this bidder wins the auction.

3. **No High Bidder (NHB):** During the whole auction, no bidder is chosen as the current high bidder. After all bidders decided to leave the auction, the winner will be randomly chosen from the bidders who accepted the standing price in the last stage.

In a laboratory experiment, Ehrhart et al. (2008) show that bidders place higher bids in the HBR in comparison to the NHB setting. Moreover, the effect that bidders place higher bids when the auctioneer declares a high bidder is even stronger in the HBF setting. The authors explain this observation through an "source-dependence effect" (Loewenstein and Issacharoff, 1994). In particular, bidders may value the status of being high bidder more, when they performed well in the task of clicking first in comparison to being randomly chosen as high bidder.

Further, the literature frequently argues that perceived ownership in auctions is stronger when the period of time a bidder has been high bidder is comparatively large (cf. Ariely and Simonson, 2003; Heyman et al., 2004). This high bidder duration may be manipulated by a changing the increment δ or the scaling of the experimental currency unit. Further, the duration of the decision and information stages may be manipulated.[10]

4.2.4. Discussion

The proposed auction framework, along with its variations, allows for systematically analyzing single facets of auction design and the emotional processing induced. In particular, various elicitors for the phenomenon of auction fever discussed in the literature can be analyzed individually and in combination. So far, the existing literature on auction fever (1) usually only focuses on manipulating *one* elicitor of auction fever, without accounting for interaction effects between the elicitors, and (2) often attributes auction fever to an increased degree of physiological arousal, without actually assessing it.

Based on the framework for emotional bidding introduced Chapter 2, the physioeconomic auction framework proposed in the present chapter allows for analyzing single

[10]It is important to note, however, that changing the duration of the decision stage also changes the degree of time pressure.

elicitors of auction fever, isolated *as well as* in combination. Therefore, interaction effects between these elicitors can be investigated. Further, the auction framework is characterized by timed information events and is, therefore, suitable for the analysis of physiological parameters. In particular, physiological responses can be directly referenced to single auction events, which is not possible when the time between single events is too short. The next section presents a proof-of-concept study for the proposed physioeconomic ascending auction framework.

4.3. A Proof-of-Concept Study

This section presents a proof-of-concept study for the proposed physioeconomic ascending auction framework. The main aim is to show (1) that the framework allows for measuring physiological differences regarding the auction design, and (2) that the auction design parameters of the framework can induce a change in bidding behavior.

4.3.1. Design of the Study

The proof-of-concept study focuses on the the impact of time pressure on bidders' behavior and levels of arousal in an ascending single-unit auction. In each session, four subjects participate as bidders in a sequence of auctions with either a *high* or *low* degree of time pressure. Based on the TPO (time pressure out) decision time rule of the auction framework, the degree of time pressure is controlled by setting the decision time τ either to 5 seconds (high) or 15 seconds (low). Therefore, bidders have to actively decide for accepting the price. The proof-of-concept study is based on a between-subject design. Thus, all participants of one session take part in either a sequence of high or low time pressure auctions, respectively. The price increment δ is set to 10 monetary units (MU), which is equivalent to €0.20 in cash. In order to adjust session times to a comparable level, the high and low time pressure treatments comprise a sequence of six and four auctions, respectively. The HBR (high bidder random) rule is chosen in combination with minimal bidder information sets, in order to avoid the source-dependence effect and to reduce the degree of perceived competition.

As a slight modification of the classic Japanese auction, bidders are allowed to rejoin

the auction.[11] Therefore, bidders are given the opportunity of changing their previous course of action and taking part in the bidding process again. The resale value of the auctioned off commodity in a single auction is the *same* for all bidders (common value). However, the resale value is *ex ante* unknown to the bidders, and determined from a uniform distribution with support on the discrete interval interval [170 MU, 270 MU] after the auction ends. Participants receive an initial lump sum of €15 plus their accumulated gains and losses in the auctions. The participant instructions are provided in Appendix A.1.

During the whole proof-of-concept study, participants' skin conductance values are recorded with a constant-current amplifier measurement system and Ag/AgCl (silver/silver chloride) electrodes.[12] The electrodes are 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). As recommended before in Section 3.5.1, subjects participate in a practice period, have to successfully complete a comprehension quiz, and are equipped with ear-muffs. The auction system of the proof-of-concept study is implemented using the z-Tree experimental software environment (Fischbacher, 2007).[13] The experimental environment, comprising the experimental laboratory and the experimental software, is documented in Appendix B.1 and Appendix B.2, respectively.

All sessions were conducted at the Karlsruhe Institute of Technology (KIT) in Karlsruhe, Germany, within a period of two weeks. Subjects were randomly recruited from a pool of undergraduate students with an academic background in economics. Altogether, 9 female and 23 male students (32 in total, mean age = 22.13 years) participated in 8 sessions. All sessions were conducted within the period of three weeks with an average room temperature and relative humidity of 21.45 °C (70.61 °F) and 49.90%, respectively.

4.3.2. Results

The proof-of-concept study aims at inducing differences in physiological processing and bidding behavior due to different degrees of time pressure. The results of the experiment

[11] This is equivalent to the BF (bidding fee) fee model with the bidding fee β being set to zero. Thus, the auction does not end until in one single stage all bidders do not accept the current standing price.

[12] For further information on the measurement system see Gharbi et al. (2008) and Appendix B.1.3.

[13] The website `http://www.iew.uzh.ch/ztree` provides further information on the z-Tree experimental software environment.

are presented in the following.

	Final Prices		Number of Bids	
Average	227.50 MU	213.75 MU	19.64	14.00
3rd Quartile	230.00 MU	220.00 MU	22.00	19.25
2nd Quartile	230.00 MU	210.00 MU	20.00	16.00
1st Quartile	220.00 MU	210.00 MU	18.00	12.00
	high	**low**	**high**	**low**

Table 4.1.: Auction Final Prices and Number of Bids

Bidding Behavior. The analysis starts with the differences in bidding behavior induced by the auction design. The final prices of the auctions and the number of bids placed by a single bidder are presented in Table 4.1 and Figure 4.2, respectively. The final prices in the high time pressure auctions are significantly higher than in the low time pressure auctions (Wilcoxon rank-sum test, $p < .001$). In Table 4.1, one can observe that all quartiles of the low treatment are consistently below the quartiles of the high treatment. Moreover, while in low time pressure auctions, average final prices are slightly below the expected resale value of 220 MU, prices in high time pressure auctions are slightly above this value. Thus, because the common resale value is *ex ante* unknown to the bidders, it can be interpreted that participants' *bidding behavior* turns from slightly risk averse to slightly risk loving when time pressure increases.

The average number of bids in high time pressure auctions are significantly higher than in low time pressure auctions (Wilcoxon rank-sum test, $p < .001$). It is important to point out that the number of bids is not equivalent to the final auction price, because bidders can *rejoin* the auction process at any stage. The accumulated distribution of the number of bids, as depicted in Figure 4.3, shows that only in 5% of the cases a bidder submitted 15 bids or less in high time pressure auctions, while in low time pressure auctions this value is almost 50%. Thus, the influence of time pressure on bidding behavior is even more salient when observing the individual bidding behavior of every single bidder.

Physiological Processing. After pointing out the differences in bidding behavior induced by the auction design, the analysis now focuses on the changes in physiological

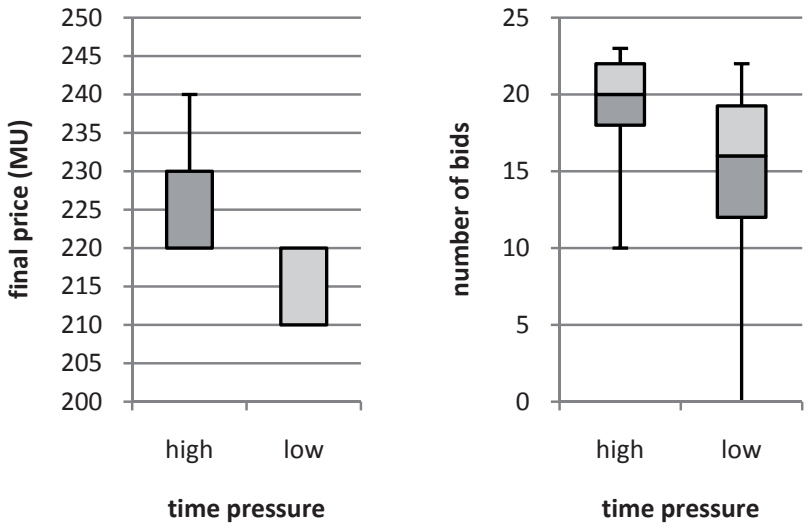


Figure 4.2.: Auction Final Prices and Number of Bids

processing. For the analysis, skin conductivity is decomposed into its tonic and phasic components with the *Ledalab* analysis software (Benedek and Kaernbach, 2010).[14] The (tonic) skin conductance level (SCL) reflects the general arousal level of the examinee, whereas a (phasic) skin conductance response (SCR) represents a short burst of emotional processing in response to a single stimulus (cf. Section 3.3.2). The amplitude of this response (SCR.amp), is a measure for the intensity of the emotional processing. ΔSCL and (transformed) SCR.amp values of the proof-of-concept study are depicted in Figure 4.4 and Figure 4.5.[15]

For each subject, the SCL values for all price stages are averaged for every single auction. These values are then referenced to an individual basic level of skin conductivity (Δ to base period). This basic level is assessed in the initial 5 minute rest period before the sequence of auction starts. As an SCR usually occurs 1 to 3 seconds after the stimulus (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 0.01μS (cf. Fowles et al., 1981). All amplitudes smaller than 0.01μS are transformed to a value of 0μS in the analyses. Following the recommendation of Venables

[14]The website `http://www.ledalab.de` provides further information on the *Ledalab* skin conductance analysis software.

[15]Technical problems in the proof-of-concept study made it impossible to collect skin conductivity data for all subjects. Altogether the data of 26 subjects could be analyzed.

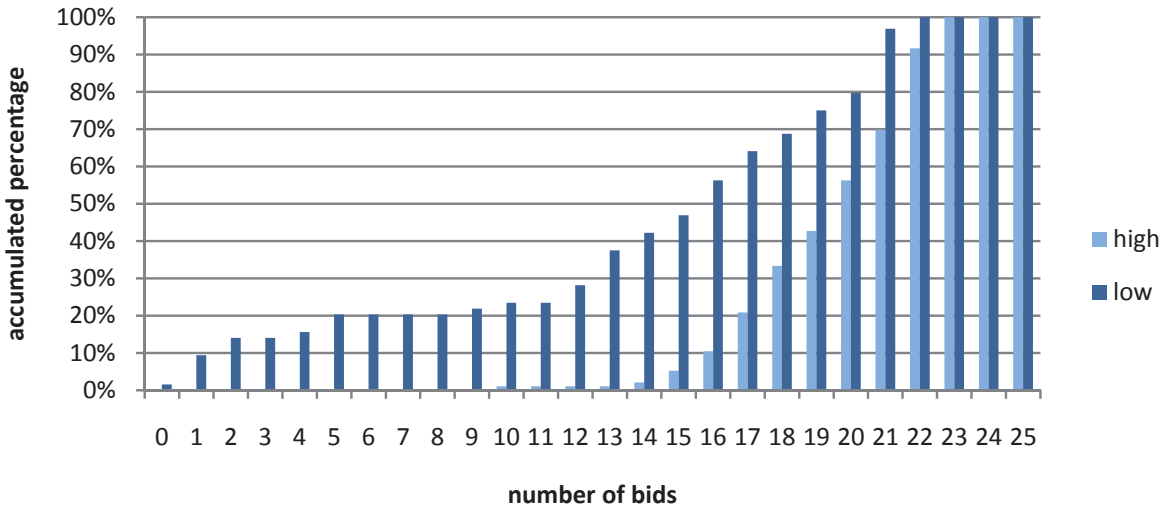


Figure 4.3.: Accumulated Percentages of the Number of Bids

and Christie (1980), all SCR.amp values are then transformed $log(x + 1)$ in order to reduce the inherent left skewness of skin conductivity. SCL and SCR.amp values are aggregated on the level of a single auction for each subject.

The skin conductance data shows a difference in physiological processing for low and high time pressure auctions, respectively. First, bidders' general level of arousal is analyzed. The ΔSCL values are significantly higher for low in comparison to high time pressure auctions (-0.08 vs. 0.40, two-tailed t-test, $p < .02$). Therefore, bidders' general level of arousal is higher in low time pressure auctions. Interestingly, this observation is counterintuitive to the understanding of time pressure and bidding behavior in the literature (cf. Section 2.2.1). Second, bidders' SCR.amp values are analyzed in response to deciding whether to accept the current standing price or not. The results show that SCR.amp values are significantly higher for low time pressure auctions (0.06 vs. 0.08, two-tailed t-test, $p < .05$). Third, bidders' SCR.amp values in response to winning or losing an auction are investigated. A 2 (time pressure) x 2 (outcome) ANOVA shows again that bidders' SCR.amp values are on average higher for low time pressure auctions. Further, SCR.amp are significantly higher when winning an auction in comparison to losing an auction. Significant interactions were not observed (time pressure: $F = 4.82$, $p < .03$; outcome: $F = 8.88$, $p < .01$; interaction: $F = 0.82$, $p = .37$).

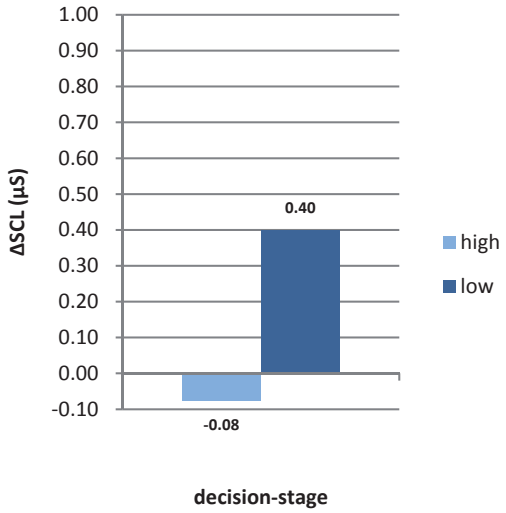


Figure 4.4.: Skin Conductance Level (SCL)

4.3.3. Discussion

The main aim of the proof-of-concept study is to show (1) that the introduced physioeconomic ascending auction framework allows for measuring physiological differences regarding the auction design, and (2) that the auction design parameters of the framework can induce a change in bidding behavior.[16] In particular, the degree of time pressure is manipulated here by changing the time a bidder has to accept the current standing price. The results of the study show that manipulating the degree of time pressure can induce a change in bidding behavior. More specifically, the low time pressure auctions yield on average final prices below the expected value of 220 MU, whereas the high time pressure auction yield on average final prices above 220 MU.

The analysis of the physiological results shows that the intensity of immediate emotion processing is stronger in the low time pressure auctions. In other words, bidders experience stronger physiological responses when winning and losing an auction in the low time pressure auctions. Similarly, also the bidders' general level of arousal, as measured by the skin conductance level (SCL), is *higher* in low time pressure auctions. This observation seems somewhat counterintuitive, because the literature on auction fever

[16] Kagel (1995) provide a thorough review of auction experiments. In this proof-of-concept study, it is important to show that the proposed physioeconomic auction framework also allows for observing changes in bidding behavior. Furthermore, there are only few laboratory experiments on time pressure in auctions at this stage (cf. Section 2.2.1).

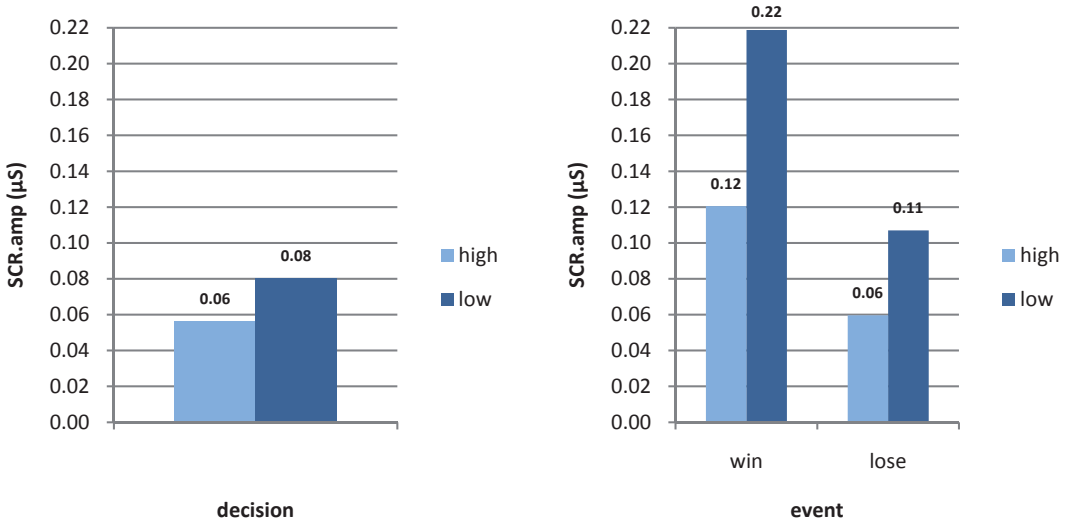


Figure 4.5.: Skin Conductance Response Amplitudes (SCR.amp)

generally conjectures higher degrees of arousal in high time pressure auctions (see Section 2.2.1). One may explain this observation, however, with the individual number of bids in this specific auction. As depicted in Figure 4.3, the variance of the number of bids is much larger in the low time pressure treatment. Generally, a higher degree of emotional processing can also cause subjects to reconsider their actions (Bechara and Damasio, 2005). The particular auction conducted in this proof-of-concept study allows bidders to *rejoin* the auction at a later stage. Therefore, a low time pressure may cause bidders to more thoroughly reconsider their actions, which is reflected both in emotional processing and bidding behavior.

Furthermore, and irrespective of the time pressure, bidders' immediate emotions are stronger when winning in comparison to losing an ascending auction. This again is contradictory to existing auction fever literature, which often conjectures that the "loser regret" is stronger than the respective "joy of winning" (see Section 2.3). Therefore, also the intensity of immediate emotions in response to the auction outcome seems to depend on various factors, which need to be systematically analyzed in future research. In this particular setting, however, bidder's joy of winning is stronger than the respective loser regret. The results of the proof-of-concept study indicate that future research has to put more focus on the interactions between auction design parameters, emotional processing, and bidding behavior. Taking physiological proxies of emotional processing into account, the introduced physioeconomic ascending auction framework can be used to investigate

these interactions in the context of ascending auctions. Furthermore, the framework allows for analyzing single elicitors of auction fever isolated *and* in combination.

4.4. Lessons Learned

The presented proof-of-concept study shows that changes in auction design parameters of the discussed framework can also result in significant changes in bidders' physiological processing. However, the proof-of-concept study also provides methodological experience for future physioeconomic auction experiments. In particular, the following insights can be drawn for conducting auction experiments with physiological measurements:

1. The behavioral data reveals different bidding behavior for low and high time pressure auctions, respectively. It remains unclear, however, what the impact of time pressure on bidding behavior is *exactly*. Do bidders place higher bids in high time pressure auctions, *or* do bidders place lower bids in low time pressure auctions? In other words, there is no *behavioral benchmark* for changes in bidding behavior. It, therefore, seems worthwhile to introduce a self-report questionnaire that asks bidders (1) whether they set themselves a bidding limit and (2) whether they tend to over- or underbid this limit during the auctions. It should be considered, however, to conduct questions regarding the subjects' behavior after all auctions ended, as such questions may have an distorting influence in between auctions.

2. The physiological data reveals different levels of bidders' physiological arousal. However, it remains unclear how this arousal is *perceived* by bidders. Again, this subjective impression can be assessed with a self-report perception questionnaire. Do bidders feel more excited in these auctions? Do they experience higher degrees of perceived competition? Based on the results of the proof-of-concept, this issue is already reflected in a perception phase in the physioeconomic session framework (cf. Section 3.5.1).

3. The design of the proof-of-concept study only allows for 4 observations per subject in the low time pressure treatments, and 6 observations in the high time pressure treatments, respectively. This, however, is a rather small number of observations compared to traditional psychophysiological experiments (Dawson et al., 2007). Due to the large inter- and inner-subject variability, the experimenter needs to

obtain more observations for physiological data than for mere behavioral data. Therefore, it is necessary to reduce the time per auction and, thereby, increase the number of auctions and observations. This can be achieved by focusing on specific events in a single study and avoid unnecessary waiting times. Particularly in the low time pressure treatments, auctions lasted up to 20 minutes due to additional waiting times.

This section focused in particular on systematically investigating the phenomenon of auction fever in ascending auctions with the newly developed physioeconomic methodology. In contrast, the following section aims at providing physiological evidence for a "utility of suspense" (Cox et al., 1982, 1983) in descending auctions. The insights of the proof-of-concept study are reflected in the experimental design and the self-report questionnaire of the "utility of suspense" experiment. The self-report questionnaire is provided in Appendix A.3.

Chapter 5.

An Experiment on the Utility of Suspense in Dutch Auctions

In contrast to the last chapter, which focused specifically on measuring auction fever in electronic ascending auctions, the present chapter addresses Research Question 4 and concentrates on descending auctions. In particular, it seeks to provide physiological evidence for a "utility of suspense" (Cox et al., 1982, 1983) in Dutch auctions based on a physioeconomic laboratory experiment.

> **Research Question 4:** *Can the methodology of physioeconomics provide physiological evidence for a utility of suspense in Dutch auctions?*

More specifically, the main interest of this experiment is (1) to provide the missing link between the utility of suspense hypothesis and actual physiological values of Dutch auction participants, and (2) to further characterize the elicited emotional state bidders experience and investigate how this emotional state is reflected in bidding behavior.

The remainder of this chapter is structured as follows. Section 5.1 introduces the Dutch auction and gives a short overview of its use in the field. Section 5.2 discusses related literature on the utility of suspense and clock speeds in Dutch auctions. Section 5.3 presents the experimental design of the physioeconomic laboratory experiment. The hypotheses and results of the experiment are discussed in Section 5.4. Moreover, Section 5.5 identifies characteristic patterns of emotional processing, which occur in the dynamic process of Dutch auctions. Section 5.6 concludes.

5.1. The Dutch Auction

In a Dutch auction, sometimes also referred to as "reverse clock auction" (Katok and Kwasnica, 2008), the auctioneer starts the auction by setting an initial high price p_{max} and then continuously decreases the standing price p_{st} by a decrement δ after each time interval τ, until one of the bidders claims the good by accepting the current standing price.[1]

5.1.1. Dutch Auctions in the Field

Dutch auctions have a long standing history in practice and in academic literature. The Dutch auction originally obtained its name from the flower market in Amsterdam, which has used this particular auction mechanism since the end of the nineteenth century (van Heck and Ribbers, 1997).[2] At the end of 2008, FloraHolland, the operator of the Dutch flower market, reported an annual turnover of €4 billion, 11 billion units of cut flowers sold, and a worldwide market share of almost 60% (FloraHolland, 2009; Huges, 2009). Over the decades, further flower markets based on the Dutch auction mechanism have emerged in many other countries.[3] Similarly, Dutch auctions are also used for other perishable goods, for instance on the fish markets in Sydney, Auckland, and Taipei. Another prominent example of the Dutch auction is the oldest discount retailer in the US: Filene's Basement (Bell and Starr, 1993). If a product is not sold within 14 selling days at Filene's Basement, its price is reduced by 25%, after 21 selling days by 50%, and after 28 selling days by 75%.[4]

The Dutch auction is also used in Internet consumer auctions. For instance, the platform *1-2-3.tv* conducts multi-unit uniform price Dutch auctions, which are simulta-

[1] As outlined by Katok and Roth (2004), the term *Dutch auction* is ambiguously also used for a multi-unit auction mechanism on eBay, in which bids are specified by price and quantity.

[2] In his well-known historical sketch of auctions, Cassady (1967) reports that a similar auction mechanism was already used occasionally in England in the seventeenth-century called "mineing." The mechanism got its name because the auctioneer reduced the price until one of the bidders shouted "Mine!"

[3] The emergence of flower markets based on the Dutch auctions can be observed, for instance, in Belgium (Euroveiling Flower Trade Center), Brazil (Veiling Holambra), Canada (*flowerbuyer.com*), France (Société Anonyme d´Intérêt Collectif Agricole (SICA) Flower Market), Germany (Landgard), Japan (Ota Floriculture Auction Co. Ltd.), and Taiwan (Taipei Flower Auction Co. Ltd.).

[4] After having been more than a century in business, Filene's Basement had to file bankruptcy in the course of the global economic crisis in 2009 and announced closing 17 of its 25 stores (The New York Times, 2009).

neously broadcasted on German television.[5] Further, in recent years consumer auction sites like *luupo.de* have emerged, on which the current standing price is unknown to the bidders. Each bidder can individually reveal the current standing price by paying a fee. For a short moment, she then has the exclusive right of buying the commodity for this price.

5.1.2. Dutch Auction Theory

From a theoretical perspective, Dutch auctions have first been analyzed in the seminal work of Vickrey (1961). Considering the single-unit case, which is also the focus of the present experiment, Vickrey analytically shows that Dutch auctions are "isomorphic" to first-price sealed-bid (FPSB) auctions. In this context, the term *isomorphic* means that these two auction mechanisms are strategically equivalent from a bidder's perspective and, thus, that the equilibrium bidding functions for the two auctions are identical. Therefore, these auctions should also yield the same revenue to the auctioneer.[6]

In a FPSB auction, each bidder submits a single sealed-bid. The auctioneer then determines the highest of all bids. The bidder who placed the highest bid obtains the commodity and has to pay the amount of her bid. The intuition behind the isomorphism of Dutch and FPSB auctions lies in the reasoning that in a Dutch auction a bidder only has to "determine [ex ante] at what point [s]he should be prepared to make a bid so as to obtain the greatest expectation of gain" (Vickrey, 1961). Therefore, the optimal bidding strategy in a Dutch auction is fully specified by the point in time, or equivalently, by the current standing price, at which one seeks to stop the clock. It is important to note that, from a theoretical perspective, this isomorphism *generally* holds "regardless of which of the assumptions about risk attitudes and value correlations apply" (McAfee and McMillan, 1987a).

For the *specific case* of independent private values, Vickrey derives a Bayesian Nash equilibrium for FPSB auctions and, thus, for the isomorphic Dutch auctions. In this equilibrium, a bidder should place her bid according to the bidding function $b(v_i)^*$, in order to maximize her expected profit.

[5] The focus of this thesis are single-unit auctions. For more information on human bidding behavior in multi-unit uniform price Dutch and English auctions, please refer to (McCabe et al., 1990).

[6] Katok and Kwasnica (2008) note that "[t]his is true even under the assumptions of risk aversion and affiliated values."

$$b(v_i)^* = \frac{n-1}{n} \cdot v_i$$

The model considers an exogenous number $n \geq 2$ of symmetric bidders. Moreover, the model assumes that each bidder i is risk neutral and independently draws a valuation from the uniform distribution function F with support on $[0, \overline{v}]$.

Contrary to the analytical reasoning of Vickrey (1961), evidence from the laboratory and the field consistently indicates that FPSB and Dutch auctions are in fact *non-isomorphic*. Thereby, Dutch auctions can yield final prices above or below those observed in the strategically equivalent FPSB auctions (e.g. Cox et al., 1982, 1983; Lucking-Reiley, 1999). In particular the clock speed, i.e. the speed at which the auctioneer decreases the price, seems to play an important role in this regard.

5.1.3. The Real-Time Element of Dutch Auctions

The behavioral non-isomorphism of FPSB and Dutch auctions is first observed in the laboratory experiments of Coppinger et al. (1980). In particular, the authors observe lower final prices in Dutch in comparison to FPSB auctions. However, Coppinger et al. did not find a satisfactory explanation for their observation and eventually conjecture that the non-isomorphism "may be due to information differences in the two types of auctions."

In their seminal laboratory experiments, Cox et al. (1982, 1983) consistently report that Dutch auctions generally yield lower final prices than the equivalent FPSB auctions. The authors argue that Dutch auctions have an inherent "real-time" element that distinguishes this auction mechanism from FPSB auctions. This real-time characteristic is, however, not considered in Vickrey's model. Cox et al. (1983) note:

> *"The fact that the Dutch auction is a 'real-time' auction and the first price auction is not, and therefore that the extensive forms of the bidding games for the two auctions are different, is viewed as being irrelevant to bidding theory. It is assumed that only the strategic forms matter."* (Cox et al., 1983)

While the real-time element of Dutch auctions has been identified as the actual cause of the non-isomorphism, the question remains *how* this real-time element is finally reflected in human bidding behavior. Cox et al. (1982) introduce two possible explanations: (1) a systematic violation of Bayes' rule and (2) a "utility of suspense."

With respect to erroneous Bayesian updating, Cox et al. (1982) argue that the real-time element of Dutch auctions allows a bidder "to observe some bidding behavior of his rivals," which is not the case for FPSB auctions. More specifically, the bidders can observe the *absence* of bidding activity in Dutch auctions, because the auction ends immediately as soon as one of the bidders places a bid. While the absence of bidding activity is actually "not informative" (Cox et al., 1982), bidders may suffer from a behavioral bias and believe that they can actually gain some additional information from their observations. In particular, a bidder may systematically violate the Bayes' rule such that she "underestimates the risk [s]he bears by continuing to let the auction clock run" (Cox et al., 1983). If, however, the bidder adequately applied the Bayes' rule, there would be no update of the *ex ante* predefined bidding strategy. Therefore, so Cox et al., while bidders can actually gain no additional information from observing the auction process whatsoever, a systematic violation of the Bayes' rule can serve as a possible explanation for the real-time effect and, thus, for lower final prices in Dutch in comparison to FPSB auctions.

Cox et al. (1982) also introduce a second explanation for the effect of the Dutch real-time element, which they call the "utility of suspense" hypothesis. The authors conjecture that bidder i may derive an additional non-monetary utility $a_i(t) \geq 0$ from participating in a Dutch auction of length t, which is additive with the utility of monetary reward. This conjecture is based on an observation the authors made during their laboratory experiments:

> *"On a more impressionistic level it is worth noting in this regard that many subjects report that they enjoy the 'clock experiment' more than the others because of the 'suspense of waiting.' In this sense they seem to perceive the Dutch auction as a 'waiting game,' in which lower bids are entered than in the first-price sealed-bid auction."* (Cox et al., 1982)

Cox et al. (1983) conduct a series of laboratory experiments in order to test between the erroneous Bayesian updating and the utility of suspense hypotheses. In particular, the authors manipulate the conversion rate between experimental monetary units (MU) and real money. In one series of treatments, they set the monetary reward level three times higher than in the other treatments. The authors argue that if the utility of suspense hypothesis was correct, then "increasing the reward level would cause Dutch

auction prices to approach the prices in the paired first price auctions." The intuition behind this reasoning is that the (non-monetary) utility of suspense does not increase with the utility gained from the monetary reward.[7] Therefore, if the monetary utility is increased through the reward level, bidders should place higher bids as the relative impact of the utility of suspense diminishes. To the contrary, there should be no such change in bidding behavior if the erroneous Bayesian updating hypothesis was correct, because the probability miscalculation model is independent from the reward level. Cox et al. report no change in final prices between low and high reward levels and therefore discard the utility of suspense hypothesis in favor of the erroneous Bayesian updating hypothesis.

5.2. Clock Speeds and Human Behavior in Dutch Auctions

As outlined in the last section, the real-time element of Dutch auctions has been identified as the actual cause of the non-isomorphism between Dutch and FPSB auctions. However, there are different theories on *how* the real-time element actually affects bidding behavior. Taking into account this real-time element, it turns out that there is not a bijective mapping between the FPSB and Dutch auction mechanisms. In addition to the defining characteristics of the FPSB auction institution, each implementation of the Dutch auction mechanism has to specify

1. the initial high price p_{max}, which also defines the distance p_{off} between the initial high price p_{max} and the highest possible valuation $\overline{v}$ of a bidder for the commodity ($p_{off} = p_{max} - \overline{v}$),

2. the decrement δ by which the current standing price p_{st} is decreased at each (discrete) tick of the Dutch clock, and

3. the time interval τ between two consecutive price steps.

[7] This assumption seems intuitive at first sight. However, the physiological data in Section 5.5 shows that the resale value of the auctioned commodity has a significant impact on the hedonic value a bidder derives from auction participation, i.e. on the utility of suspense. Therefore, and in contrary to the assumption of Cox et al. (1983), the utility of suspense may actually increase with the utility gained from the anticipated monetary reward.

5.2.1. Dutch Auction Clock Speeds in the Literature

Over the past decades, experimental economists have consistently reported evidence that the seller revenue in Dutch auctions depends crucially on the clock speed at which the standing price is decreased. Thereby, slow Dutch auctions yield higher and fast Dutch auctions lower seller revenues than FPSB auctions, respectively. The clock speed θ can be defined as the quotient of the decrement δ and the time interval τ, i.e. $\theta = \delta/\tau$.[8] An overview of studies on Dutch auctions, along with the respective clock speed and research methodology is provided in Table 5.1.

Table 5.1.: Selected Literature on Clock Speeds in Dutch Auctions

Author(s)	TH	LE	CFE	δ	τ	θ	Dutch vs. FPSB
Vickrey (1961)	X						=
Coppinger et al. (1980)		X		\$0.50	7 sec	0.07 \$/sec	<
Cox et al. (1982)	X	X		\$0.20	2 sec	0.10 \$/sec	<
				\$0.30	2 sec	0.15 \$/sec	<
				\$0.40	2 sec	0.20 \$/sec	<
				\$0.60	2 sec	0.30 \$/sec	<
Cox et al. (1983)	X	X		(3 x) \$0.60	2 sec	(3 x) 0.30 \$/sec	<
Lucking-Reiley (1999)			X	5 % of p_{max}	1 day	5 %/day	>
Carare and Rothkopf (2005)	X						>
Katok and Kwasnica (2008)	X	X		5 MU	1 sec	5.00 MU/sec	<
				5 MU	10 sec	0.50 MU/sec	<
				5 MU	30 sec	0.17 MU/sec	>

(TH = theory, LE = lab experiment, CFE = controlled field experiment)

(δ = decrement, τ = time interval, θ = clock speed, sec = second(s), MU = monetary units)

As outlined before, the experiments of Coppinger et al. (1980) and Cox et al. (1982, 1983) consistently indicate that the Dutch auction generally yields lower final prices than the FPSB auction. To the contrary, Lucking-Reiley (1999) finds in a controlled field experiment on the Internet that Dutch auctions yield higher revenues than FPSB auctions. Carare and Rothkopf (2005) explain this outcome with the existence of incremental transaction costs in slow Dutch auctions, which may for example stem from the costs of monitoring the auction process. Thereby, Carare and Rothkopf are able to formally show that slow Dutch auctions can result in higher revenues than in FPSB auctions, because the latter incur less transaction costs.

[8] Note that sometimes the clock speed is simply defined as the time interval between two consecutive price steps (Katok and Kwasnica, 2008). However, the literal meaning of the term *speed* indicates a progress per time.

5.2.2. A Tradeoff between Transaction Costs and Utility of Suspense

Building on these previous insights, Katok and Kwasnica (2008) finally present a unified experiment in which they show that the clock speed in Dutch auctions has a systematic impact on final prices, or equivalently, on sellers' revenues. The authors discard the erroneous Bayesian updating hypothesis of Cox et al. (1983) as an explanation for differences in final prices due to varying clock speeds. In particular, they argue that human decision makers generally fail to perform Bayesian updating properly and, thus, "there is no reason to believe a few extra seconds would make a difference."[9] In the experiment, auction participants are induced with private resale values for an artificial commodity for which they compete in a FPSB or Dutch auction. Katok and Kwasnica observe that fast Dutch auctions (with clock speeds of 5 price decrements per second and 0.5 price decrements per second) result in lower revenues and the slow Dutch auction (with a clock speed of 0.17 price decrements per second) results in higher revenues than the benchmark FPSB auction. Formally, the authors conjecture that these differences depend on the tradeoff between transaction costs (in the spirit of Carare and Rothkopf, 2005) and utility of suspense (in the spirit of Cox et al., 1982, 1983), both of which are believed to depend on the elapsed auction time.

More precisely, classically bidders are believed to bid optimally in the sense that they weigh the expected marginal benefits with the marginal costs. In a sealed-bid auction, this means that bidders equate the benefits of lowering their bid with the opportunity costs incurred by the increased probability of not winning the auction. In the Dutch auction, these static marginal effects are possibly distorted by additional dynamic marginal effects of the inherent real-time element. On the one hand, marginal benefits may be increased through utility of suspense. Hence, at any given standing price, bidders have a higher marginal benefit per second in fast Dutch auctions compared to fast Dutch auctions. On the other hand, transaction costs steadily increase the marginal costs side, which *ceteris paribus* induces bidders of slow Dutch auctions to stop the auction earlier. In the framework of Katok and Kwasnica (2008), the overall real-time effect of Dutch in comparison to FPSB auctions will, thus, depend on the relative size

[9] However, the Katok and Kwasnica (2008) do not discuss whether the utility of suspense is independent of the anticipated monetary payoff. This is the major assumption of Cox et al. (1983) for the erroneous Bayesian' updating hypothesis. This issue will be discussed again in Section 5.5.

of the utility of suspense compared to the transaction costs.

Katok and Kwasnica extend the model of Cox et al. (1982, 1983) such that the utility of suspense $a(t)$ also depends on the time interval τ between two price steps: $a(t) = (a/\tau) \cdot t$. The constant a represents one unit of non-monetary joy of Dutch auction participation. Therefore, bidders derive more utility of suspense from one second of participation in a fast in comparison to a slow Dutch auction. In fact, the amount of utility of suspense is the same when considering the number of price steps in this model. For instance, 10 price steps yield 10 units of non-monetary joy of Dutch auction participation. However, bidders place higher bids in the slow Dutch auctions, because for the same price more auction time elapses in these auctions and, therefore, the transaction costs are higher.[10]

5.3. Experimental Design

This chapter presents an experiment, which investigates the utility of suspense explanation of Cox et al. (1982, 1983) and Katok and Kwasnica (2008). The main interest of this experiment is (1) to provide the missing link between the utility of suspense hypothesis and actual physiological values of Dutch auction participants, and (2) to further characterize the elicited emotional state bidders experience and investigate how this emotional state is reflected in bidding behavior. Furthermore, Section 5.5 identifies characteristic patterns of emotional processing, which occur in the dynamic process of Dutch auctions.

The experiment presented in this chapter is similar to that of Katok and Kwasnica (2008), but also includes physiological measurements of bidders' heart rate and skin conductivity as proxies for their arousal during the auction process. Moreover, in addition to Katok and Kwasnica, who exclusively investigate Dutch auctions where bidders have independent private values, I also conduct common value Dutch auctions, in which the resale value of the artificial commodity is *ex ante* unknown but identical to all bidders. The particular advantage of a common value auction is that bidders need not perform Bayesian updating.[11]

[10] Katok and Kwasnica note: "it is as if the same amount of enjoyment is garnered from the auction for each 'tick' of the clock regardless of how slow the clock is, but costs per tick of the clock increase as the clock slows down."

[11] Recall that erroneous Bayesian updating is proposed by Cox et al. (1982, 1983) as a possible alternative explanation for the non-isomorphism of Dutch and FPSB auctions.

5.3.1. Clock Speed, Utility of Suspense, and Emotional States

The first aim of the experiment is to provide physiological evidence that the utility of suspense depends on the clock speed. The experiment is based on the framework for emotional bidding introduced in Chapter 2. Figure 5.1 depicts the conjectured relation between the auction system, the utility of suspense, the current emotional state of a bidder, and her bidding behavior. As outlined in Chapter 2, a bidder's current emotional state can be directly influenced by the auction system. Katok and Kwasnica (2008) argue that bidders derive a higher *utility of suspense* per second in fast Dutch auctions. Following this reasoning, fast clock speeds should also be reflected in a bidder's current emotional state. More specifically, bidders should experience higher degrees of physiological arousal in fast Dutch auctions. In this experiment, the change of the bidder's current emotional states due to the clock speed is measured with physiological parameters for the first time.

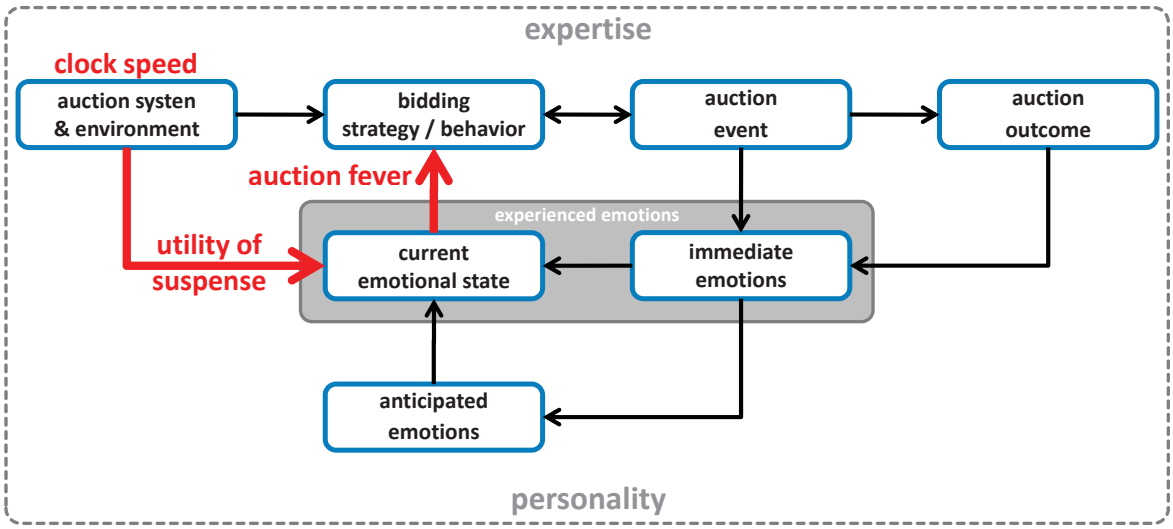


Figure 5.1.: Clock Speed in the Framework for Emotional Bidding

The second aim of the experiment is to further characterize the elicited emotional state and investigate how this emotional state is reflected in bidding behavior. In this regard, the central claim is that the higher *utility of suspense* in fast Dutch auctions stems from an increased level of *perceived competition*. When the clock speed is high, bidders have less time to revise their decisions and, hence, may perceive a stronger degree of competition. Following the terminology of Ku et al. (2005) and of Malhotra et al. (2008), the corresponding current emotional state may be referred to as "competitive

arousal." Subsequently, such an intense current emotional state may affect a bidder's bidding behavior, which has been defined as *auction fever* in Section 2.1.2. In this experiment, bidders level of perceived competition is assessed with a self-report perception questionnaire.

5.3.2. Treatment Structure

In the experiment presented in this chapter, I conduct slow and fast Dutch auctions, in which the standing price is decreased by $\delta = 1$ monetary units (MU) every $\tau = 0.5$ seconds or every $\tau = 5.0$ seconds, respectively. Thereby the experimental set-up allows for more fine grained bids than that of Katok and Kwasnica, who chose price decrements of $\delta = 5$ MU.[12] This translates into clock speeds of 2.0 MU per second and 0.2 MU per second, which are in between the range of clock speeds analyzed by Katok and Kwasnica. The experiment is implemented in z-Tree (Fischbacher, 2007) and is based on a between-subject design (cf. Kagel, 1995), i.e. bidders exclusively participate in one of the four treatments depicted in Figure 5.2.[13]

Clock Speed / Value Model	Fast (2.0 MU/sec)	Slow (0.2 MU/sec)
Common Value (CV)	CV_fast	CV_slow
Independent Private Value (IPV)	IPV_fast	IPV_slow

Figure 5.2.: Treatment Structure of the Dutch Auction Clock Speed Experiment

The Dutch auctions are designed as follows. In all treatments, the auctioneer starts the auction at the initial high price of 120 MU and then consecutively lowers the standing price by $\delta = 1$ MU per time interval τ. This time interval τ is 0.5 seconds in the fast and 5.0 seconds in the slow treatments, respectively. There are three bidders in each auction. The auction is finished as soon as one of the three bidders accepts the current standing price. The winning bidder receives the resale value for the commodity and has to pay the price at which she accepted to finish the auction. In the independent private value

[12] As a matter of fact, in email correspondence, Elena Katok suggested to use decrements of 1 MU to allow for a "cleaner analysis."

[13] The website `http://www.iew.uzh.ch/ztree` provides further information on the z-Tree experimental software environment.

(IPV) treatments, bidders receive an individual resale value of the artificial commodity before the auction starts, which is independently drawn from a uniform distribution with support on the discrete integer interval [21 MU, 120 MU]. In the CV treatments, the common resale value is *ex ante* unknown to the bidders and determined from a uniform distribution with support on the discrete interval interval [46 MU, 95 MU] after the auction ends.

Before the experiment starts, the participants are endowed with a lump sum payment of €15. The experimental currency is set to monetary units (MU) with 1 MU being equivalent to €0.20. Depending on their individual performance, the bidders accumulate all gains and losses during the auctions on their individual accounts. The individual accounts are paid out in cash to the participants at the end of the experiment.[14]

5.3.3. Session Structure

In order to allow for physiological measurements, it is necessary to adapt the experimental design of Katok and Kwasnica slightly by introducing rest periods in between different auctions, which allow the participants' physiological values to return to an individual basic level. Therefore, the experiment applies the physioeconomic session framework introduced in Section 3.5.1. Further, following the recommendations of the proposed physioeconomic methodology (cf. Section 3.5.1), subjects' interactions with the experimental system are limited to mouse inputs and subjects are equipped with a pair of ear-muffs.[15] The Dutch auction instance of the physioeconomic session framework is depicted in Figure 5.3. Each session of the experiment comprises three stages.

First Stage. The first stage corresponds to the preparation phase of the physioeconomic session framework. Subjects have to successfully complete a quiz regarding the instructions of the experiment, in order to ensure full comprehension of its rules. The participant instructions are provided in Appendix A.2. The quiz is followed by an initial practice period and a five minute rest period. The initial practice period, which comprises a test auction in which no money is gained or lost, is applied in order to introduce the experimental environment to subjects and, thus, reduce the impact of novelty on

[14] In this experiment, the average payment was €34.00, with €23.00 and €47.80 being the minimum and maximum payments, respectively. Sessions lasted between 90 to 150 minutes.

[15] The experimental environment, comprising the experimental laboratory and the experimental software, is documented in Appendix B.1 and Appendix B.3, respectively.

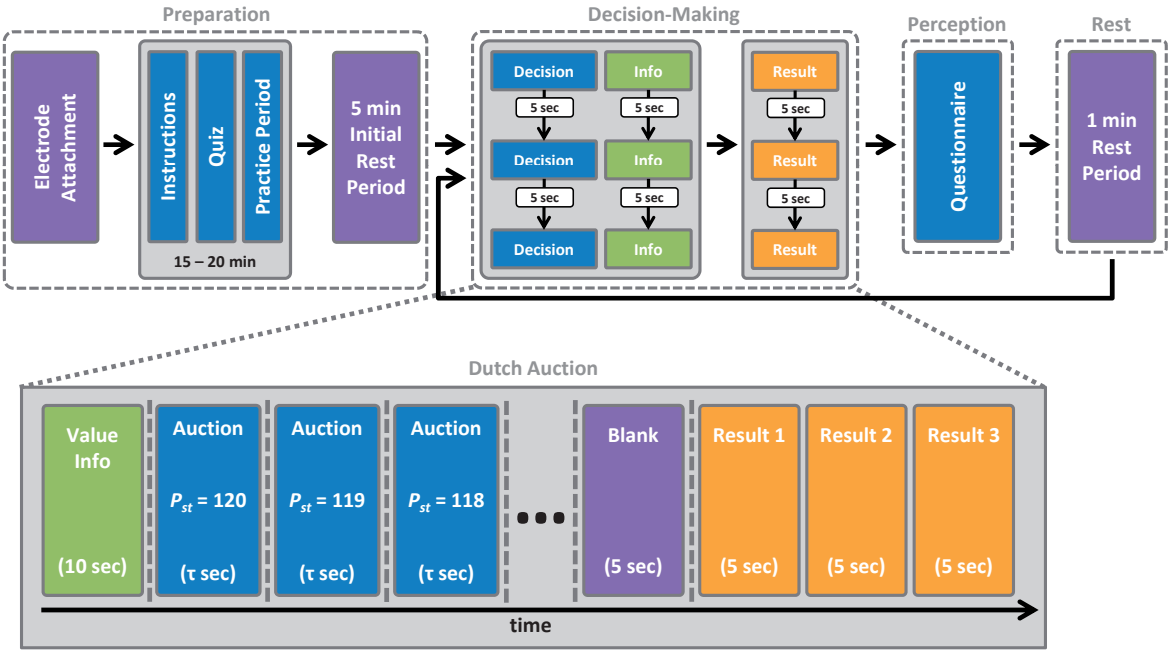


Figure 5.3.: Dutch Auction Instance for Physioeconomic Session Framework

physiological values (cf. Dawson et al., 2007). The five minute rest period enables to assess an individual basic level of physiological arousal for each subject (cf. Boucsein, 1992).

Second Stage. In the second stage, the subjects consecutively participate as bidders in 15 periods of Dutch auctions. A Dutch auction is an instance of the decision-making phase of the physioeconomic session framework. Six participants are invited for a single experimental session. In a random stranger matching (cf. Kagel, 1995), participants are randomly reassigned to two groups of three before every single auction period. Each group independently plays a single Dutch auction with three bidders each.

Third Stage. In the third stage, the bidders have to answer a self-report questionnaire regarding their individual feelings during the auctions.[16] The questionnaire is based on a series of statements to which subjects indicate agreement or disagreement on a 5-

[16]Note that the physioeconomic session framework depicted in Figure 5.3 allows for an optional questionnaire after each period of decision-making. In this experiment, however, the questionnaire is conducted after all 15 auctions have finished. The reason is that the perception questionnaire includes questions regarding the subjects' behavior and, therefore, may have an distorting influence in between the auctions.

point Likert scale. In order to reduce the impact of social desirability biases, each statement occurs twice with one statement being the reverse of the other. In particular, the questionnaire addresses the degree of excitement, competition, and arousal in the auction, but also whether participants set themselves a limit before the auction starts and if they tend to overbid or underbid this limit. The self-report questionnaire is provided in Appendix A.3. Further, the subjects' individual risk preference is assessed with the questionnaire of Holt and Laury (2002) in order to check whether there are differences in risk preferences across treatments.[17]

5.3.4. Procedure

The experiment was conducted at the Karlsruhe Institute of Technology (KIT) in Karlsruhe, Germany. Altogether, 17 female and 79 male students (96 in total, mean age = 22.64 years) participated in 16 sessions (6 students per session, 4 sessions per treatment). Subjects are randomly recruited from a pool of undergraduate students with an academic background in economics. During the whole experiment, participants' skin conductivity was recorded with a constant current amplifier measurement system and Ag/AgCl (silver/silver chloride) electrodes.[18] The electrodes were attached on the thenar and hypothenar eminences of the palm of the the non-dominant hand by use of standard EDA electrode paste (cf. Boucsein, 1992). Further, the measurement system recorded an electrocardiogram (ECG) for each subject, which was later transformed into tonic and phasic heart rates. All sessions were conducted within the period of three weeks with an average room temperature and relative humidity of 23.55 °C (74.39 °F) and 46.80%, respectively.

5.4. Hypotheses and Results

As outlined in the last section, the main interest of this experiment is (1) to provide the missing link between the utility of suspense hypothesis and actual physiological values of Dutch auctions, and (2) to further characterize the elicited emotional state bidders

[17] Based on the answers in the questionnaire and a dice, each subject received an additional monetary payoff Holt and Laury (e.g. 2002). In the experiment, subjects were on average slightly risk averse. Differences in risk preferences between treatments were not observed.

[18] For further information on the measurement system see Gharbi et al. (2008) and Appendix B.1.3.

experience and investigate how this emotional state is reflected in bidding behavior. In particular, the central claim is that fast clock speeds increase bidders' levels of physiological arousal and perceived competition, which in turn induces them to protract placing a bid. Based on the framework for emotional bidding and the reasoning of Section 5.3, the following subsections 5.4.1 to 5.4.4 outline the corresponding hypotheses and the results of the physioeconomic experiment.

5.4.1. Utility of Suspense

The model of Katok and Kwasnica (2008) conjectures that bidders experience fast Dutch auctions more exciting than slow Dutch auctions and, therefore, derive a higher *utility of suspense* per second in fast Dutch auctions. Following this reasoning, fast clock speeds should also be reflected in a bidder's current emotional state. More specifically, bidders should experience higher degrees of physiological arousal in fast Dutch auctions. This conjecture is reflected in hypothesis H1:

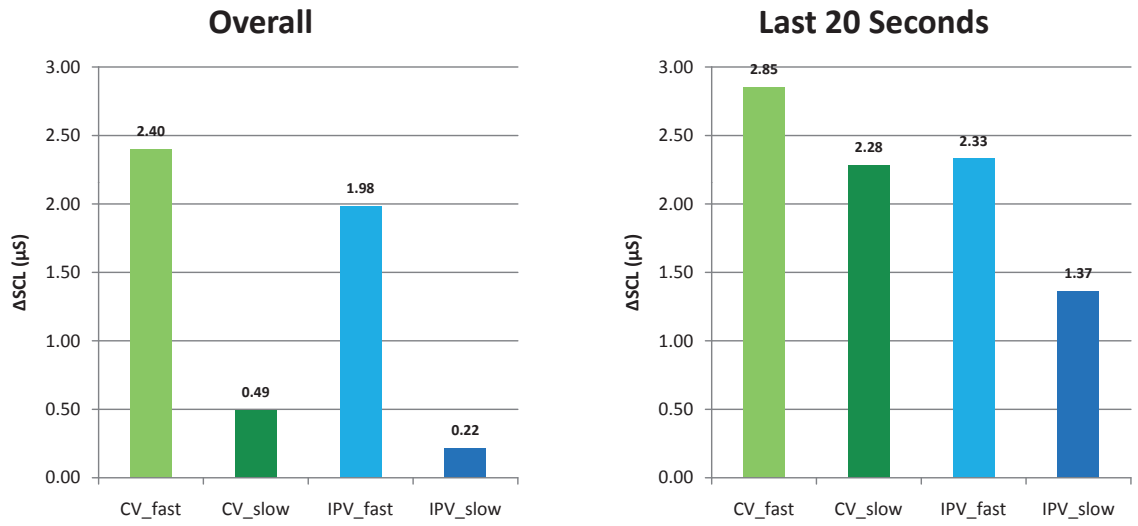
> **H1:** *The average level of physiological arousal is higher in fast in comparison to slow Dutch auctions.*

The hypothesis is subdivided into two sub-hypotheses. In particular, it is assessed whether physiological arousal in terms of skin conductivity and heart rate depends on the clock speed of the Dutch auctions:

> **H1a:** *The average skin conductance level (SCL) is higher in fast in comparison to slow Dutch auctions.*

> **H1b:** *The average heart rate (HR) is higher in fast in comparison to slow Dutch auctions.*

Regarding hypotheses H1a and H1b, Figure 5.4 and Figure 5.5 depict bidders average SCL and HR, respectively. Because these physiological parameters have an inherent between-subject variability (cf. Dawson et al., 2007), every SCL and every HR value is referenced separately for each subject to an individual basic level of physiological arousal (ΔSCL and ΔHR). The basic level is individually assessed for each subject based on the initial 5 minute rest period. The left part of the figures depicts the overall level of physiological arousal during the whole auction process. Both for SCL and HR, the



(SCL = skin conductance level, μS = microsiemens)

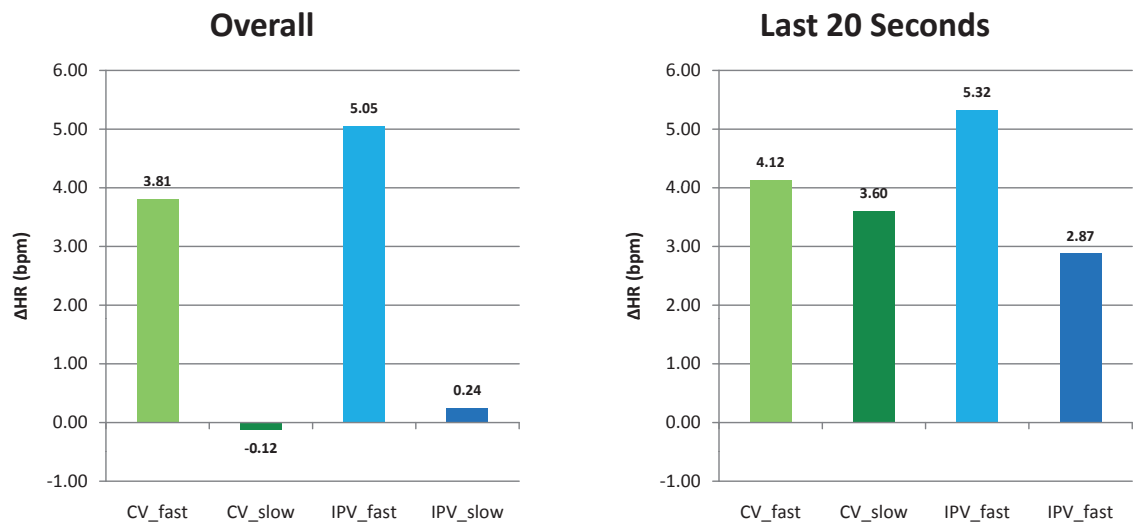
Figure 5.4.: Average SCL During the Auction Process

average level of physiological arousal is significantly higher for fast in comparison to slow Dutch auctions. Two-tailed t-tests confirm that the SCL is higher in the fast CV (2.40 vs. 0.49, $p < .001$) and IPV (1.98 vs. 0.22, $p < .001$) treatments, respectively. Equivalently, two-tailed t-tests confirm that the HR is higher in the fast CV (3.81 vs. -0.12, $p < .001$) and IPV (5.05 vs. 0.24, $p < .001$) treatments, respectively.

In contrast, the right part of Figure 5.4 and Figure 5.5 concentrates on the last 20 seconds of an auction. Again, two-tailed t-tests confirm that the SCL is higher in the fast CV (2.85 vs. 2.28, $p < .05$) and IPV (2.33 vs. 1.37, $p < .001$) treatments, respectively. Equivalently, a two-tailed t-test confirms that the HR is higher in the fast IPV (5.32 vs. 2.87, $p < .001$) treatment, respectively.[19]

Summarizing the physiological data over the whole auction process and the last 20 seconds of an auction, the results are in favor of hypothesis H1. Fast Dutch auctions induce a higher degree of physiological arousal in comparison to slow Dutch auctions. Thereby, this experiment provides the missing link between the utility of suspense hypothesis and actual physiological values of Dutch auction participants. Katok and Kwasnica (2008) *conjecture* that bidders experience fast Dutch auctions more exciting and, therefore, derive a higher utility of suspense. However, a direct link between clock speeds and excitement in Dutch auctions has not been provided before.

[19]However, the difference in HR for the last 20 seconds of a common value auction is not significant.



(HR = heart rate, bpm = beats per minute)

Figure 5.5.: Average HR During the Auction Process

Building on this first main result, the following subsections focus on further characterizing the elicited emotional state bidders experience (cf. Section 5.4.2) and investigate how this emotional state is reflected in bidding behavior (cf. Section 5.4.3 and Section 5.4.4).

5.4.2. Perceived Competition

After providing physiological evidence that the utility of suspense depends on the clock speed of Dutch auctions, I now focus on further characterizing the elicited current emotional state. The conjecture behind the experiment is that fast clock speeds induce a current emotional state, which is characterized by increased levels of physiological arousal and perceived competition. Following the terminology of Ku et al. (2005) and of Malhotra et al. (2008), this emotional state is referred to as "competitive arousal" in the following. The interaction of the clock speed and the current emotional state of a bidder is reflected in hypothesis H2:

> **H2:** *Fast Dutch auctions induce a higher degree of 'competitive arousal' than slow Dutch auctions.*

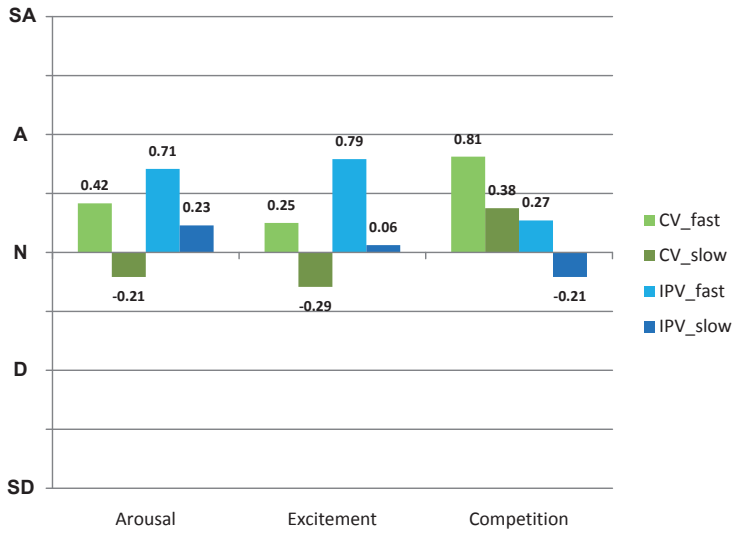
The hypothesis is subdivided into several sub-hypotheses. In particular, it is assessed whether the level of perceived arousal, competition, and excitement depends on the clock

speed of the Dutch auctions:

H2a: *The perceived level of arousal is higher in fast in comparison to slow Dutch auctions.*

H2b: *The perceived level of competition is higher in fast in comparison to slow Dutch auctions.*

H2c: *The perceived level of excitement is higher in fast in comparison to slow Dutch auctions.*



(SD = strongly disagree, D = disagree, N = neutral, A = agree, SA = strongly agree)

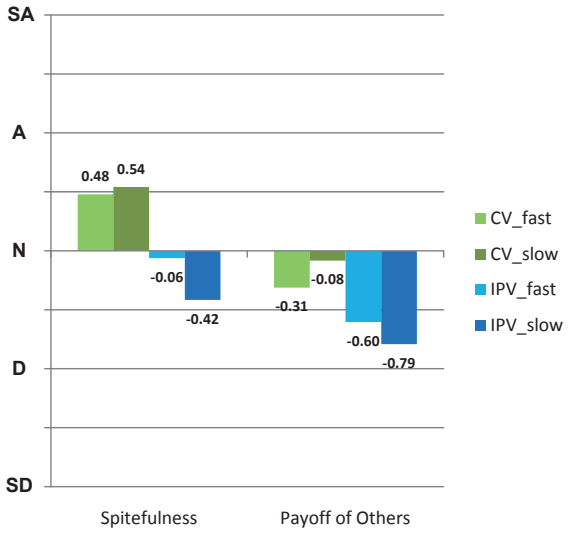
Figure 5.6.: Bidder Perception: Arousal, Excitement, and Competition

Regarding hypotheses H2a, H2b, and H2c, Figure 5.6 depicts bidders' perceived levels of arousal, competition, and excitement. Conducting 2 (value model) x 2 (clock speed) ANOVAs for perceived arousal and excitement shows that, similar to the objectively measured arousal, bidders report a higher degree of perceived arousal and excitement in the fast treatments.[20] Further, an ANOVA regarding the level of perceived competition reveals that on average bidders perceive fast Dutch auctions more competitive than slow

[20] Arousal: (value model: $F = 4.06$, $p < .05$; clock speed: $F = 9.32$, $p < .01$; interaction: $F = .16$, $p = .69$). Excitement: (value model: $F = 4.89$, $p < .05$; clock speed: $F = 9.84$, $p < .01$; interaction: $F = .21$, $p = .64$).

Dutch auctions.[21] Thus, the results of the self-report questionnaire are in line with hypotheses H2a, H2b, and H2c.

Summarizing the results of the physiological data in Section 5.4.1 and the self-report questionnaire, the null hypothesis can be rejected in favor of hypothesis H2. Therefore, I conclude that fast clock speeds induce a current emotional state which is characterized by increased levels of *arousal* and a stronger degree of *perceived competition*. Moreover, subjects also state that they are more excited in the fast treatments. Therefore, bidders really derive a *utility of suspense* from participating in fast Dutch auctions. By further investigating the physiological parameters, one can observe in Figure 5.4 and Figure 5.5 that the utility of suspense starkly depends on the current stage of the auction process. More specifically, bidders are particularly excited at the end of a Dutch auction.



(SD = strongly disagree, D = disagree, N = neutral, A = agree, SA = strongly agree)

Figure 5.7.: Bidder Perception: Spitefulness, Relevance of Other Bidders' Payoffs

Value Models. The main focus of the analysis is the impact of clock speed on bidders' arousal and perceived competition. However, it is also interesting to observe differences in bidders' emotional processing for different value models. Figure 5.6 indicates that bidders perceive a higher degree of competition in the CV treatments. This seems intuitive, as the commodity for sale has the same value to all bidders in the CV auctions.

[21] Competition: (value model: $F = 4.22$, $p < .001$; clock speed: $F = 2.78$, $p < .01$; interaction: $F = .59$, $p = .44$).

In contrast, a bidder with a high valuation in the IPV treatments has a comparatively high subjective probability of winning the auction and, thus, may perceive a lower degree of competition. Section 5.5.1 will focus specifically on the impact of induced valuations on bidders' emotional processing. Figure 5.7 depicts the degree of perceived spitefulness and how important the payoff of other bidders was for a bidder's own decision-making. The corresponding ANOVAs reveal that bidders are more spiteful in the CV treatments, i.e. they grudge other bidders a positive payoff (cf. Section 2.2.1). Further, the other bidders' payoffs gain a higher degree of importance for an individual bidder's decision-making in the CV treatments.[22] In contrast to the results presented above, however, spitefulness and the relevance of other bidders' payoffs are not affected by the clock speed of the Dutch auctions.

5.4.3. Preselected Bidding Strategy

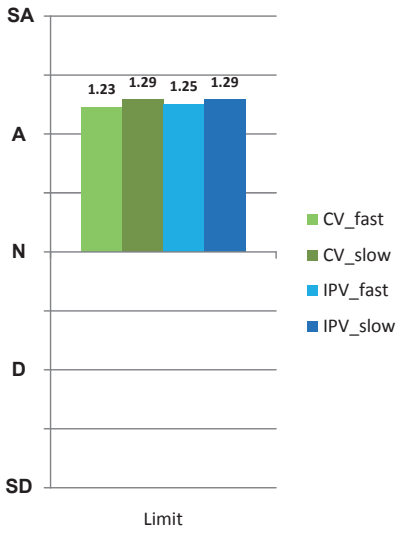
The analysis now focuses on how the elicited current emotional state is reflected in bidding behavior. In this regard, the central claim is that fast clock speeds in Dutch auctions can cause *auction fever*. As defined in Section 2.1.2, auction fever is an intense current emotional state elicited in the course of one or more auctions that distorts a bidder's preselected bidding strategy. Therefore, it first has to be assessed, whether bidders commit themselves to a bidding strategy before the auction starts. This translates into hypothesis H3:

> **H3:** *Bidders cognitively set themselves a price limit before the Dutch auction starts at which they intend to end the auction.*

It is important to note, however, that the preselected bidding strategy does not necessarily need to be derived by means of auction theory. As already observed by Vickrey (1961), some of the bidders may be "insufficiently sophisticated to discern the equilibrium-point strategy." In a rather behavioral approach, one can argue that bidders may set themselves a *price limit* by estimating a subjective valuation for the commodity and then heuristically deriving a corresponding bidding strategy (Ariely and Simonson, 2003). This is in line with the observation of an Internet survey conducted by Ku et al.

[22] Spitefulness: (value model: $F = 30.08$, $p < .001$; clock speed: $F = 1.27$, $p = .26$; interaction: $F = 2.04$, $p = .16$). Relevance of other bidders' payoffs: (value model: $F = 6.44$, $p < .05$; clock speed: $F = .01$, $p < .92$; interaction: $F = 1.12$, $p = .29$).

(2005). The authors report that 82% of the survey respondents set themselves a price limit prior to bidding.



(SD = strongly disagree, D = disagree, N = neutral, A = agree, SA = strongly agree)

Figure 5.8.: Bidder Perception: Setting a Preselected Price Limit

The results of the self-report questionnaire of my experiment with respect to setting a preselected price limit are depicted in Figure 5.8. The results show that independent of the value model and independent of the clock speed bidders on average agree that they *ex ante* set themselves a price limit at which they intend to place a bid and end the auction. A 2 (value model) x 2 (clock speed) ANOVA shows that differences in responses between treatments are not significant (value model: $F = .00$, $p = .95$; clock speed: $F = 8.88$, $p = .73$; interaction: $F = .00$, $p = .95$).

Therefore, the null hypothesis can be rejected in favor of hypothesis H3. Bidders in fact cognitively set themselves a price limit before the Dutch auction starts at which they intend to end the auction.

5.4.4. Bidding Behavior

In line with the framework for emotional bidding, the last sections showed that (H3) bidders *ex ante* set themselves a price limit at which they intend to end the auction, and (H1, H2) fast Dutch auctions induce a current emotional state which is characterized by increased levels of arousal and perceived competition. Again, the central claim is

that fast clock speeds in Dutch auctions can cause *auction fever*. Therefore, this section investigates whether the induced current emotional state distorts the preselected bidding strategy and leads bidders to place lower bids. This translates into hypothesis H4:

> **H4:** *The current emotional state in fast Dutch auctions causes bidders to protract placing a bid at their preselected price limit.*

This hypothesis is subdivided into three sub-hypotheses:

> **H4a:** *Fast Dutch auctions result in lower final prices than slow Dutch auctions.*
>
> **H4b:** *In fast Dutch auctions bidders tend to place bids below their preselected price limit.*
>
> **H4c:** *In fast and in slow Dutch auctions bidders do not tend to place bids above their preselected price limit.*

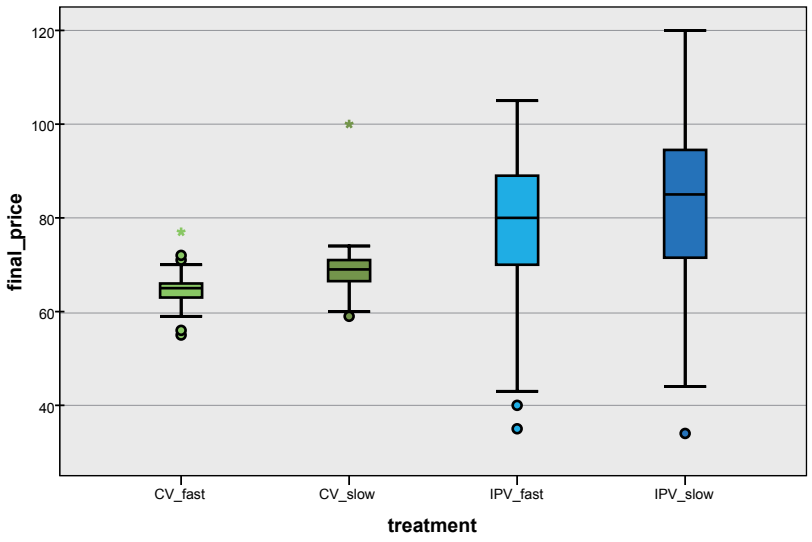
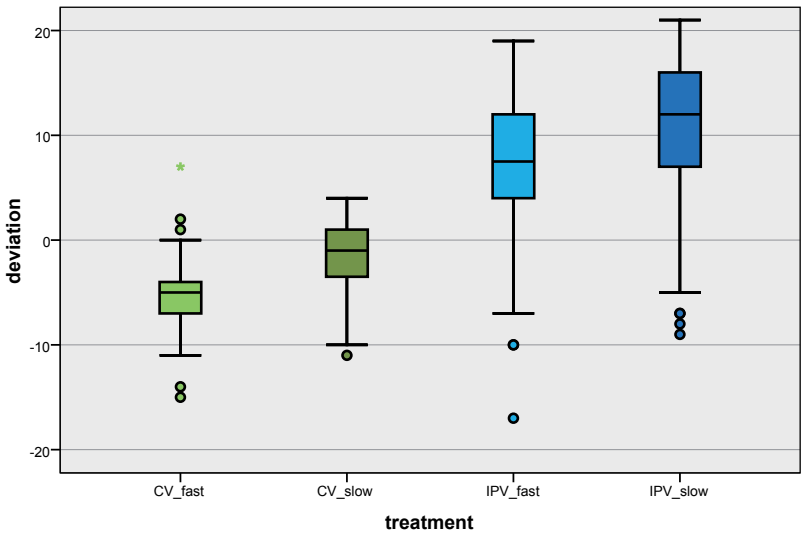


Figure 5.9.: Final Prices in the Dutch Auctions

The final prices of the auctions are presented in Figure 5.9. In the CV treatments, average final prices are 64.68 MU and 68.56 MU in the fast and slow setting, respectively (two-tailed t-test, $p < .001$). In the IPV treatments, average final prices are 77.99 MU and 82.43 MU in the fast and slow setting, respectively (two-tailed t-test, $p < .001$). The

results show that fast auctions yield significantly lower prices in both the CV and the IPV treatments. Therefore, the null hypothesis can be rejected in favor of H4a. While the IPV final prices replicate the results of Katok and Kwasnica (2008), the CV final prices show that the impact of clock speeds on the final prices holds *irrespective* of the value model.



(RNNE = Risk Neutral Nash Equilibrium)

Figure 5.10.: Deviations from the RNNE Bidding Strategy

Following economic theory and assuming risk neutral bidders, I will now focus on theoretical predictions of bidding behavior in the respective CV and IPV Dutch auctions. The deviations from the risk neutral Nash equilibrium (RNNE) bidding strategy are depicted in Figure 5.10.

CV Treatments. In the CV treatments, the resale value of the artificial commodity is the same for every bidder and uniformly drawn from the discrete interval $[46, 95]$ after the auction ended. Therefore, a risk neutral bidder (who also expects the other bidders to be risk neutral) will bid at a price of 70 MU in the unique symmetric Nash equilibrium: bids placed at any integer value above 70 MU would exceed the expected resale value of 70.50 MU and, therefore, incur an expected loss. Bids placed at any integer value below 70 MU will result in economic profits of zero, because one of the other two bidders, who placed their bid at 70 MU, will win the item. Consequently, if all three bidders intend to place their bid at 70 MU, the expected economic profit of each bidder is:

Table 5.2.: Estimation of the Empirical IPV Bidding Function

	IPV (fast)	Std. err.	IPV (slow)	Std. err.
β	.6784604***	.031571	.6497064***	.0431917
c	12.65028***	3.097043	19.74208***	4.246681
R-squared	.7964796		.6572489	
Observations	120		120	

$*p < 0.05$, $**p < 0.01$, $***p < 0.001$

$$\Pi^*_{CV} = \frac{1}{3} \cdot (70.5 - 70)$$

In the experiment, the winning bidders bid at 98% and 92% of the RNNE on average in the slow and fast treatment, respectively. Bids placed below the RNNE are consistent with bidder's risk aversion. The intuition is that risk aversion has two opposing effects in the CV auction. On the one hand, bidders would like to lower their bid in order protect them from overpaying the *ex ante* uncertain value of the commodity. On the other hand, lowering the bid increases the probability of losing. Thus, overall bidders will slightly adjust their bid downward. However, risk aversion cannot explain why participants of the fast treatment place bids which are on average 3.89 price increments below the average bid in the slow treatment.

IPV Treatments. Now consider the IPV auctions and suppose again that bidders behave according to the RNNE bidding strategy. Following the reasoning of Vickrey (1961), the equilibrium bidding strategy $b(v)^*$ is given by

$$b(v_i)^* = \frac{2}{3} \cdot (v_i - 20) + 20 = \frac{2}{3} \cdot v_i + \frac{20}{3},$$

where v_i is the individual resale value of bidder i.[23] Thus, the optimal bidding strategy follows a simple linear structure of the type $y = \beta \cdot v + c$, which can also be estimated from the experimental data. The results of the linear regression analysis are presented in Table 5.2.

In both IPV treatments, the slope of the bidding function closely resembles the optimal value of 0.66. However, the intercepts are significantly above those of the RNNE bidding

[23] The exact discrete bidding function, which takes the possibility of ties into account, may differ by at most one bid increment.

Table 5.3.: Estimation of the Intercepts with Fixed β Coefficient

	IPV (fast)	Std. err.	IPV (slow)	Std. err.
β	.66		.66	
c	13.78611***	0.5838331	18.10556***	0.8092157

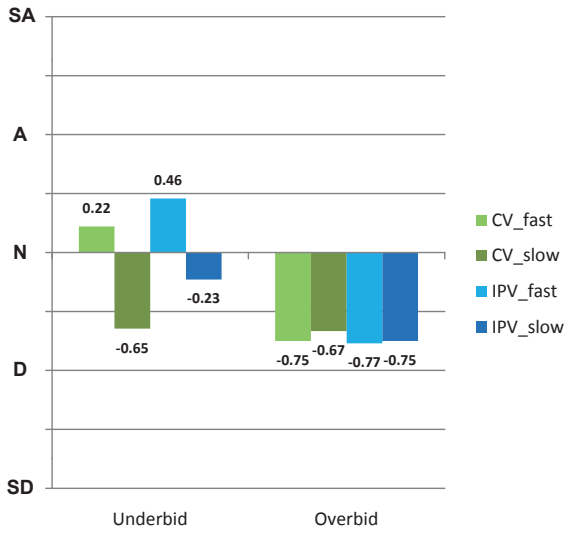
$*p < 0.05, **p < 0.01, ***p < 0.001$

strategy, which is in line with bidder's risk aversion. Contrary to the CV treatment, bidders face no uncertainty with respect to the resale value of the artificial commodity. Therefore, risk averse bidders tend to increase their bid compared to the risk neutral equilibrium in order to increase the probability of winning. Again, the difference of the intercepts ($19.74 - 12.65 = 7.09$) in the estimates for the slow and fast treatment cannot be explained by risk aversion. However, notice that the leverage of β is very large because it is only possible to observe the bids of the winning bidders, who have an average resale value of 96.49 MU and 96.31 MU in the slow and fast treatment, respectively. By repeating the estimation of the intercepts while fixing β at its theoretical value of $\beta = 0.66$, the remaining difference between the intercepts amounts to 4.31 MU. The results are summarized in Table 5.3. Alternatively, by simply comparing the means of the final prices, a similar price differential of 4.44 MU can be observed.

In the IPV treatments, bidders have different valuations for the auctioned off commodity. Therefore, some of the auctions may result in an inefficient outcome. The outcome of a Dutch auction is defined *efficient*, if the bidder with the highest valuation is the first bidder who accepts the current standing price and obtains the commodity. Both the fast and slow setting yield high efficiency ratios. Overall, 86.67% of fast and 89.17% of slow IPV auctions are efficient, respectively. Thus, only 13.33% and 10.83% of the auctions yield inefficient outcomes.

Bidder Perception. As discussed in Section 5.4.3, bidders *ex ante* set themselves a price limit at which they intend to end the auction. Figure 5.11 depicts the results of the self-report questionnaire with respect to the question whether bidders tended to *overbid* or *underbid* their preselected price limit. The results show that, irrespective of the value model and the clock speed, bidders do not tend to overbid their preselected bidding limit.[24] However, participants in the fast treatments generally confirm that they tend to

[24]Differences among treatments do not turn out to be significant for overbidding (value model: $F = .08$, $p = .77$; clock speed: $F = .08$, $p = .77$; interaction: $F = 0.03$, $p = .86$)



(SD = strongly disagree, D = disagree, N = neutral, A = agree, SA = strongly agree)

Figure 5.11.: Bidder Perception: Underbidding and Overbidding

underbid their price limit, i.e. they protract placing their bid.[25] Therefore, the results of the self-report questionnaire are in favor for hypotheses H4b and H4c.

Summary. Summarizing the results of the behavioral data and the self-report questionnaire, the null hypothesis can be rejected in favor of hypothesis H4. Therefore, I conclude that bidders *underbid* their preselected price limit in fast Dutch auctions. The price differences between the fast and slow treatments translate into an average bid protraction of about 4 price decrements in the fast Dutch auctions, i.e. approximately 2 seconds. In other words, when the standing price reaches the final price of the slow Dutch auctions, bidders wait about 2 seconds longer in the fast treatments before accepting the price. Moreover, I conclude that fast clock speeds induce *auction fever*. In fast Dutch auctions, bidders experience an intense current emotional state (H1, H2) that distorts (H3) a bidder's preselected (H4) bidding strategy. This is the second main result of this experiment.[26]

[25] Underbidding: (value model: $F = 4.45$, $p < .05$; clock speed: $F = 11.19$, $p < .01$; interaction: $F = 0.00$, $p = .96$)

[26] Recall, that the main interest of this experiment is (1) to provide the missing link between the utility of suspense hypothesis and actual physiological values of Dutch auctions, and (2) to further characterize the elicited emotional state bidders experience and investigate how this emotional state is reflected in bidding behavior.

5.4.5. Immediate Emotions on Auction Outcome

This section focuses on immediate emotions bidders experience when learning the auction outcome of a Dutch auction. As outlined in Section 2.3, the framework for emotional bidding suggests that revealing the auction outcome triggers immediate emotions as a "joy of winning," "winner regret," and "loser regret." Therefore, I test whether bidders indeed show psychophysiological signs of immediate emotions when learning the auction outcome. This translates into hypothesis H5:

> **H5:** *Upon learning the auction outcome of a Dutch auction, bidders experience an immediate emotion.*

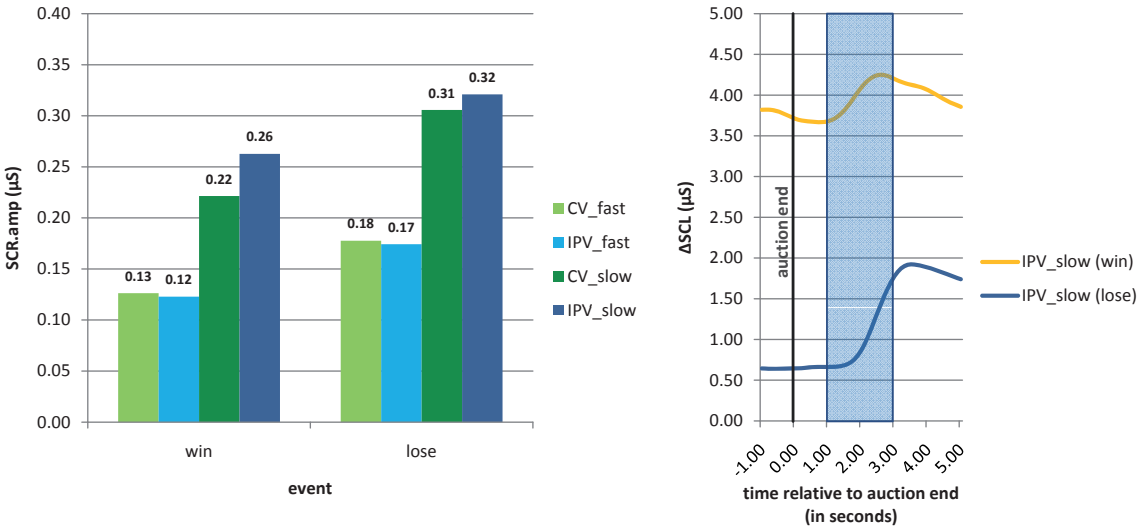
Concentrating on changes in emotional processing due to the clock speed and the auction outcome, hypothesis H5 is further subdivided into two sub-hypotheses:

> **H5a:** *Bidders processing of "loser regret" has a different intensity than that of the respective "joy of winning."*
>
> **H5b:** *Bidders' intensity of immediate emotions processing is different in fast Dutch auctions in comparison to slow Dutch auctions.*
>
> **H5c:** *Bidders' intensity of immediate emotions processing is different in common value in comparison to independent private value auctions.*

Filiz-Ozbay and Ozbay (2007) argue that bidders cannot experience "winner regret" in Dutch auctions, because "in the descending auction the winner never learns whether she would have won if she waited a bit more." In other words, it remains unknown, at what standing price the second highest bidder would have placed a bid. In contrast, so the authors, bidders can experience "loser regret," because the losing bidders are informed about the price at which the auction ended.[27] Therefore, the design of the experiment only allows for two possible emotions upon learning the auction outcome: "joy of winning" and "loser regret." H5a conjectures that these two emotions are processed with different intensities. Furthermore, as bidders have higher levels of arousal and perceive stronger competition in the fast treatments, hypothesis H5b conjectures

[27] Recall that loser regret is sometimes also referred to as "frustration of losing," respectively (e.g. Ding et al., 2005; Peters and Bodkin, 2007). Ding et al. (2005) argue that "anticipated regret is similar to [the] concept of anticipated frustration."

that bidders also process immediate emotions upon learning the auction outcome with different intensities. Finally, there may also be a different intensity depending on the respective value model. This conjecture is reflected in hypothesis H5c.



(SCR.amp = Skin Conductance Response Amplitude)

Figure 5.12.: SCR upon Winning and Losing

Bidders' log transformed skin conductance response amplitudes (SCR.amp) in response to the auction outcome are depicted in the left part of Figure 5.12. The SCR.amp is a proxy for the intensity of immediate emotions induced by a discrete stimulus (see Section 3.3.2). 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 0.01μS (cf. Fowles et al., 1981). All amplitudes smaller than 0.01μS are transformed to a value of 0μS in the analyses. 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).[28] Following the recommendation of Venables and Christie (1980), all SCR.amp values are then transformed $log(x+1)$ in order to reduce the inherent left skewness of skin conductivity. Exemplified for the IPV_slow treatment, the right part of figure Figure 5.12 shows the undecomposed skin conductance values. One can observe

[28]The website `http://www.ledalab.de` provides further information on the *Ledalab* skin conductance analysis software.

a response about 1 to 3 seconds after the auction end.

With respect to hypothesis H5, it is obvious that the SCR.amp is everywhere significantly different from zero (two-tailed t-test, $p < .001$). A linear regression based on the value model, the clock speed and the auction outcome provides support for hypotheses H5a. More specifically, bidders' SCR.amp values regarding "loser regret" are larger than the respective "joy of winning" values.[29] This confirms the results of Delgado et al. (2008), who found in a neuroeconomic experiment on the FPSB auction that bidders' behavior is actually more dominated by the anticipation of losing an auction than by the respective anticipated joy of winning.

Furthermore, the results also provide support for H5b. The intensity of immediate emotions is consistently stronger when the clock speed is slow, i.e. bidders respond stronger to the auction outcome in slow Dutch auctions. Therefore, while bidders experience higher levels of arousal and perceived competition in fast Dutch auctions, the actual end of the auction is perceived less intense than in the slow treatments. This is particularly interesting, when considering the differences in average nominal payoffs of the winning bidder. Recall that fast Dutch auctions yield lower final prices and, thus, on average a higher nominal payoff for the winner than slow Dutch auctions. Bidders respond stronger when winning a slow Dutch auction, although the average payoff is higher when winning a fast auction. Equivalently, bidders experience less immediate regret in the fast treatments, although the average amount of "money left on the table" (Engelbrecht-Wiggans, 1989) is higher. Finally, the null hypothesis cannot be rejected in favor of hypothesis H5c. Differences in emotional processing due to the value model are not significant.

Figure 5.13 depicts bidders perceived emotional processing regarding the auction outcome. In particular, bidders were asked to report (1) the degree of irritation they perceived when losing an auction, and (2) the importance of the non-monetary joy of winning in contrast to their nominal payoff. In other words, bidders were asked in the second question whether it is more important to win the auction than gaining a high payoff. On average, bidders report that they are slightly irritated when losing an auction and that they value the nominal payoff more than the non-monetary joy of winning in the Dutch auction, respectively. The results do not indicate a difference in bidder perception regarding neither the value model, nor the clock speed. This again underlines

[29] Details on the linear regression: (Value model: $p = .436$; Clock speed: $p < .001$; Winner: $p < .001$).

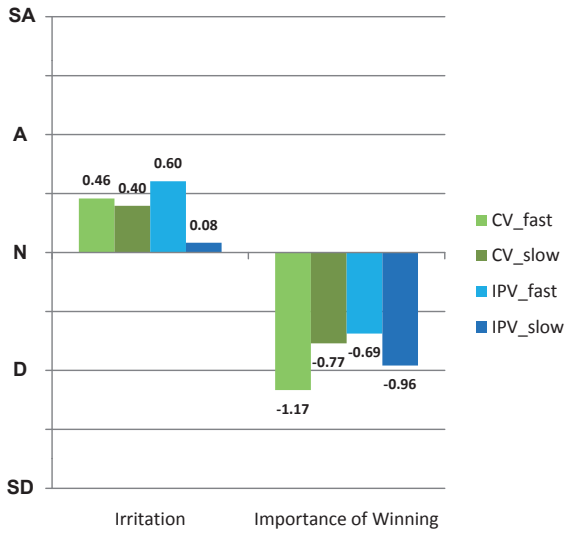


Figure 5.13.: Bidder Perception: Irritation of Losing, Importance of Winning
(SD = strongly disagree, D = disagree, N = neutral, A = agree, SA = strongly agree)

the advantage of physioeconomics. Measuring psychophysiological parameters allows for a more fine grained analysis of emotional processing in the moment emotions *actually occur*, while bidder perception questionnaires only allow for an *ex post* impression of subjective feelings.

5.5. Characteristic Patterns of Emotional Processing in Dutch Auctions

Based on the framework for emotional bidding, the last sections provided physiological evidence for a utility of suspense in Dutch auctions. Moreover, it has been shown that the elicited emotional state is characterized by higher degrees of perceived competition and excitement, which results in a distortion of the bidders' preselected bidding strategies. In contrast, the following subsections identify *characteristic patterns* of emotional processing in Dutch auctions. More specifically, Section 5.5.1 discusses how induced values in the independent private value (IPV) treatments affect bidders' emotional processing. Then, Section 5.5.2 focuses on the moment, when a bidder places a bid.

5.5.1. Induced Values and Bidders' Arousal

In the independent private value (IPV) treatments, bidders each receive an individual valuation for the artificial auctioned off commodity. This individual valuation is independently drawn, for each subject, from a uniform distribution with support on the discrete integer interval [21 MU, 120 MU]. Bidders are informed about their individual valuation before the auction starts. This subsection investigates, how inducing a bidder with a random private value influences her emotional processing.

Value Class	Value Interval	
HIGH	88 MU	120 MU
MEDIUM	54 MU	87 MU
LOW	21 MU	53 MU
Total Range	21 MU	120 MU

Table 5.4.: Value Classes for Bidders' Independent Private Values

For the analysis, bidders' randomly drawn independent private values are categorized into three different value classes: *LOW*, *MEDIUM*, and *HIGH*. As listed in Table 5.4, the three value classes segment the range of the value distribution into three intervals of almost equal size. By applying Bayes' rule, bidders can derive a probability function of having been induced with the highest valuation in the auction, which depends on the induced value (e.g. Krishna, 2002; Seifert, 2006).[30] If the bidders' individual bidding functions are symmetric and monotonically increasing in a bidder's private value, the probability of having the highest valuation is also the probability of winning the auction.

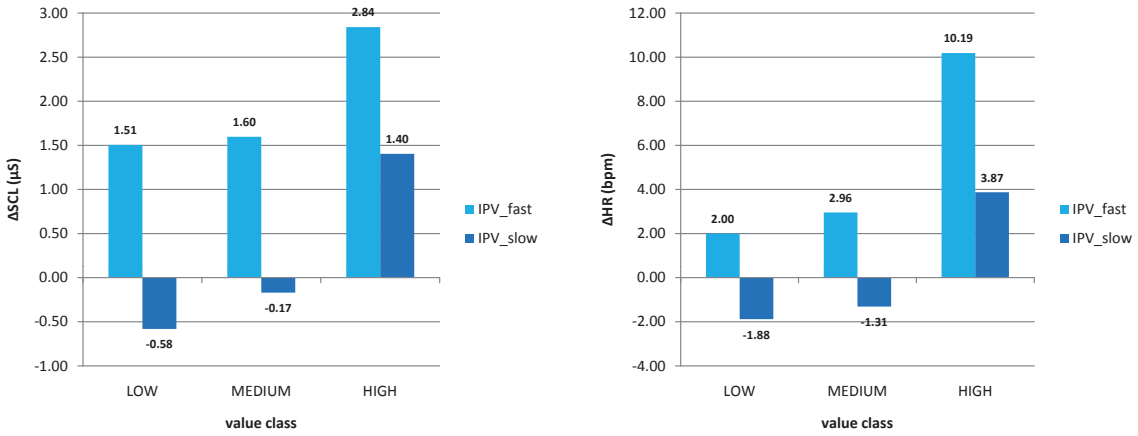
The conjecture of this subsection is that bidders' degree of physiological arousal is affected by their individual induced value. This conjecture is reflected in hypothesis H5:

> **H6:** *Bidders' degree of physiological arousal is higher for comparatively large induced independent private values.*

More specifically, when a bidder is induced with a value of the HIGH value class, she has a high probability of winning the auction. Therefore, she may also get more excited about participating in the auction. In contrast, when the bidder is induced with a value

[30] Note that the expected values of the first, second, and third order statistic lie in the respective value classes. The first, second, and third order statistic is the highest, second-highest, and third-highest induced value of the bidders in an auction (Seifert, 2006, p. 142).

of the LOW value class, she has a low probability of winning the auction. Consequently, she may also have a little degree of physiological arousal.



(SCL = skin conductance level, HR = heart rate, bpm = beats per minute)

Figure 5.14.: Level of Physiological Arousal for Different Value Classes

The average level of bidders' physiological arousal for the three different value classes is depicted in Figure 5.14. Referenced to the initial base period, the left part shows bidders' skin conductance level (SCL), while the right part shows bidders' heart rate (HR). Moreover, Figure 5.15 and Figure 5.16 show the curve progressions of the SCL and HR values, respectively, for the last 20 seconds of an auction.

Linear regressions for bidders' HR and SCL values reveal a significant impact of the clock speed and the value class on bidders' level of physiological arousal.[31] Therefore, the null hypothesis can be rejected in favor for hypothesis H6. Bidders have a higher degree of physiological arousal when they are induced with a comparatively high valuation for the auctioned off commodity.

As argued before, this effect presumably stems from the probability of winning an auction, which bidders derive from their individual resale value.[32] The physiological data shows that bidders are more excited in a Dutch auction, if they have a high individual resale value and, correspondingly, a high probability of winning the auction. When the

[31] Linear regression for skin conductance level (SCL): (Clock speed: $p < .001$; Value class: $p < .001$). Linear regression for heart rate (HR): (Clock speed: $p < .001$; Value class: $p < .001$).

[32] Note that it does not matter, whether bidders adequately apply Bayes' rule or not. Even if bidders cannot derive the exact probability of having the highest value, they can approximate whether it is comparatively high or low. This is also reflected in the different levels of physiological arousal for the three value classes.

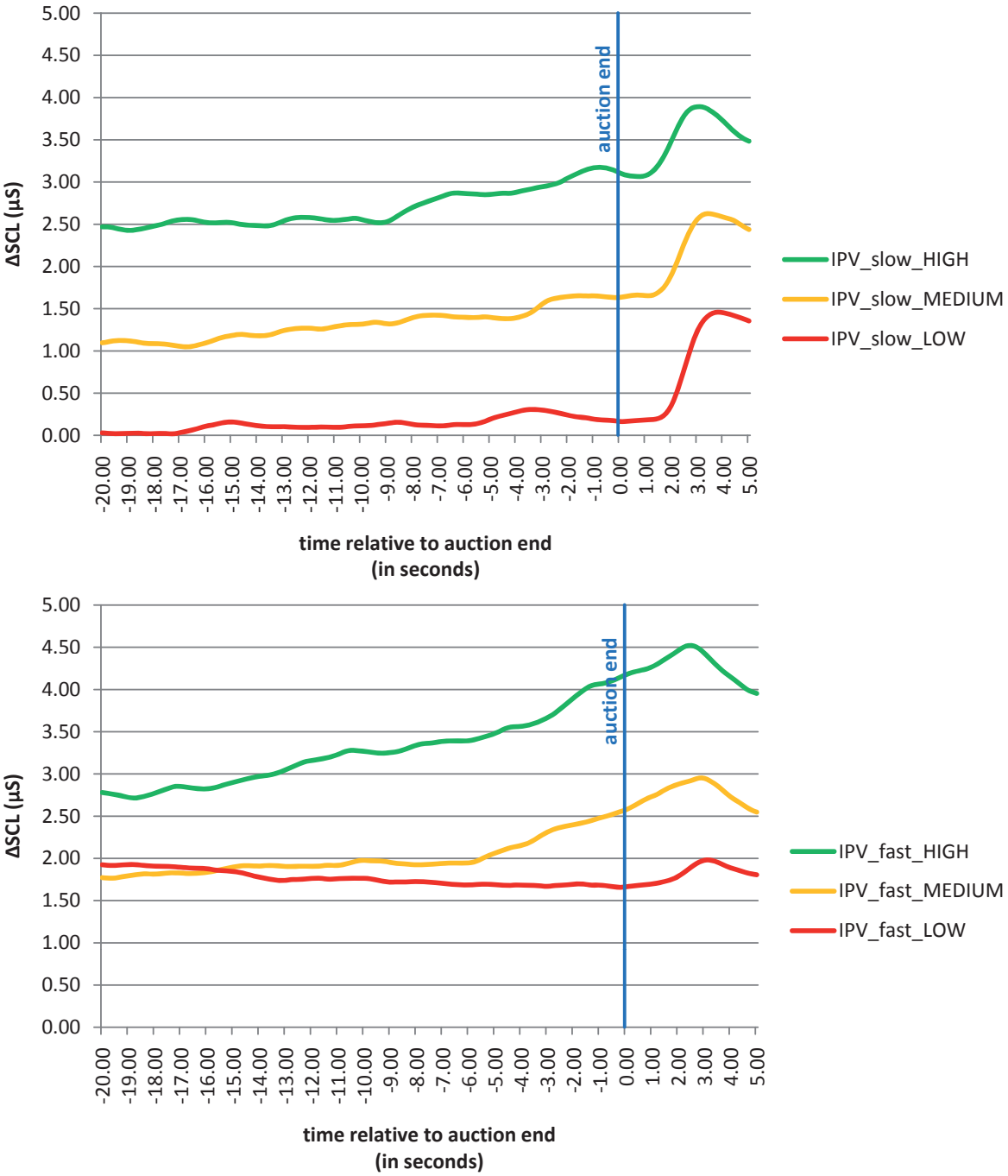


Figure 5.15.: Skin Conductance Level (SCL)

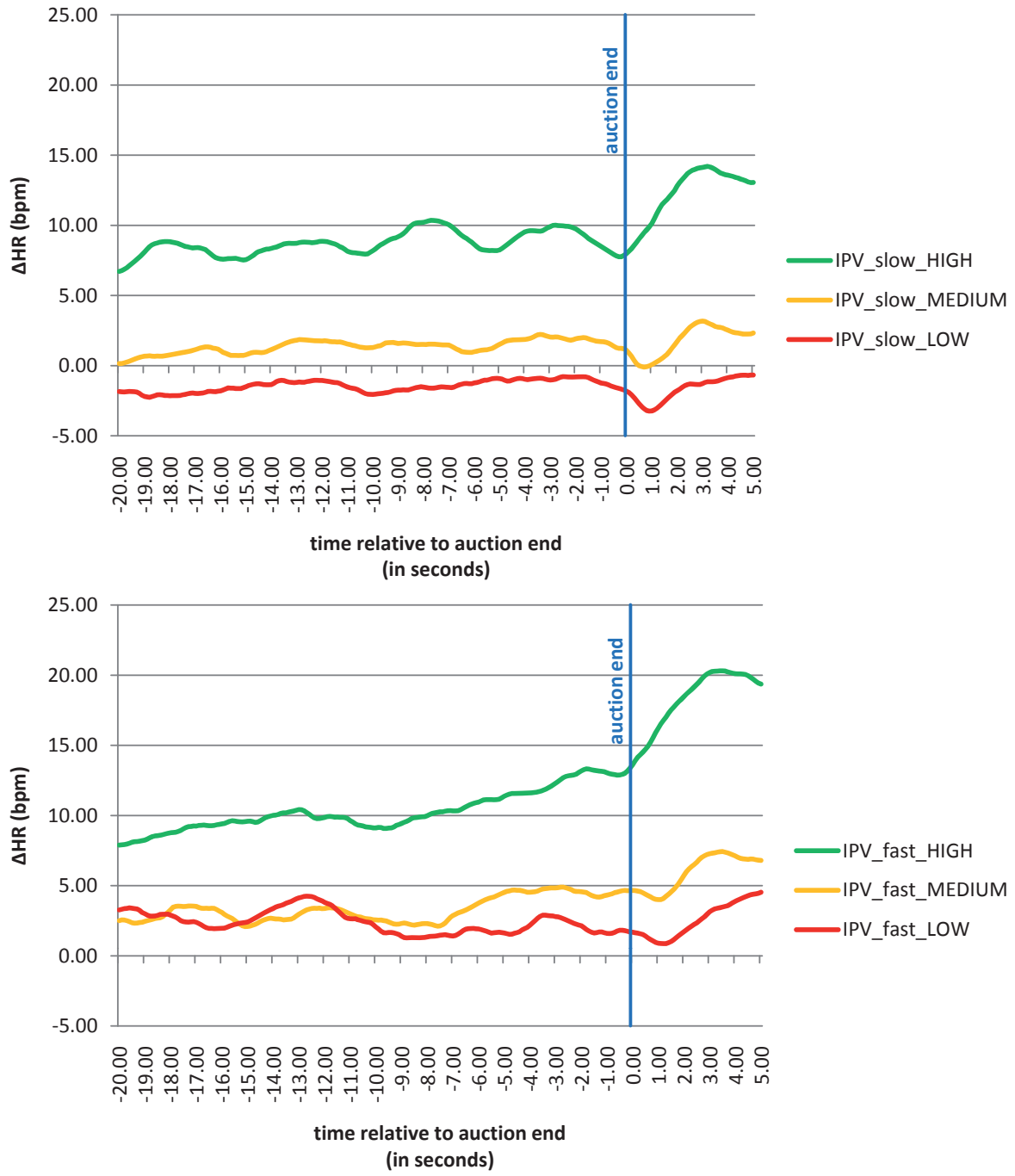


Figure 5.16.: Heart Rate (HR)

individual resale value is high, bidders also show a higher degree of physiological arousal. In contrast, when the individual resale value is low, bidders also show a lower degree of physiological arousal. Again, this effect is not reflected in the model of Katok and Kwasnica (2008). In their model, which also focuses on the independent private value case, the utility of suspense only depends on the time between two subsequent price steps and not on the induced valuation.

Along with the higher probability of winning goes also a higher expected payoff. However, the experimental design of the present study does not allow for distinguishing, whether the bidders' arousal is high in the HIGH value class because of (1) the higher probability of winning, (2) the higher expected monetary payoff, or (3) both. In the spirit of Cox et al. (1983), this can be investigated by varying the conversion rate between experimental monetary units and real money. The authors use different conversion rates to distinguish between the erroneous Bayesian updating and the utility hypothesis, and discard the utility of suspense hypothesis. Cox et al. base their reasoning on the assumption that the utility of suspense does not depend on the anticipated monetary payoff. However, the physiological data of the present experiment indicates that the anticipated payoff plays an important role for a bidder's level of excitement.

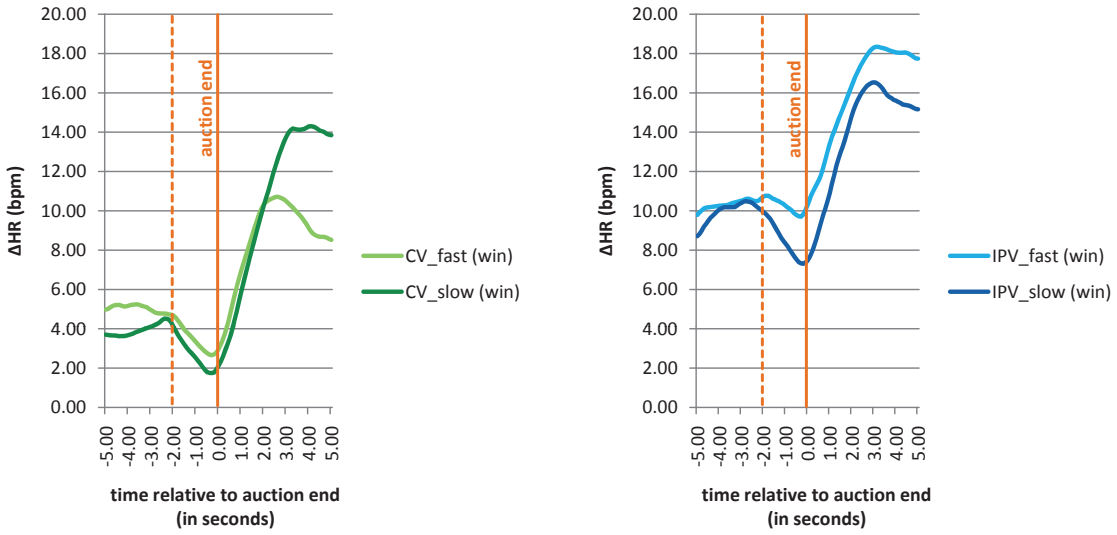
5.5.2. Preparation for Action

The following analysis focuses on the moment, when a bidder places a bid in a Dutch auction. As a single-unit Dutch auction ends as soon as the first bidder places a bid, this moment is also the single most salient and anticipated event in such an auction. Therefore, this moment has a strong influence on bidders' emotional processing. Section 5.4.5 investigated the intensity of immediate emotions in *response* to learning the outcome of a Dutch auction. In contrast, this subsection investigates emotional processing in the seconds directly *before* the winning bidder places her bid.

In particular, the analysis focuses on phasic[33] changes in bidders' heart rates based on their electrocardiogram. In this study, the heart rate is quantified by measuring the time between the peaks of two successive R-waves. In the literature, this time interval is referred to as *inter-beat interval (IBI)* (cf. Jennings et al., 1981). In order to be able to analyze phasic changes in bidders' heart rates, one has to very precisely identify

[33] As described in Section 3.3.2, the term *phasic* refers to quick changes in emotional processing, i.e. changes lasting for a few seconds. In contrast, the term *tonic* refers to ongoing changes.

every single heart beat of each bidder, by detecting the peaks of the corresponding R-wave. For the analysis, the IBIs are detected by using the *Open ANSLAB* analysis software (Wilhelm and Peyk, 2005).[34] However, as the phasic heart rate analysis is very sensitive to inaccuracies in the peak detection, the result of the peak detection is manually reviewed by inspecting single IBI anomalies.[35]



(HR = Heart Rate, bpm = beats per minute)

Figure 5.17.: Preparation for Action

The average heart rate of the winning bidder is depicted in Figure 5.17. Again, the heart rate of each subject is referenced to an individual basic level, which is assessed in the initial 5 minute rest period. The figure shows the heart rate in a 10 seconds time window, relative to the auction end, i.e. the moment when the bidder places her bid. One can observe that the heart rate drops about two seconds before the bid is actually placed. This effect occurs irrespective of the value model and the clock speed. Such a characteristic heart rate pattern signifies increased arousal and tension and is, for example, also observed in competitive rifle shooting (cf. Konttinen et al., 1998). This pattern occurs immediately *before* the bidder places her bid. In contrast, a physiological response in skin conductivity can only be observed *after* the auction ends (cp. Figure

[34] For further information regarding the *Open ANSLAB* physiological data analysis software, please refer to `http://www.psycho.unibas.ch`.

[35] For instance, the automatic R-wave peak detection may not detect a single peak. Then, there is a IBI anomaly, because the corresponding IBI is extraordinary big. This anomaly can be fixed by manually setting the missing peak.

5.15). As soon as the auction ended, the heart beats faster again.

The physiological data shows that bidders become very tense about two seconds before they actually place a bid. This indicates a "preparation for action" (Requin et al., 1991): bidders become tense and prepare for placing a bid. In consequence, their heart beats slower for an instant. Most interestingly, the time span of about 2 seconds also matches the average time of bid protraction reported in Section 3.3.2. Therefore, future research should also investigate, how the arousal induced by the preparation for action affects bidding behavior. Furthermore, the preparation for action effect may be helpful for developing intelligent decision support systems, which provide the decision-maker with a biofeedback. This biofeedback system could not only indicate high levels of tonic activation, but also abnormal changes in the inter-beat intervals. Additionally, it would be worthwhile investigating, whether this characteristic pattern depends on a bidder's expertise and performance. For instance, Pojman et al. (2009) finds differences in phasic heart rate activity in a study with expert and novice marksmen.[36]

5.6. Discussion

The main interest of this experiment was (1) to provide the missing link between the utility of suspense hypothesis and actual physiological values of Dutch auctions, and (2) to further characterize the elicited emotional state bidders experience and investigate how this emotional state is reflected in bidding behavior.

First, the chapter provides the missing link between the utility of suspense hypothesis and actual physiological values of Dutch auction participants. Previous studies argue that the effect of lower prices in fast Dutch auction stems from hedonic value bidders derive from auction participation. This hedonic value has been titled "utility of suspense" (Cox et al., 1982, 1983). Katok and Kwasnica (2008) *conjecture* that bidders experience fast Dutch auctions more exciting and, therefore, derive a higher utility of suspense. In this experiment, I provide physiological evidence for this conjecture and show that bidders have higher degrees of arousal in fast Dutch auctions.

Second, the chapter further characterizes the elicited emotional state and investigates how this emotional state is reflected in bidding behavior. Bidders perceive fast Dutch

[36] More specifically, Pojman et al. (2009) find in a rifle shooting task that novices have a stronger heart rate variability than experts, when they pull the trigger.

auctions more exciting and experience a higher degree of perceived competition. This emotional state may be referred to as "competitive arousal" (Ku et al., 2005). Moreover, fast clock speeds can induce *auction fever*. Bidders state that they cognitively set themselves a price limit before the Dutch auction starts. However, they consistently underbid this price limit in the fast treatments. In line with previous research, the results show that final prices are significantly lower in Dutch auctions with a fast clock speed. Furthermore, while the independent private value (IPV) auctions replicate the results of Katok and Kwasnica (2008), the common value (CV) auctions show that the impact of clock speeds on the final prices holds irrespective of the value model.

Third, I also provide physiological evidence that the market outcome is emotionally processed with respect to a joy of winning or a loser regret. Interestingly, the intensity of bidders' immediate emotions is consistently stronger in the slow treatments. Therefore, while bidders experience higher levels of arousal and perceived competition in fast Dutch auctions, the actual end of the auction is perceived less intense than in the slow treatments. Furthermore, the regret of losing an auction is stronger than the respective joy of winning an auction. This confirms the results of Delgado et al. (2008), who argue that bidders' behavior is actually dominated by the anticipation of losing an auction, and not by the respective anticipated joy of winning.

Moreover, Section 5.5 identified characteristic patterns of emotional processing Dutch auctions. First, inducing a bidder with an individual resale value for the auctioned off commodity has a direct impact on her physiological arousal. If a bidder is induced with a high value, she gets more excited about participating in the auction. In contrast, when the bidder is induced with a low value, she almost has the same level of arousal as in the initial 5 minute rest period. This effect presumably stems from the perceived probability of winning an auction, which bidders derive from their individual resale value. However, this effect is not reflected in the utility of suspense model of Katok and Kwasnica (2008). Second, about 2 seconds *before* a Dutch auction ends, the winning bidder's heart rate drops. This indicates a "preparation for action" (Requin et al., 1991): the bidder becomes tense and prepares for placing a bid.

Future research should further investigate the issue of clock speeds in Dutch auctions. Thereby, in particular the initial high price p_{max} and the conversion rate to real money can be systematically manipulated in addition to the clock speed. First, by changing the initial high price, the experimenter can question the conjecture of Katok and Kwasnica

(2008), whether "the same amount of enjoyment is garnered from the auction for each 'tick' of the clock". The physiological data of my experiment indicates that particular the end of a Dutch auction is perceived exciting. Second, by changing the conversion rates, the experimenter can further analyze whether the impact of induced values on a bidder's level of arousal stems from (1) the higher probability of winning, (2) the higher expected monetary payoff, or (3) both. In this regard, one can also investigate the assumption of Cox et al. (1983). The authors argue that the utility of suspense *does not depend* on the anticipated monetary payoff. In consequence, Cox et al. discard the utility of suspense hypothesis in favor for the erroneous Bayesian updating hypothesis. However, the physiological data of the present experiment indicates that the anticipated payoff plays an important role for a bidder's level of excitement.

Chapter 6.

Conclusion and Outlook

The question of how human individuals derive economic decisions is probably as old as economics. In recent years, particularly the interactions between emotional processing and cognitive reasoning have gained more and more attention. In the words of Thaler (2000), the traditional homo economicus is becoming "more emotional," i.e. economists devote more attention to the study of emotions and include emotional factors in their models of decision-making. The main goal of this thesis is to develop a structured methodology, which allows to systematically analyze how emotional processing and cognitive reasoning interact in electronic auctions. This chapter summarizes the main contributions of this thesis, discusses its implications, and outlines avenues for future physioeconomic research.

6.1. Contributions

The fundamental elements of the physioeconomic methodology are provided in Chapter 2 and Chapter 3. Chapter 2 focuses on how cognitive reasoning and emotional processing of human bidding behavior interact. A profound understanding of these dynamic interactions is essential for successful market engineering. This objective is reflected in Research Question 1.

> **Research Question 1:** *How do cognitive reasoning and emotional processing interact in deriving market decisions?*

Therefore, in Chapter 2, I propose a unified framework for emotional bidding in electronic auctions. In this framework, I combine the traditional perspective of auction

theory with the emotional processing induced by the auction system and environment, the auction events, and the auction outcome. Based on the framework, a definition for auction fever is derived: auction fever is defined as an intense current emotional state elicited in the course of one or more auctions that distorts a bidder's preselected bidding strategy. Definitions of auction fever in the literature cover a wide spectrum, ranging from overbidding an analytically optimal bidding strategy to mere descriptions of an intense emotional state. Therefore, a new definition is needed, which is based on the proposed framework. Moreover, Chapter 2 provides a detailed literature review on single elements of the framework for emotional bidding. Thereby, results from the literature are summarized of how bidding behavior is affected by emotional processing.

Chapter 3 focuses on how emotions can actually be *measured* in economic experiments. More specifically, this chapter investigates how emotions can be objectively recorded, by including physiological measurements in economic experiments. This translates into Research Question 2.

> **Research Question 2:** *How can economic laboratory experiments be augmented to allow for physiological measurements as proxies for emotional processing?*

I develop a methodology called *physioeconomics*. Physioeconomics extends existing methods of experimental economics by measuring autonomic nervous system activity using well-established psychophysiological methodology, in order to gain a profound understanding of the dynamic process of human economic decision-making. Experimental economics provides a well-established methodology for analyzing human behavior in economic decision-making. Therefore, the paradigms underlying experimental economics methodology should consequently also be adhered to in physioeconomic experiments. Chapter 3 discusses physiological parameters for their use in economic experiments and identifies in particular skin conductivity and heart rate. These parameters allow for assessing the (tonic) arousal of a subject's current emotional state, as well as the intensity of (phasic) responses to single events. Then, a physioeconomic session framework is proposed, in which methodological implications are reflected for conducting such experiments. Importantly, it has been pointed out that physiological measurements have to be accompanied by a sophisticated experimental structure and complementary questionnaires, in order to identify specific emotions and their valence. Finally, the chapter

provides a detailed literature review of experiments with an economic focus, which already apply physiological measurements.

Based on the foundations of Chapter 2 and Chapter 3, the following chapters describe *how* the framework for emotional bidding and the newly developed physioeconomic methodology can be used to systematically investigate emotions and their impact on bidding behavior in electronic auctions. Chapter 4 focuses on Research Question 3, i.e. on the case of auction fever in ascending electronic auctions.

> **Research Question 3:** *Is the newly developed physioeconomic methodology suitable to measure emotional processing in electronic auctions?*

I introduce a basic ascending auction framework for physioeconomics in Chapter 4, which is an instance of the physioeconomic session framework discussed in Chapter 3. The basic framework allows for a series of variations, for instance introducing different degrees of time pressure, perceived ownership, and previous investments. Thereby, single elicitors of auction fever can be investigated both in isolation as well as in combination. Finally, a proof-of-concept study is presented, which shows that changes in auction design parameters of the proposed framework can actually result in significant changes in bidders' physiological processing and behavior.

In contrast to Chapter 4, which focuses specifically on ascending auctions, Chapter 5 addresses Research Question 4 and concentrates on descending auctions. In particular, it provides physiological evidence for a "utility of suspense" (Cox et al., 1982, 1983) in Dutch auctions.

> **Research Question 4:** *Can the methodology of physioeconomics provide physiological evidence for a utility of suspense in Dutch auctions?*

Consistently with previous research, the results of the experiment in Chapter 5 show that fast Dutch auctions yield lower final prices than slow Dutch auctions. Moreover, I show that this effect does not only hold for independent private values, but also for common values. Previous studies argue that this effect stems from hedonic value bidders derive from auction participation (Cox et al., 1982, 1983; Katok and Kwasnica, 2008). Indeed, in my experiment bidders have higher degrees of physiological arousal and perceive the auctions more exciting in the fast treatments. In particular, I find evidence that the utility of suspense stems from the clock speed and the current stage of the

auction process. Bidders are more aroused in fast auctions and especially in the final stages of an auction. Furthermore, the data reveals that bidders tend to underbid their preset price limit in fast Dutch auctions. Moreover, Chapter 5 identifies characteristic patterns of bidders' emotional processing in Dutch auctions. More specifically, it has been shown that (1) inducing a bidder with a resale value influences her level of arousal, and (2) the heart rate of the winning bidder momentarily decreases about two seconds before she places her bid.

6.2. Implications

Weinhardt et al. (2003) argue that apart from the market engineer, a number of further stake holders is involved in electronic markets: the sellers, the buyers, the regulators, and the providers of complementary services. Accordingly, this thesis has important implications for a variety of interest groups. These implications will be discussed in the following.

6.2.1. Market Engineering

The success of electronic market design crucially depends on a profound understanding of the behavior of market participants. When taking into account the emotional processing of market participants, the market engineer faces two important challenges, regarding both the auction mechanism design and the user interface design. First, how can the auction system *induce* emotionality and, thus, attract excitement oriented consumers? As described in Section 2.4.2, emotions are, for a substantial part of the bidders, an important incentive for participating in Internet consumer auctions. With respect to the competition between market platforms, it will therefore be increasingly important for market places to distinguish themselves by *how* products are sold. In particular in consumer markets, emotionless and unexciting market models will hardly have the potential to draw the attention of (new) customers and eventually end up as losers in this highly competitive business segment. Second, what is the *impact* of emotionality on bidding behavior, and subsequently, on the auction outcome and seller revenue?

In order to approach both challenges, this thesis provides a structured methodology for systematically *measuring* emotions in electronic auctions. Particularly, the framework for ascending auctions introduced in Chapter 4 allows for systematically analyzing single

elicitors of auction fever in isolation as well as in combination. Thereby, physioeconomic experiments can also help to enrich or stress-test economic models.[1] With explicit focus on integrating emotional factors into economic models, Engelbrecht-Wiggans and Katok (2007) note: "To the extent that auction theory is there to guide auction designers, accepting a model that fits some data without clearly understanding why it does may lead to poor designs" (Engelbrecht-Wiggans and Katok, 2007). As described in Section 5.5, the measurement of physiological parameters can help identifying characteristic patterns of human emotional processing in auctions and, thereby, gain a deeper understanding of the underlying emotional processing. For instance, inducing bidders with an independent private value has a direct impact on her level of arousal. However, this effect has not been reflected in models of the utility of suspense so far (Cox et al., 1982, 1983; Katok and Kwasnica, 2008).

6.2.2. Auction Participants

Auction participants can be distinguished into the buyers and the sellers. On the one side, the sellers want to maximize their revenues and attract auction participants. As argued before, particularly buyers in Internet consumer auctions are often attracted by the hedonic value they derive from auction participation. However, some sellers may want to explicitly minimize the impact of emotions, e.g. in government spectrum license auctions. Physioeconomic experiments can contribute to developing exciting auction mechanisms and systematically analyze how this emotionality is reflected in final prices. For instance, Chapter 5 shows that a high clock speed induces higher levels of arousal and lower final prices in Dutch auctions.

On the other side, a profound understanding of how emotional processing and cognitive reasoning interact is also important for the buyers in an auction. For instance, Sokol-Hessner et al. (2008) show that decision behavior and emotional processing significantly change when bidders are told to "think like a trader." In this vein, being aware of behavioral biases and avoiding such situations can help bidders, and their respective principals, to prevent getting caught up in auction fever. Similarly, bidders can gain strategic advantages by knowing behavioral biases of their competitors.

[1] Similarly, Rubinstein (2001) notes with respect to experimental economics: "Experimental economics provides us with a safeguard which protect us from mistaken intuitions. An economist's intuition is often distorted by his own model's assumptions."

6.2.3. Complementary Service Providers

Measuring bidders' physiological parameters may also be used to provide bidders with a biofeedback. In this vein, skin conductivity and cardiovascular activity can be integrated by complementary service providers into a sophisticated decision support system. For instance, a bidder on eBay may be warned when her level of arousal reaches an individual threshold. As a matter of fact, at the end of 2009, the electronics company Philips announced developing a biofeedback system for financial traders based on skin conductivity. In a joint project with the Dutch bank ABN AMRO, Philips seeks to "mitigate the negative effect that emotions may have on financial decision-making processes" (Royal Philips Electronics Inc., 2009). In the corresponding concept study, the trader is equipped with a bracelet, which measures skin conductivity. The bracelet transmits the physiological data to an illuminated bowl, "a saucer-like object which displays a moving pattern to illustrate the user's mood" (The Economist, 2009). When the bowl turns into a deep red color, the trader is advised to take a break and cool down. Going one step further, such a biofeedback decision support system may also integrate auction events and bidders' physiological responses. With respect to perceived ownership, for instance, a bidder may be warned, when she has an individual high physiological response to the event of having been outbidden in an auction. The methodology introduced in this thesis provides the basic elements for such a technology.

6.2.4. Regulators

Emotional aspects of human bidding behavior also have important implications for the regulators of electronic markets. Apparently, legal scholars already debated in ancient Rome, whether auctions were void if the winner was infected by "bidder's heat" (Malmendier, 2002). However, as Roman law provides the basis for many legal system in Europe, including Germany, similarities can be found in the current legal situation. Concerning German law, for instance, Heiderhoff (2001) argues that time pressure in Internet consumer auctions and uncertainty about the behavior of other bidders may foster "irrational" bids.[2] Following this reasoning, and taking into account that bidders cannot physically inspect the item, Heiderhoff (2001) argues that bidders are inherently

[2] I would like to thank Tim Klümper for pointing out this insightful legal perspective of auction fever to me. Again, this shows that emotions in electronic auctions call for an interdisciplinary approach, comprising multiple disciplines.

disadvantaged in Internet consumer auctions.[3] Therefore, so the author, a bidder should be able to withdraw from the contract of sale (cf. §119 (1) German Civil Code). Heiderhoff even claims that, under extreme circumstances, the contract can be void by *violation of morality* (cf. §138 (1) German Civil Code). In particular, this applies if the bidder's "weak will" is exploited by the seller.[4]

In this respect, the high levels of arousal elicited in the course of auctions may impair a bidder's ability to decide with free will, or a bidder may take a different decision if she was not experiencing this arousal. Physioeconomic experiments can provide the regulators of electronic markets, as well as judges concerned with law suits, with insightful data of how emotional processing interferes with decision-making in electronic auctions. This has important implications for the design of electronic auctions, as well as for consumer rights, and opens interesting questions for future research.

6.3. Outlook

This thesis provides the main elements to systematically measure emotions and their impact in electronic auctions. Based on the framework for emotional bidding, future research can investigate interactions between cognitive reasoning in physioeconomic auction experiments. In particular, single elicitors of auction fever, as for instance perceived competition (e.g. Heyman et al., 2004; Ku et al., 2005), previous investments (Ku, 2008; Park et al., 2008), and perceived ownership (Heyman et al., 2004; Ehrhart et al., 2008), can be systematically analyzed, isolated as well as in combination. Moreover, there are challenges for future research on emotions in auctions, which have only gained little attention in the literature at this stage and are, therefore, frequently neglected. These challenges, along with how physioeconomic auction experiments can contribute to resolving them, will be discussed in the remainder of this thesis.

[3] In particular, Heiderhoff (2001) refers to the legal term "situative Unterlegenheit."

[4] Heiderhoff (2001) uses the legal term "gezielte Ausnutzung von Willensschwäche" in this context. If the contract is void by violation of morality ("Sittenwidrigkeit"), the contract never existed. In contrast, if the bidder is able to *withdraw* from the contract of sale, she can be made responsible for costs that occurred because the seller could not sell the item to someone else.

6.3.1. Interdependent Utilities

The degree of rivalry increases *ceteris paribus* along with the number of bidders in an auction (cf. Section 2.2). However, rivalry can also become more intense, when a bidder's utility does not only depend on her own individual monetary gains and losses, but also on the utilities of other bidders. This concept of utility is usually referred to as "interdependent utilities" (e.g. Schall, 1972; Bault et al., 2008). For instance, subjects may develop personal rivalries with other individuals and perceive feelings of envy or gloating (Smith et al., 1996). In the context of auctions, the literature has identified in particular "spitefulness" and (non-monetary) "joy of winning" as sources for such interdependencies.

Bidders' utility functions which exhibit such interdependencies can result in "head-to-head battles" (Ku et al., 2008) among a small (sub-)group of bidders. In a survey among bidders participating live auctions, Johns and Zaichkowsky (2003) observe a U-shaped dependency between the number of bidders and the degree of rivalry. In auctions with only two active bidders, the authors state that "the bidding war was more personal." However, when an auction attracted a large number of active bidders, there is a "race to bid on and win the item." In contrast, Ku et al. (2005) argue that rivalry is particularly intense when only two bidders compete in a single auction. Based on data from a laboratory experiment, the authors report that bidders experience higher levels of self-report arousal and place higher bids in high rivalry treatments, i.e. when bidders face one single opponent in comparison to facing eight other individuals. Thus, so the authors conclude, rivalry and arousal seem to be higher with few rather than with many bidders. These observations seem to be contradictory to the statement above that rivalry increases *ceteris paribus* along with the number of bidders. However, when taking interdependent utilities into account, one may conjecture an interaction between the degree of utility interdependencies and the number of bidders.

As depicted in Figure 2.2 in Section 2.3, the immediate emotions upon winning and losing an auction can be distinguished into (1) emotions regarding the monetary payoff and (2) emotions regarding the social competition.[5] Both categories of emotions play an important role for human decision-making in auctions (e.g. Delgado et al., 2008; Engelbrecht-Wiggans and Katok, 2008). However, the phenomenon of auction fever seems to be particularly depending on emotions regarding the social competition. For

[5]Recall that interdependent utilities are an inherent characteristic of the social competition.

instance, Häubl and Popkowski Leszczyc (2004) argue that for the experience of auction fever, it is a necessary condition "that an auction participant competes directly with other human bidders." Heyman et al. (2004) refer to this phenomenon as the "opponent effect" and Delgado et al. (2008) argue that actually the "fear of losing the social competition" inherent in auctions is responsible for overbidding.

Engelbrecht-Wiggans and Katok (2008) intentionally exclude emotions regarding the social competition by letting subjects compete with computerized agents.[6] Engelbrecht-Wiggans and Katok argue that "theories [of spitefulness] require inter-personal comparisons and, therefore, cannot explain similar behavior by subjects who were bidding against computerized rather than human competitors." Following this reasoning, the experimenter can investigate the impact emotions originated in interdependent utilities, by benchmarking human behavior when bidding against computerized agents with bidding against human individuals. This seems to be a promising approach for investigating the significance of interdependent utilities for auction fever. The actual intensity difference of emotional processing can then be simultaneously assessed with physiological parameters and the methodology of physioeconomics.

6.3.2. Product Characteristics

Ariely and Simonson (2003) argue that the occurrence and degree of auction fever is subject to the specific characteristics of the auctioned item, e.g. "whether the product offered is such that the allure of its low starting price has the potential to generate emotional involvement."[7] At this stage, there has been little research on how the phenomenon of auction fever depends on product characteristics. This research question is particularly important, however, because the literature on auction fever analyzes auctions ranging from retail products, such as electronic equipment, to collectibles, such as

[6] It is important to note here that Engelbrecht-Wiggans and Katok (2008) explicitly tell subjects that they compete against computerized agents. In contrast, similar studies deceive subjects by telling them that they are bidding against human individuals while they are actually competing against computerized agents (e.g. Häubl and Popkowski Leszczyc, 2004; Ku et al., 2008). Regarding this procedure in auction experiments, Ockenfels et al. (2006) criticize that it remains unclear to what extent participants "will actually believe any part of the information they are given," if the subject pool has been exposed to deception in experiments before.

[7] The conjecture that characteristics of the auctioned commodity have an impact on the degree of auction fever is supported by the observation of Lee and Malmendier (2010). The authors report that the amount of overbidding in eBay auctions depends on the product category, with proportions of overbidding ranging "between 30% and 60% for most categories."

one-cent coins and fiberglass cows (cf. Ku et al., 2005; Lucking-Reiley et al., 2007).

In particular, I conjecture that a product's value, scarcity, and public interest play an important role for the occurrence of auction fever. First, if the value of the item is comparatively high, this affects bidder's individual involvement and, thus, arousal. For instance, Ku et al. (2008) report that bidding behavior is more aggressive when stakes are high by manipulating conversion rates. The perceived loss of the current high bidder in the event of being outbidden is probably higher when stakes are high. Second, Smith (1990) argues that bidders are often uncertain about their own product valuation. In this respect, Lucking-Reiley (1999) notes that this uncertainty inherently increases in Internet auctions, where bidders' information regarding product quality and seller reliability is rather limited and biased. Third, product scarcity affects rivalry among bidders. For instance, Hou (2007) argue that a long auction duration only then positively affects the endogenous number of bidders, if scarcity is sufficiently high and bidders do not have "more options at any point of time."

A promising approach for analyzing the influence of product characteristics seems to be auctioning off real world commodities, or "real goods," in laboratory experiments (Kahneman et al., 1990). While the theory of induced values is a well-established methodological approach to induce real world behavior, one can also directly auction off real goods. Kahneman et al. (1990) conduct a now famous auction experiment in which participants can place bids on coffee mugs.[8] In another well-known auction experiment comprising real goods, Lucking-Reiley (1999) conducts a controlled field experiment. In particular, the authors auction off collector cards. Ehrhart et al. (2010) conduct a laboratory experiment comprising real goods to investigate the effect of perceived ownership on bidding behavior, by auctioning off USB mass storage devices. The authors argue that it is particularly important to properly choose the auctioned commodity when conducting economic experiments with real goods. Therefore, before running the laboratory experiment, Ehrhart et al. initially conduct a survey study to assess which objects are actually appropriate.

One main advantage, so Ehrhart et al. (2010), for using real goods in auction fever

[8]Kahneman et al. (1990) analyze the endowment effect, i.e. effect of actual ownership, by endowing coffee mugs to one half of the participants (sellers), while the other half (buyers) receives no coffee mugs. Sellers and buyers can then exchange the coffee mugs through a double-sided auction. The authors report that the average price a seller is willing to accept (WTA) for a coffee mug is significantly larger than the average price a buyer is willing to pay (WTP).

experiments is that subjects can actually develop a psychological attachment with an object, which is not or not to this extent the case for money.[9] Going one step further, it would now be particularly interesting to use real world commodities for identifying those product characteristics which actually mediate psychological attachment. Therefore, I believe that using real world commodities is a promising approach for investigating auction fever. The actual differences in emotional processing can then be assessed with physiological parameters and the methodology of physioeconomics.

6.3.3. Emotional State Induction

Traditionally, economic laboratory experiments are conducted in a controlled, clinical environment (Guala, 2005). However, Bosman and van Winden (2002) report that a subject's "emotional state systematically influences bidding behavior." More specifically, in this study subjects are asked to report their current emotional state *before* taking part in an auction. Therefore, and with respect to the emotional bidding framework, future research should take into account how external influences, i.e. influences which are not directly related to the bidding task, affect emotional processing and bidding behavior.

More specifically, one can investigate the influence of inducing a specific current emotional state, by using methodologies of emotion psychology. Thereby, one can analyze more specifically *if* and under *which circumstances* an unrelated arousal has an impact on bidding behavior. Such an emotional state can be induced, for instance, by means of videos (Rottenberg et al., 2007), pictures (Bradley and Lang, 2007), music (Eich et al., 2007), or tasks proceeding the actual experiment (Roberts et al., 2007). For instance, the experimenter can show videos of sport events in between the auctions to induce a competitive atmosphere.

6.3.4. Bidder Heterogeneity

As discussed in Section 2.4, auctions are particularly sensitive to heterogeneities among consumers, as they "systematically pick those buyers as winners" who have a tendency to overbid (Lee and Malmendier, 2010). This amplification effect leverages behavioral biases among bidders and disproportionally pronounces the behavior of even a small

[9] This is in line with the observation of Wolf et al. (2008), who find that even the time a bidder has for observing the item plays an important role for developing her attachment.

group of bidders. For instance, bidders can be categorized based on their personality and their expertise. Future research on emotions in auctions should also put more focus on identifying systematic differences in bidding behavior and emotional processing, which can be linked to differences in personality or expertise.

First, standardized questionnaires of personality psychology can be used to categorize bidders according specific personality traits (McCrae and Costa, 1999) or their ability to regulate emotions (Gross and John, Oliver P., 2003). Second, experienced bidders may also have a different pattern of emotional processing. Regarding economic decision-making in general, Falk and Heckman (2009) note that "it is an empirically interesting question how experience, learning, etc. affect behaviors." Specifically for the case of electronic auctions, the phenomenon of auction fever seems to be less prominent for experienced bidders (Bramsen, 2008b). Again, the actual differences in emotional processing can then be assessed with physiological parameters in physioeconomic auction experiments.

6.3.5. Summary

This section outlined four main challenges for future research on emotions in auctions. In particular, I identify interdependent utilities, product characteristics, emotional state induction and bidder heterogeneity. While these issues only gained little attention in auction literature so far, this thesis provides the main elements to systematically investigate these challenges in physioeconomic experiments. Based upon the unified framework for emotional bidding in auctions, such experiments can contribute to enriching the understanding of how cognitive and emotional processes interact in market decision-making.

Appendix A.

Participant Instructions and Questionnaires

A.1. Participant Instructions for the Proof-of-Concept Study

This appendix lists the participants instructions of the proof-of-concept study presented in Chapter 4. The instructions were translated to English from the original German version.

A.1.1. Introduction

This is an experiment in market decision-making. During the entire experiment, your heart rate, skin conductance and pulse will be recorded for further analysis. If you follow the instructions carefully and make good decisions, you can earn a considerable amount of **CASH**. The experiment consists of a sequence of [**4 / 6 auctions**]. At the end of the session you will receive fifteen Euros (€15) PLUS your total earnings from all [**4 / 6 auctions**]. This experiment uses tokens for calculation. At the beginning of the experiment you will be endowed with an initial amount of 750 token on your experimental account. The experimental system will use this experimental account to enter your gains and losses from the auctions you participated in.

A.1.2. Session Agenda

After the instructions there will be a rest period of **5 minutes**, which is essential for the measurement of the physiological parameters. Please try to calm down and relax during this rest period. After the rest period you will take part as a bidder in [**4 / 6 consecutive auctions**]. In each auction you and the three other participants of the experiment will compete to purchase a fictitious asset. After each auction there is another rest period of **1 minute**. The auction process will be described in detail in the next section.

After the end of the experiment you will be asked to enter your anonymous participant identification and your seat number. Your questionnaire answers and the data collected during the auctions will be processed anonymously. Therefore, a mapping between you and the data assessed in this experiment is not possible.

A.1.3. Auction Description

In each auction you participate as a bidder in an auction with the three other participants of the experiment, in which a single fictitious asset is auctioned off. Starting from 0 tokens, the auction system increments the current standing price in each round by 10 tokens. In each round you have to decide, whether you are willing to accept the current standing price or not. For this decision you have [**5 / 15 seconds**]. If you let this time pass without taking a decision, this equals to not accepting the current standing price.

The auction ends as soon as no bidder accepts the current standing price in one round. The winner of the auction is the high bidder of the last round. If no bidder accepts the bid in the first round, no bidder wins the auction. If only one bidder accepts the current standing price in one round, she is automatically the current high bidder. If more than one bidder accepts the current standing price, one of these bidders will be randomly selected as the current high bidder.

The resale value is identical for all bidders, but will not be revealed until the auction has ended. The resale value for the asset will be drawn randomly from the values 170 tokens, 180 tokens, 190 tokens, . . . , 250 tokens, 260 tokens, 270 tokens with equal chance of being chosen. The winner of the auction receives the resale value minus the price at which she won the auction.

Example: Suppose that you won the auction at a price of 240 token. Then the following cases are possible:

1. The random resale value is larger than 240 tokens.
   ⇒ This results in a gain: resale value - 240 tokens.

2. The random resale value is exactly 240 tokens.
   ⇒ This results in a payoff of zero.

3. The random resale value is smaller than 240 tokens.
   ⇒ This results in a loss: resale value - 240 tokens.

A.1.4. Payment

At the beginning of the experiment you receive an initial payment of **750 tokens**. At the end of the experiment, your earnings from all auctions will be totaled and converted to dollars at the rate of two cents (2¢) for each token. The total payment will be paid to you in **CASH** after the experiment.

A.1.5. Concluding Remarks

If you have any questions, please raise your hand and I will come to where you are sitting and answer them. Please only use your free hand to operate the computer and try to avoid any other body movements, as these would result in unwanted measurement artifacts. Please also try to handle the mouse with very little energy. You will now be equipped with ear muffs in order to reduce the influence of background noise on the measurement data.

Before the experiment begins, you will be asked to answer a few comprehension questions in a short quiz on your computer screen. Please enter the answers on your computer. After the quiz you will take part in one sample auction, in which gains and losses will not be considered. Before the sequence of auction starts, there will be a rest period of **5 minutes**.

A.2. Participant Instructions for the Utility of Suspense Experiment

This appendix lists the participants instructions of the utility of suspense experiment presented in Chapter 5. The instructions were translated to English from the original German version. CV and IPV refer to the common value and independent private value treatments, respectively. Section A.2.2 only applies for the CV treatments, Section A.2.2 only for the IPV treatments. The numbers 0.5 and 5 indicate the time interval τ between two consecutive price steps.

A.2.1. Introduction

This is an experiment in market decision-making. During the entire experiment, your heart rate, skin conductance and pulse will be recorded for further analysis. If you follow the instructions carefully and make good decisions, you can earn a considerable amount of **CASH**. The experiment consists of a sequence of 15 auctions. At the end of the session you will receive fifteen Euros (€15) PLUS your total earnings from all 15 auctions.

A.2.2. Auction Description

In each auction you and two other participants will compete to purchase a fictitious asset. The price of the asset will start at 120 tokens and decrease every [**0.5 seconds / five seconds**] by 1 token. Any of the bidders can stop the auction and purchase the asset at the price displayed on the screen by clicking the "Accept" button. The first person to click the button purchases the asset and pays the price displayed on the screen. The other participants will earn 0 tokens in this auction. If you purchase an asset, your earnings equal the difference between your resale value for that asset and the price you paid for the asset:

Your Earnings = Resale Value - Purchase Price

Common Value

The resale value is identical for all bidders, but will not be revealed until the auction has ended. The resale value for the asset will be between 46 and 95 tokens. Each number between 46 and 95 has an equal chance of being chosen. It is as if the numbers were stamped on 50 balls, one number on each ball, and placed in an urn. A random draw from the urn determines the resale value of an asset for one specific auction. The winner of the auction receives the resale value of the asset and has to pay the purchase price at which the auction ended.

Example: Assume that you clicked the "Accept" button at a price of 65 tokens. Then the following cases are possible:

1. The random resale value is smaller than 65 tokens, e.g. 51 tokens.
   ⇒ This results in a loss of 51 tokens - 65 tokens = -14 tokens.

2. The random resale value is exactly 65 GE.
   ⇒ This results in a payoff of zero, as 65 tokens - 65 tokens = 0 tokens.

3. The random resale value is larger than 65 tokens, e.g. 79 tokens.
   ⇒ This results in a gain of 79 tokens - 65 tokens = 14 tokens.

If one of the other two bidders clicks the "Accept" button before you, you receive a payoff of zero tokens in this auction.

Independent Private Value

Resale values will differ among individuals and auctions. For each bidder the individual resale value for the asset will be between 21 and 120. Each number from 21 to 120 has an equal chance of being chosen. It is as if the numbers were stamped on 100 balls, one number on each ball, and placed in an urn. A random draw from the urn determines the resale value of an asset for an individual bidder. Your chance of drawing a resale value between 21 and 30 is 10%, between 31 and 40 is 10%, between 41 and 50 is 10%, and so on. Do not reveal your resale values to anyone. It is your own private information and will change from auction to auction. The winner of the auction receives the individual resale value of the asset and has to pay the purchase price at which the auction ended.

Example: Assume that your individual resale value for the asset is 85 tokens. Then the following cases are possible:

1. You place a bid of more than 85 tokens, e.g. 95 tokens.
   ⇒ This results in a loss of 85 tokens - 95 tokens = -10 tokens.

2. You place a bid of exactly 85 tokens.
   ⇒ Payoff of zero, as 85 tokens - 85 tokens = 0 tokens.

3. You place a bid of less than 85 tokens, e.g. 72 tokens.
   ⇒ This results in a gain of 85 tokens - 75 tokens = 10 tokens.

If one of the other two bidders clicks the "Accept" button before you, you receive a payoff of zero tokens in this auction.

A.2.3. Session Agenda

After these instructions you will be asked to answer a few comprehension questions in a short quiz on your computer screen. You have to answer all questions correctly in order to continue with the experiment. After the quiz you will take part in one sample auction, in which gains and losses will not be considered. Before the sequence of 15 auctions starts, there will be a rest period of 5 minutes, which is essential for the measurement of the physiological parameters. Please try to calm down and relax during this rest period.

After the rest period you will take part as a bidder in 15 consecutive auctions. In each auction you and two other participants will compete to purchase a fictitious asset. You will not be matched with the same two participants for two consecutive auctions. You will not be told with which of the other participants in the room you are matched, and they will not be told that you are matched with them. What happens in one auction has no effect on what happens in any other auction. After each auction there is another rest period of 1 minute.

A.2.4. Payment

At the beginning of the experiment you receive an initial payment of 75 tokens. At the end of the experiment, your earnings from all 15 auctions will be totaled. This payoff

will then be converted into Euro at the rate of twenty cents (20¢) for each token. The total payment will be paid to you in **CASH** after the experiment.

A.2.5. Concluding Remarks

If you have any questions, please raise your hand and I will come to where you are sitting and answer them. Please only use your free hand to operate the computer and try to avoid any other body movements, as these would result in unwanted measurement artifacts. Please also try to handle the mouse with very little energy. You will now be equipped with ear muffs in order to reduce the influence of background noise on the measurement data.

A.3. Self-Report Questionnaire for the Utility of Suspense Experiment

Anonymous Participant-Identification: _____

Questionnaire

Please read the following instructions thoroughly. On the next pages you will find **20 statements**, which suit to describe your impressions in the preceding experiment. Please mark for each statement one of the five boxes with a cross:

SD (strongly disagree), if you cannot agree on the statement or if you regard it absolutely inapplicable.	**SD** D N A SA
D (disagree), if you rather do not agree on the statement or if you regard it inapplicable.	SD **D** N A SA
N (neutral), if you neither agree nor disagree, or if you regard it neither applicable nor inapplicable.	SD D **N** A SA
A (agree), if you rather agree on the statement or if you regard it applicable.	SD D N **A** SA
SA (strongly agree), if you fully agree on the statement or if you regard it fully applicable.	SD D N A **SA**

Your answers will be assessed and processed **anonymously**. Therefore, a mapping between you and your answers is not possible. Please also briefly submit comments and notes regarding your strategy and the experiment in general.

Please turn over the page now and start with answering the questions.

1.	Before each auction I set myself a price at which I intended to end the auction.	SD	D	N	A	SA
2.	The auction mechanism in this experiment is exciting.	SD	D	N	A	SA
3.	I did not want that another player gained a profit in an auction.	SD	D	N	A	SA
4.	I never accepted a lower price than I initially intended.	SD	D	N	A	SA
5.	I was in a competition with the other participants of this experiment.	SD	D	N	A	SA
6.	I was irritated when another bidder accepted the price before me.	SD	D	N	A	SA
7.	I sometimes accepted a higher price than I initially intended.	SD	D	N	A	SA
8.	I felt aroused when participating in the auctions.	SD	D	N	A	SA
9.	Winning an auction was more important to me than my individual payoff.	SD	D	N	A	SA
10.	The payoffs of other bidders played an important role in my own decision-making.	SD	D	N	A	SA
11.	Before the auction, I did not think about which price I was going to accept.	SD	D	N	A	SA
12.	The auction mechanism used in this experiment is boring.	SD	D	N	A	SA
13.	I would rather have ended the auction earlier by accepting a higher price than letting another bidder gain a profit.	SD	D	N	A	SA
14.	I sometimes accepted a lower price in the auctions than I initially intended to.	SD	D	N	A	SA
15.	The other participants in the experiment were not in a competition with me.	SD	D	N	A	SA
16.	I did not care when another bidder accepted the price before me.	SD	D	N	A	SA
17.	I never accepted a higher price than I initially intended.	SD	D	N	A	SA
18.	I did not feel aroused while participating in the auctions.	SD	D	N	A	SA
19.	My individual payoff was most important to me – mere winning was not that important to me.	SD	D	N	A	SA
20.	The payoffs of other bidders were not important to me.	SD	D	N	A	SA

How did you decide on a bid price? If you had a price limit, what was it?

SD = Strongly disagree **D = Disagree** **N = Neutral** **A = Agree** **SA = Strongly agree**

Comments and Notes

- voluntary -

…regarding your strategy:

…regarding the experiment:

Appendix B.

Experimental Environment

B.1. Experimental Laboratory

B.1.1. Participant Cabin

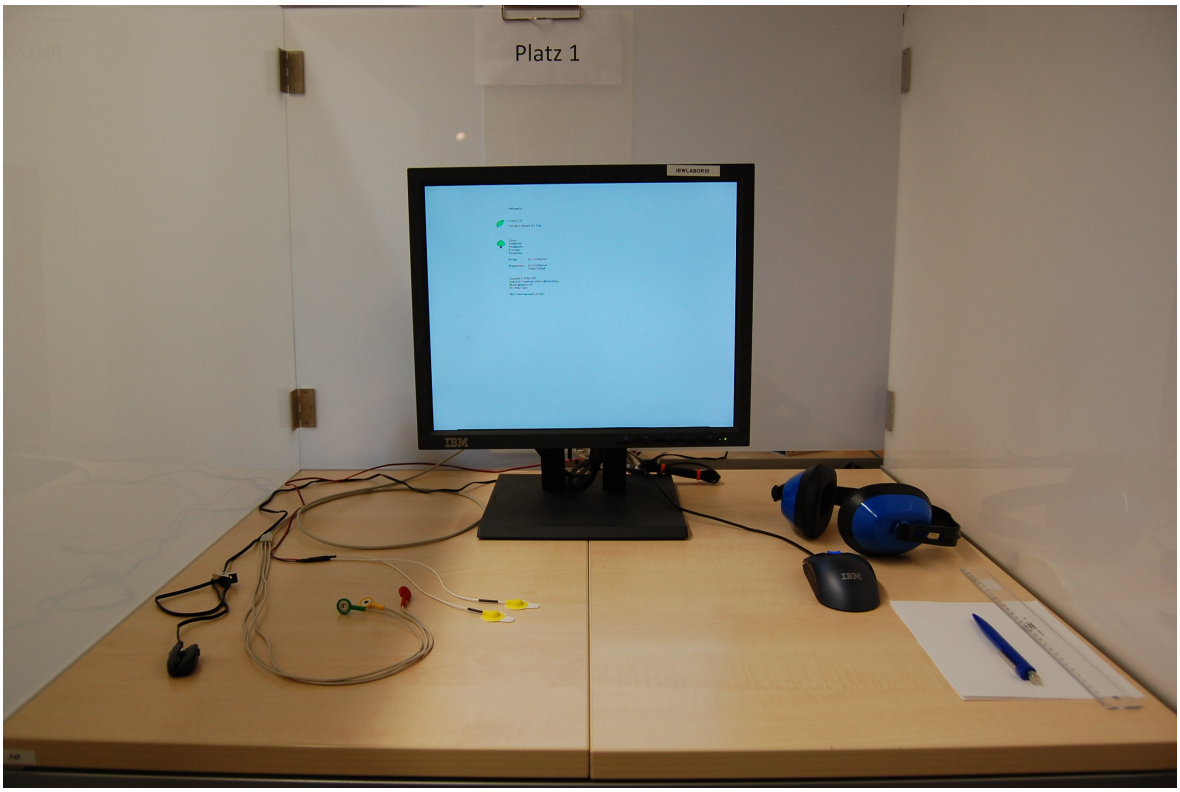


Figure B.1.: Participant Cabin in the Experimental Laboratory
(Subjects are equipped with a pair of ear-muffs, a pen, a blank sheet of paper, and a ruler. Interaction with the experimental system is limited to mouse inputs.)

B.1.2. Participant Measurement

Figure B.2.: Participant with Attached Measurement System
(In this case a staff member for documentation.)

B.1.3. Participant Cabin Backside

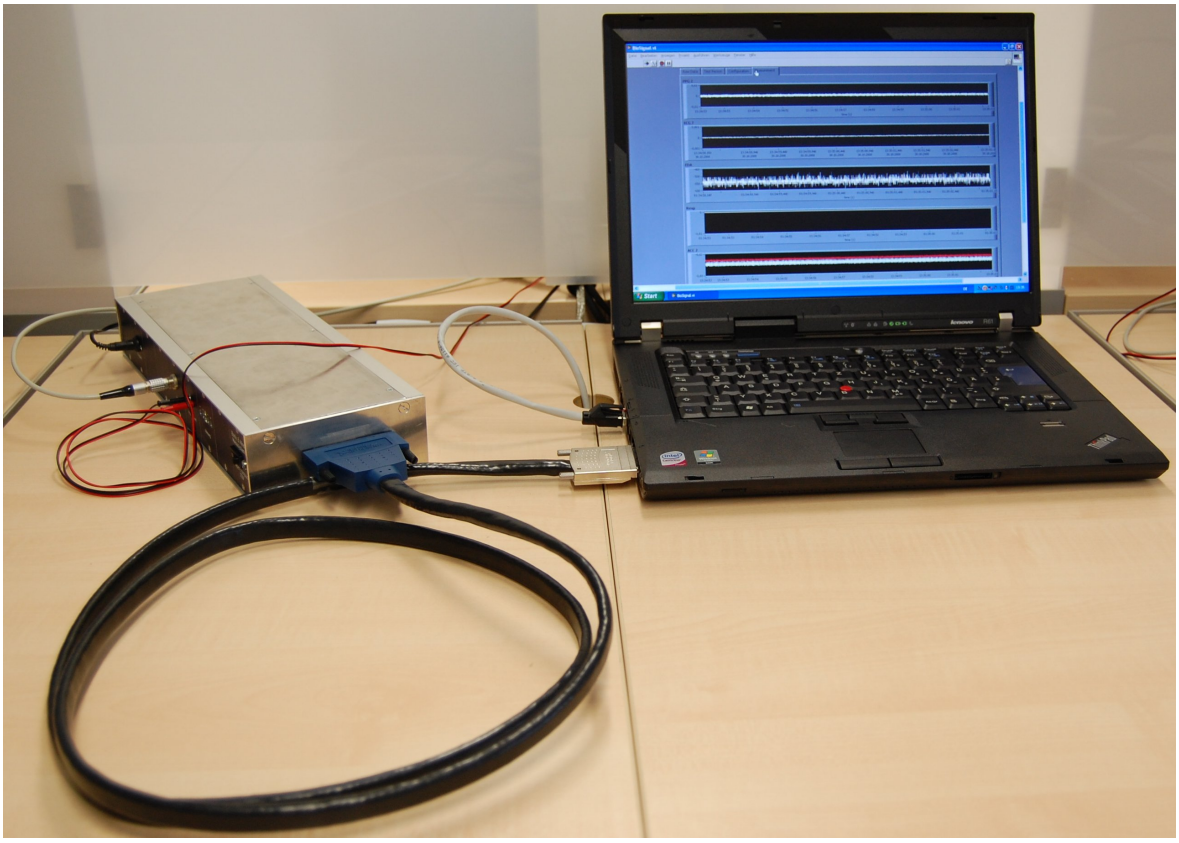


Figure B.3.: Participant Cabin Backside with Measurement System

The laboratory biosignal measurement system depicted in Figure B.3 was developed by the research group *hiper.campus*[1] and the *Institut für Technik der Informationsverarbeitung (ITIV)*[2] at the Karlsruhe Institute of Technology (KIT). Please refer to Gharbi et al. (2008) for technical specifications of the measurement system.

[1] http://www.hoc.kit.edu/hiper-campus
[2] http://www.itiv.kit.edu/

B.2. Experimental Software of the Proof-of-Concept Study

The experimental software is developed using the z-Tree platform (Fischbacher, 2007). The screen of the 5 minute initial rest period and the 1 minute rest period in between auctions is depicted in Figure B.4. Figure B.5 shows the value information screen, which is displayed before the auction starts. The auction screen is depicted in Figure B.6. The auction outcome screens in case of winning and losing an auction are depicted in Figure B.7 and Figure B.8, respectively. All screens were translated from the original German version.

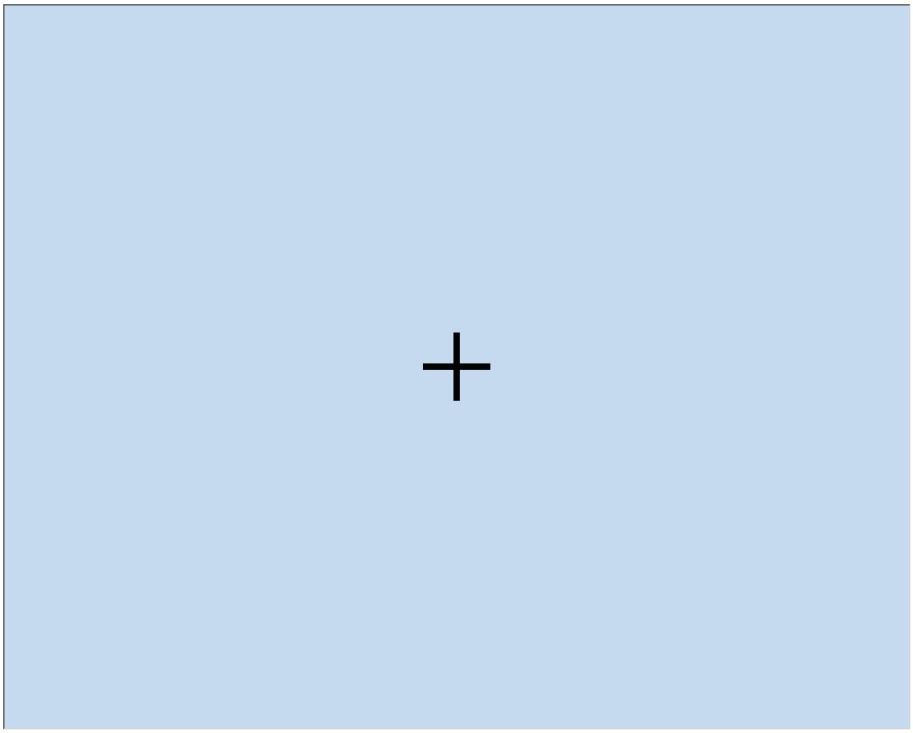


Figure B.4.: Screenshot: Rest Period

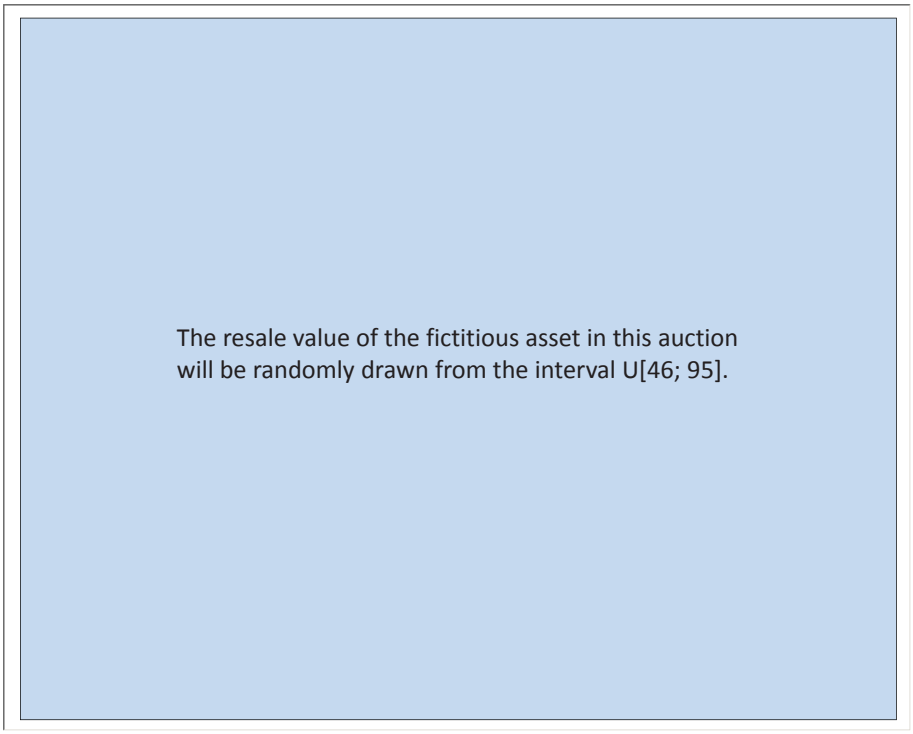


Figure B.5.: Screenshot: Value Information

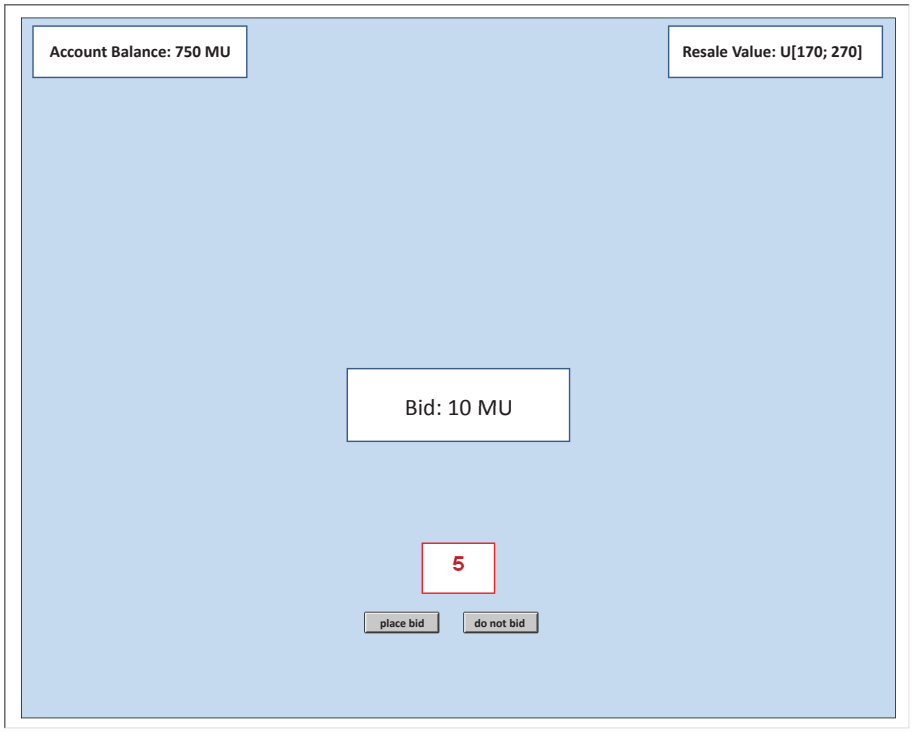


Figure B.6.: Screenshot: Auction Screen

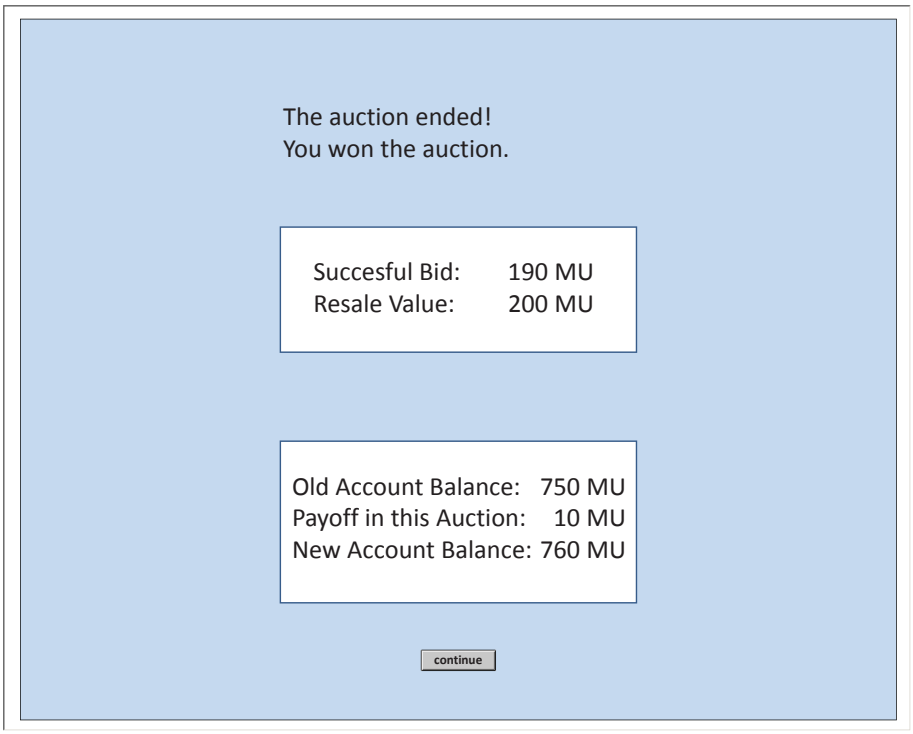


Figure B.7.: Screenshot: Auction Outcome (Win)

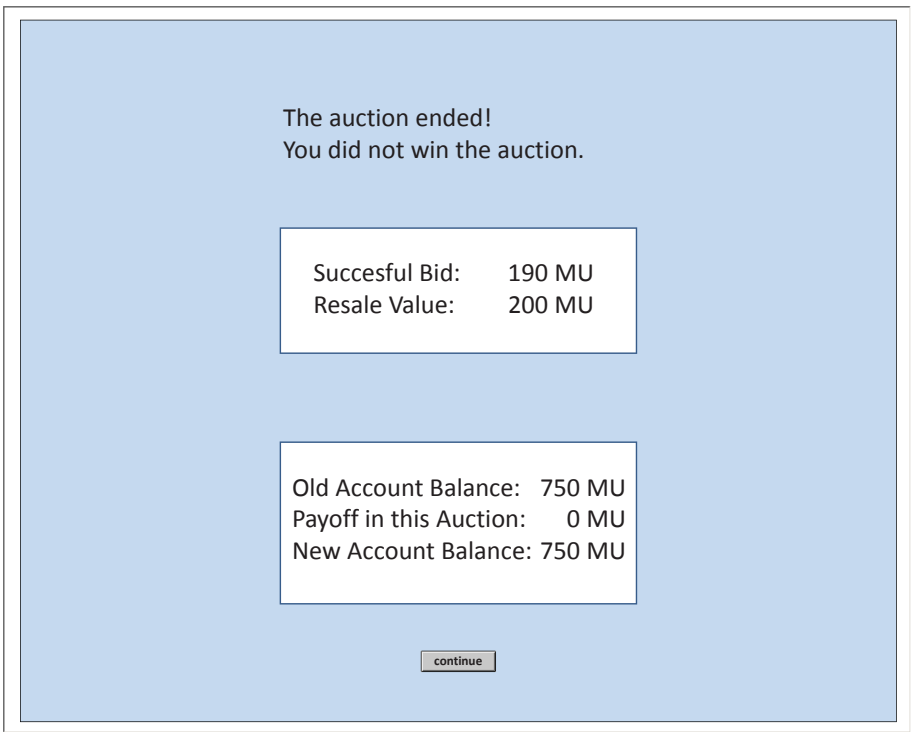


Figure B.8.: Screenshot: Auction Outcome (Lose)

B.3. Experimental Software of the Utility of Suspense Experiment

The experimental software is developed using the z-Tree platform (Fischbacher, 2007). The screen of the 5 minute initial rest period and the 1 minute rest period in between auctions is depicted in Figure B.9. Figure B.10 and Figure B.11 show the value information screens for the common value (CV) and independent private value (IPV) treatments, respectively. These are displayed before an auction starts. The respective auction screens are depicted in Figure B.12 and Figure B.13. The auction outcome screens in the case of winning an auction for the CV and IPV treatments are depicted in Figure B.14 and Figure B.15, respectively. The auction outcome screens in the case of losing an auction for the CV and IPV treatments are depicted in Figure B.16 and Figure B.17, respectively. All screens were translated from the original German version.

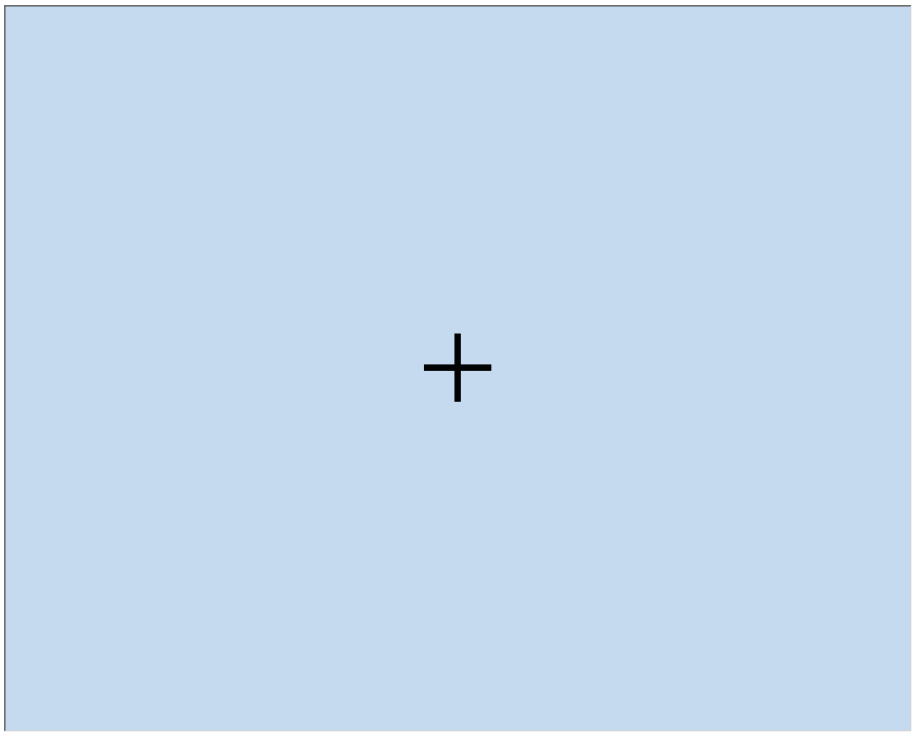


Figure B.9.: Screenshot: Rest Period

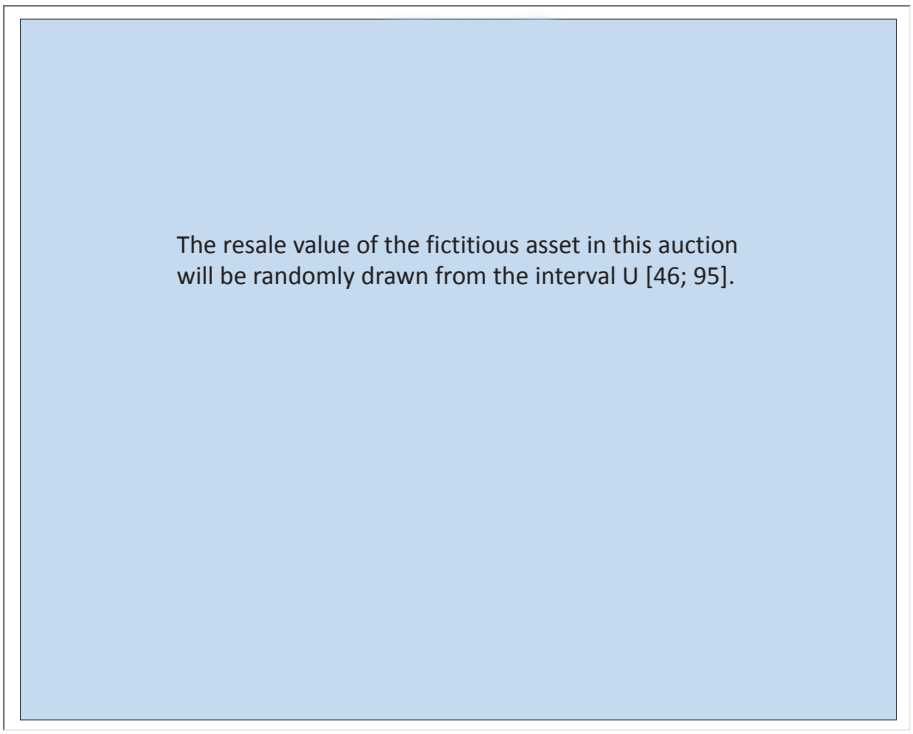


Figure B.10.: Screenshot: Value Information in CV Treatments

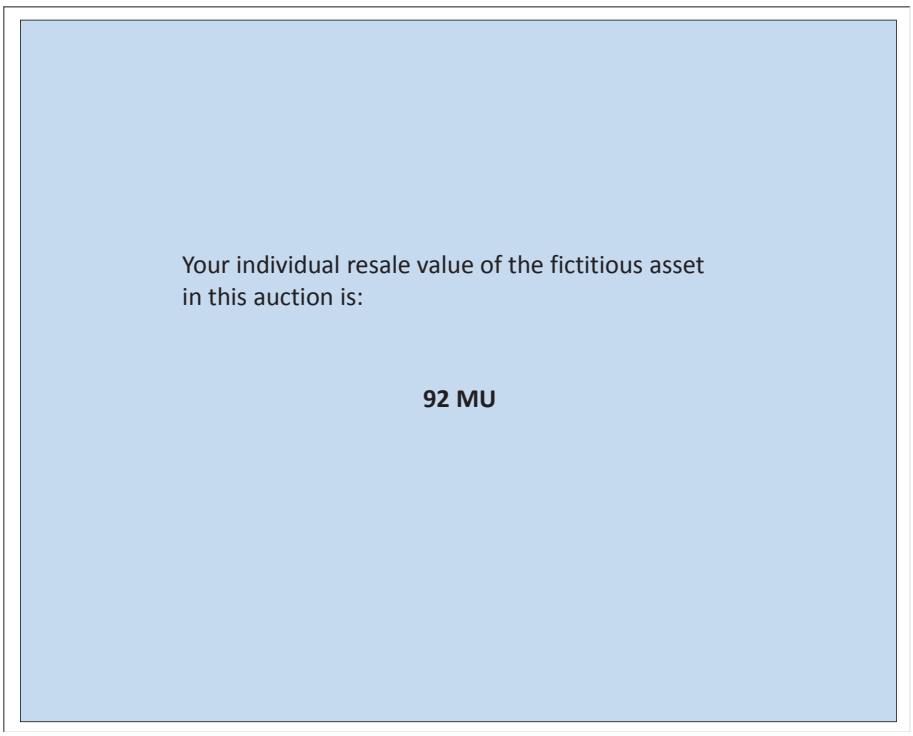


Figure B.11.: Screenshot: Value Information in IPV Treatments

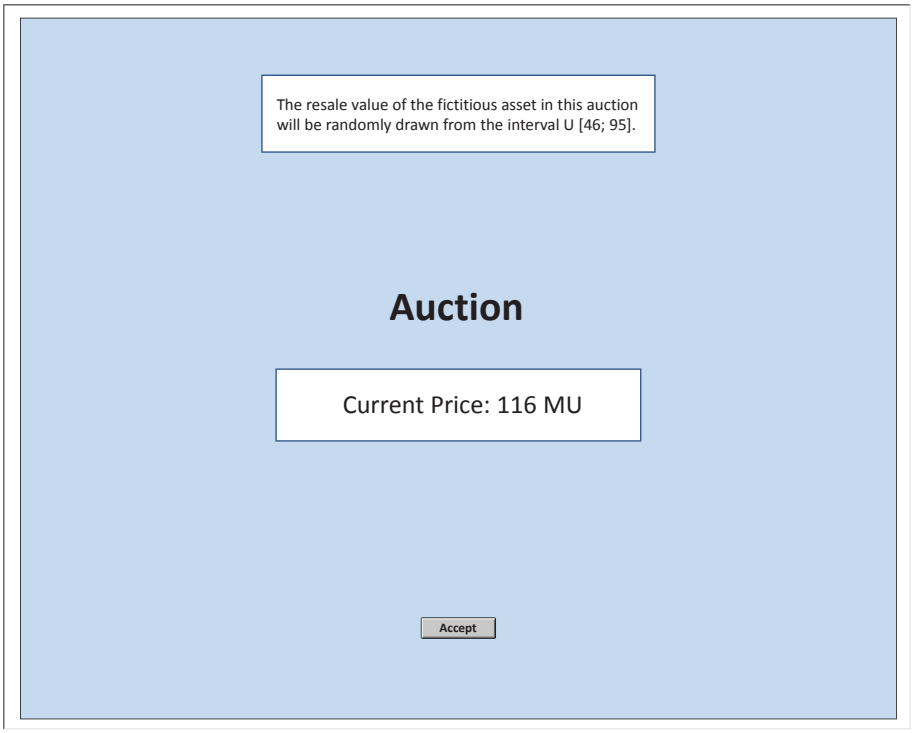


Figure B.12.: Screenshot: Dutch Auction in CV Treatments

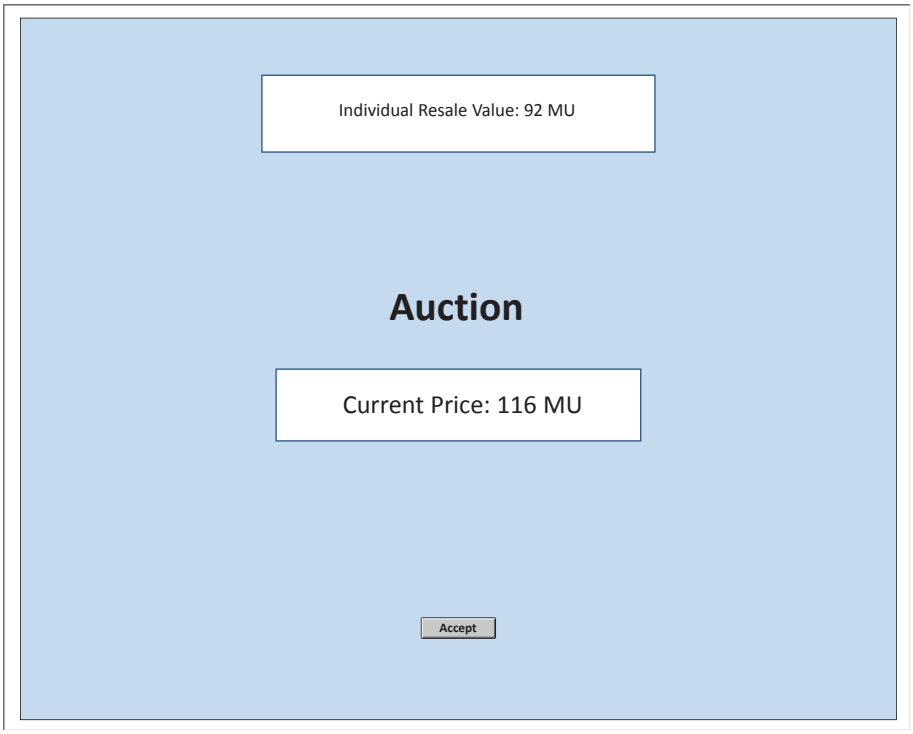


Figure B.13.: Screenshot: Dutch Auction in IPV Treatments

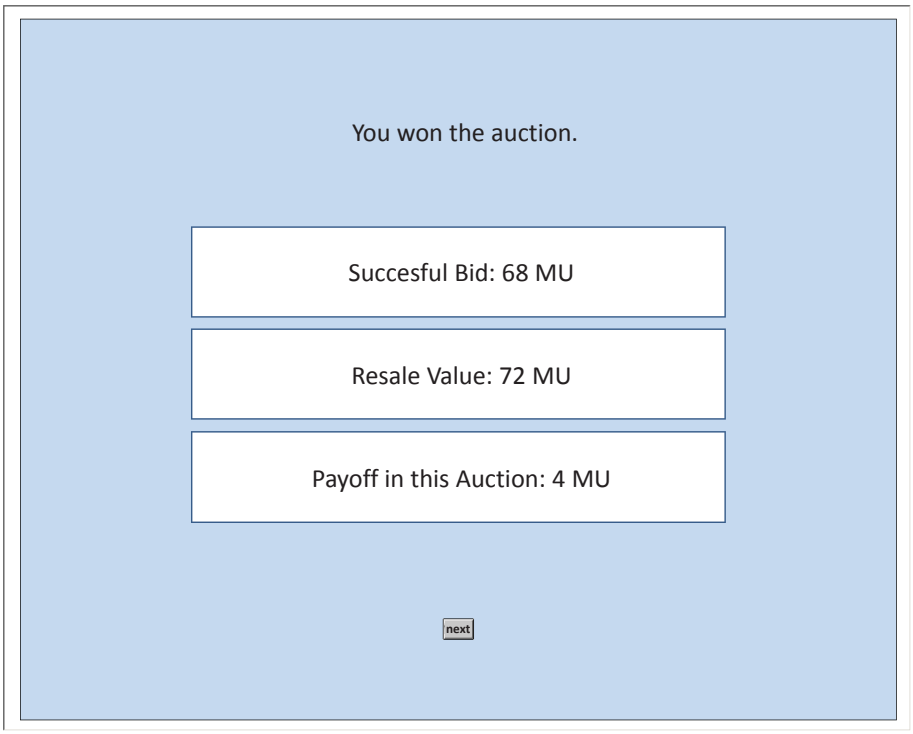


Figure B.14.: Screenshot: Auction Outcome in CV Treatments (Win)

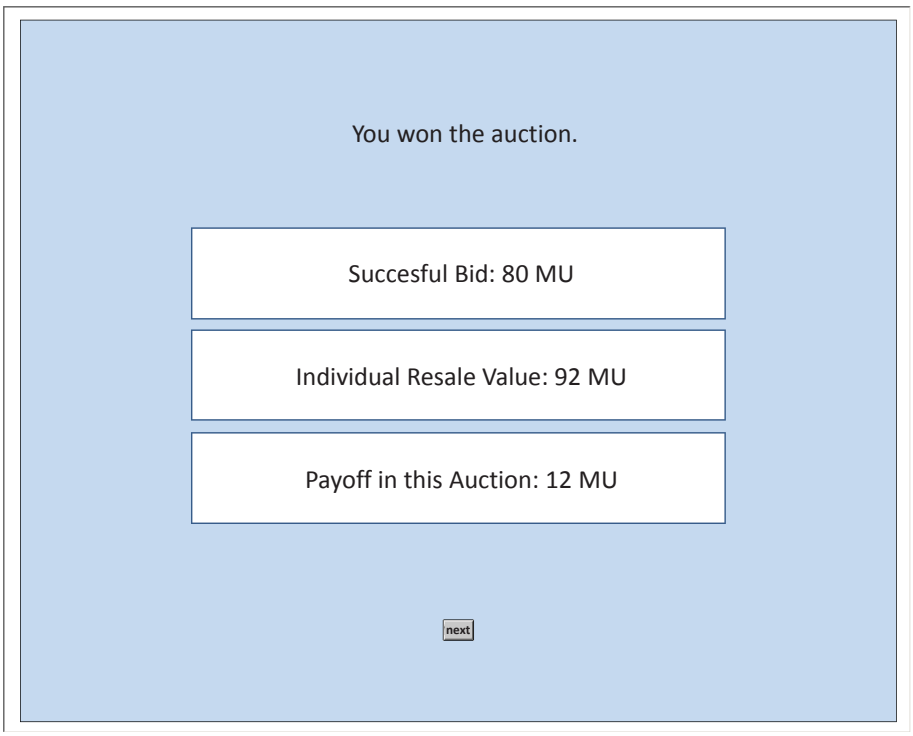


Figure B.15.: Screenshot: Auction Outcome in IPV Treatments (Win)

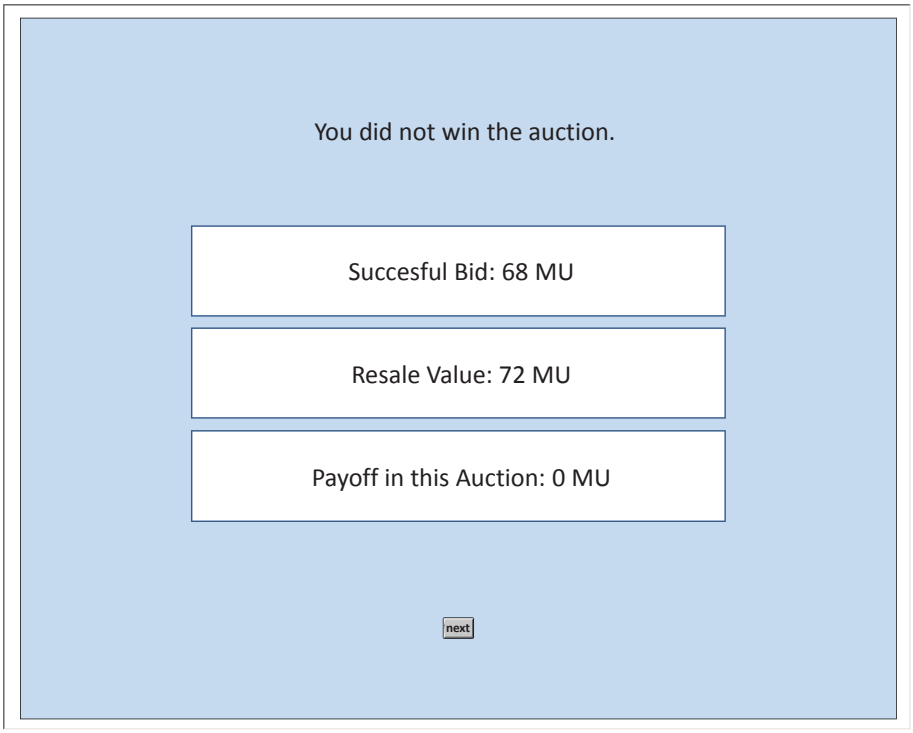


Figure B.16.: Screenshot: Auction Outcome in CV Treatments (Lose)

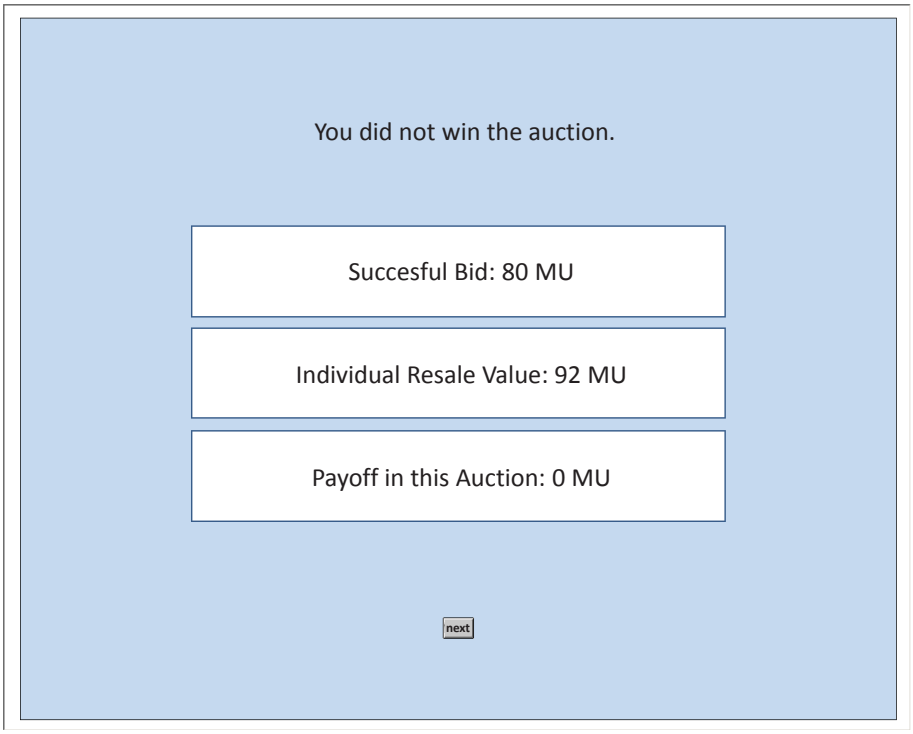


Figure B.17.: Screenshot: Auction Outcome in IPV Treatments (Lose)

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List of Abbreviations

A	Agree
ABN	Algemene Bank Nederland
ACM	Association for Computing Machinery
AMRO	Amsterdam-Rotterdam
ANOVA	Analysis of Variance
ANS	Autonomous Nervous System
ANSLAB	Autonomous Nervous System Laboratory
BC	Bidder Count
BF	Bidding Fee
BI	Bidder Identity
BOLD	Blood Oxygen Level Dependency
BPM	Beats per Minute
CFE	Controlled Field Experiment
CRRA	Constant Relative Risk Aversion
CV	Common Value
D	Disagree
ECG	Electrocardiogram
ECIS	European Conference on Information Systems
EDA	Electrodermal Activity
EEG	Electroencephalography
EF	Entry Fee
EMCIS	European Mediterranean Conference on Information Systems
FPSB	First-Price Sealed-Bid
fMRI	functional Magnetic Resonance Imaging
FS	Field Study
HBI	High Bidder Identity
HBF	High Bidder First
HBR	High Bidder Random
HR	Heart Rate
HRB	Highest Rejected Bid
IBI	Inter-Beat Interval
IISM	Institute of Information Systems and Management
IME	Information and Market Engineering
IPV	Independent Private Value
ITIV	Institut für Technik der Informationsverarbeitung
KIT	Karlsruhe Institute of Technology

LAB	Lowest Accepted Bid
LE	Laboratory Experiment
μS	Microsiemens
MIS	Management of Information Systems
MU	Monetary Unit
N	Neutral
NF	No Fee
NHB	No High Bidder
NoB	Number of Bidders
NOB	Number of Bids
NTP	No Time Pressure
PC	Perceived Competition
PF	Participation Fee
PI	Previous Investment
PET	Positron Emission Tomography
PF	Participation Fee
PNAS	Proceedings of the National Academy of Sciences
PO	Perceived Ownership
RNNE	Risk Neutral Nash Equilibrium
RV	Review
SA	Strongly Agree
SAM	Self-Assessment-Manikin
SC	Skin Conductance
SCL	Skin Conductance Level
SCR	Skin Conductance Response
SCR.amp	Skin Conductance Response Amplitude
SD	Strongly Disagree
sec	Seconds
SICA	Société Anonyme d´Intérêt Collectif Agricole
SPR	Society for Psychophysiological Research
SPSB	Second-Price Sealed-Bid
SV	Survey
TH	Theory
TOE	Time of Entry
TOX	Time of Exit
TPI	Time Pressure In
TPO	Time Pressure Out
UK	United Kingdom
US	United States
USB	Universal Serial Bus
WTA	Willingness to Accept
WTP	Willingness to Pay

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List of Symbols

β	bidding fee
δ	price increment (decrement) in ascending (descending) auctions
η	entry fee
θ	clock speed of an auction
Π^*_{CV}	a bidder's expected economic profit in a common value auction
τ	time interval between two consecutive price steps
φ	participation fee
a	one unit of non-monetary joy of Dutch auction participation
$a(t)$	utility of suspense after t seconds of Dutch auction participation
$b(v_i)^*$	equilibrium bidding strategy
p_{max}	initial high price in a Dutch auction
p_{off}	high price offset (distance between p_{max} and $\overline{v}$)
p_{st}	current standing price in an auction
t	elapsed auction time
$\overline{v}$	highest possible valuation of a bidder in an auction

List of Tables