Using Heart Rate Measurements to Understand and Support Decision Making in Electronic Auctions

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Emotions in Electronic Commerce

**Excitement**

Users’ experienced emotional intensity and derived hedonic value from shopping

**Social Presence**

Users’ perception of social embeddedness and interaction with another human being

**Time Pressure**

Users’ perception of time restrictions imposed on them when making a decision

**Auction Fever**

Intense emotional state experienced by bidders who bid over pre-set price limits
Auction Platforms

Madbid.com

*Excitement*

Kindle Fire HD

*Price*

£3.07

*Time Pressure*

00:00:08

madmax_de

*Social Presence*

Bidder | Amount
--- | ---
madmax_de | £3.07
sniper0 | £3.06
madmax_de | £3.05
sniper0 | £3.04
CatherineH11 | £3.03
madmax_de | £3.02
Focus of Investigation: Auction Fever

Auction Fever

Bidders’ “adrenaline starts to rush, their emotions block their ability to think clearly, and they end up bidding more than they ever envisioned” (Murnighan, 2002, p. 63)

Selected Literature on Auction Fever

- Internet auctions often yield higher prices than fixed-price offers (Jones, 2011)
- Rivalry, social facilitation, and time pressure increase “competitive arousal” and bidding (Ku et al., 2005)
- Time pressure induces aggressive bidding behavior in ascending auctions (Haruvy & Popkowski Leszczyc, 2009)

Alternative Explanations

- Search costs (Carare & Rothkopf, 2005)
- Winner’s curse (Kagel & Levin, 1986)
- Bidder’s curse (Lee & Malmendier, 2011)
- Winner regret & loser regret (Engelbrecht-Wiggans & Katok, 2011)
- Quasi-/pseudo-endowment (Heyman et al., 2004)

Approach: Investigate the auction fever phenomenon in a controlled laboratory experiment with physiological measurements.
Agenda

(1) An Experiment on Auction Fever

(2) Feature Selection

(3) Different Auction Paradigms

(4) Decision Support
Research Model

(Adam et al., 2015, Journal of Retailing)
Laboratory Environment

After the end of the auction, the resale value will be drawn randomly from the interval [46; 95].

Auction

Current Price: 57 MU
### Experimental Design

#### Setting
- ascending clock auctions
- 3 bidders per auction
- initial price = 25 MU (1 MU = 0.20 €)
- increment = 1 MU per time interval
- 15 rounds/auctions (1 practice round)
- 6 subjects per session
- 240 subjects in 40 sessions
- between-subjects design
- random stranger matching
- initial 5 minute resting period

#### Time Pressure

<table>
<thead>
<tr>
<th></th>
<th>Low time pressure</th>
<th>High time pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[time interval $\tau = 5.0$ s]</td>
<td>[time interval $\tau = 0.5$ s]</td>
</tr>
<tr>
<td><strong>Social Competition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human competitors</td>
<td>HUM_LTP (72 subjects)</td>
<td>HUM_HTP (72 subjects)</td>
</tr>
<tr>
<td>Computer competitors</td>
<td>COM_LTP (48 subjects)</td>
<td>COM_HTP (48 subjects)</td>
</tr>
</tbody>
</table>
Bidders experience less arousal in auctions with high time pressure.

Bidders experience more arousal in auctions with computer competitors.

HTP = High Time Pressure
LTP = Low Time Pressure
θHR = Normalized Heart Rate
Time Pressure and Bidding Behavior

Bidders place higher bids in ascending clock auctions with high time pressure.

Computer competitors mitigate the effect of time pressure on bids.

HTP = High Time Pressure
LTP = Low Time Pressure
MU = Monetary Units
Arousal and Bidding Behavior

### Table: Mediation Analysis

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Arousal (ΘHR)</th>
<th>Bid</th>
<th>Bid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b</td>
<td>SE</td>
<td>t-stat</td>
</tr>
<tr>
<td>Dummy: HTP</td>
<td>.047</td>
<td>.009</td>
<td>5.380</td>
</tr>
<tr>
<td>Dummy: COM</td>
<td>-.019</td>
<td>.009</td>
<td>-2.197</td>
</tr>
<tr>
<td>Dummy: risk_averse</td>
<td>.002</td>
<td>.009</td>
<td>.185</td>
</tr>
<tr>
<td>Dummy: female</td>
<td>.006</td>
<td>.010</td>
<td>.578</td>
</tr>
<tr>
<td>Arousal (ΘHR)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arousal x COM</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **N** = 210
- R² = .149
- N = 210
- R² = .125
- **N** = 210
- R² = .165

* + p < .10; * p < .05; ** p < .01; *** p < .001

### Mediation Analysis Results

- **Bidders’ arousal mediates the effect of time pressure on bids.**
- **Computer competitors mitigate the effect of arousal on bids.**

### Table: Indirect Effect Analysis

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Indirect Effect</th>
<th>SE</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUM</td>
<td>.999</td>
<td>.424</td>
<td>.312 2.039</td>
</tr>
<tr>
<td>COM</td>
<td>.083</td>
<td>.357</td>
<td>-.584 .839</td>
</tr>
</tbody>
</table>
Emotions in Response to Auction Outcome

Joy of winning is stronger than frustration of losing in ascending clock auctions.

Time pressure and human competitors mitigate the intensity of immediate emotions in response to the auction outcome.

Ascending auctions have the potential to convey a more rewarding experience than descending auctions (e.g., Dutch auctions).

Legend:
- HTP = High Time Pressure
- LTP = Low Time Pressure
- HUM = Human Competitors
- COM = Computer Competitors
- SCR = Skin Conductance Response
Study 2 – Avatars & Social Competition

The resale value is drawn from a discrete uniform distribution on the interval (110 MU, 155 MU).

**auction**

- current price: 90 MU

  - 5

  - place bid
  - exit

bidders:

- star_bidder (YOU)
- victory_flash
- turbo_pirate

The resale value is drawn from a discrete uniform distribution on the interval (110 MU, 155 MU).

**auction**

- current price: 90 MU

  - 5

  - place bid
  - exit
Study 2 – Avatars & Social Competition

- **Social Competition**
  - Time Pressure: Medium time pressure, No time pressure
  - Final Price (MU)
    - Social competition [human opponents]
    - Increased social competition [human opponents with nicknames and avatars]

- **Social Competition**
  - Time Pressure: Medium time pressure, No time pressure
  - Arousal (Psychometric Scale)
    - Social competition [human opponents]
    - Increased social competition [human opponents with nicknames and avatars]

- **Auction Outcome**
  - Treatment: SCO_MTP, SCO_NTP, ISC_MTP, ISC_NTP
  - Intensity of Immediat Emotion (Psychometric Scale)
    - Loser
    - Winner
Agenda

(1) An Experiment on Auction Fever
(2) Feature Selection
(3) Different Auction Paradigms
(4) Decision Support
Physiological Measures (Candidate Features)

Physiological Features

- Time-base
- Frequency-base
- Geometry-base

+ Normalizations

Observation Window

- Size
- Offset
- Type

Total combinations: 5772 (Candidate Features)

Much more possible model inputs than observations
Approach – Evolutionary Algorithm

**Non-Dominated Sorting Genetic Algorithm II (NSGA-II)**
[Deb et al. 2002]

- Evolutionary-based metaheuristic
- Minimizes objectives based on their fitness values
  - $R^2$ is supposed to be maximized $\rightarrow$ minimize $R^2 \times (-1)$
- Does not calculates a single solution but a **Pareto Front**
- Orders individuals based on their **Rank**
  - $\forall i \in \{1..\beta\}: f_i(a) \leq f_i(b)$
  - $\exists i \in \{1..\beta\}: f_i(a) < f_i(b)$
- Starts with random initial population
  of 25 CFs (max. 50 CFs) per individual
- Existing **MATLAB** implementation
Approach – Robustness

Due to the stochastic nature of the Evolutionary Algorithm, the robustness of the results needs to be backed by:

- **Multiple Runs**
  - 100-times for each prediction model

- **Splitting the Dataset**
  - Use Training, Validation, and Test data

- **Cross Validation**
  - Use 10-Fold Cross Validation at each iteration

- **No single result**
  - Use sum of all results
Results – Measures

% of solutions containing CF

(left bar) MLR Milliseconds (ms)  
(left bar) MLR Beats (b)  
(right bar) ANN Model Milliseconds (ms)  
(right bar) ANN Model Beats (b)
Results – Windows & Offsets

Selection Type: ms

Selection Type: b
Agenda

(1) An Experiment on Auction Fever

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(4) Decision Support

Clock speed induces excitement

Excitement mediates impact on prices

Clock speed mitigates immediate emotions

Frustration of losing stronger than joy

- Arousal is correlated with bids in FPSB auctions when the bidders compete with human opponents.
- Stronger immediate emotions in FPSB auctions when competing with human opponents.
- Higher arousal in FPSB auctions when competing with human opponents.

- first-price sealed-bid (FPSB) auctions
- human or computer opponents
- independent private values \(\{11, \ldots, 110\}\)

\(\ThetaHR\)
Agenda

(1) An Experiment on Auction Fever

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(4) Decision Support
**Consideration**

- Arousal can have *detrimental* effects on decision making.
- Being aware of arousal might help to *regulate emotions*.

![Emotion Regulation & Biofeedback Diagram](image)
Sample Trading Interface

Trading
You are an informed trader.

Period 1/3

Order Book

Buy Orders [MU] | Sell Orders [MU]
---|---
10 | 10
31 | 31
26 | 26
34 | 34
25 | 25
13 | 13
27 | 27
21 | 21
13 | 13

Time Remaining
31 Seconds

Additional Information
Apart from you, there are 11 other market participants. Of these 1 are participants in this room and 10 are computer agents.

Targets
MY # Shares: 0
MY Avg Price: 2
MKT Avg Price: 60
MKT # Shares: 23

You sold one security.

Order Submission

Buy Order

Dividend Interval: [21, 41] MU

Sell Order

Live Biofeedback

Trading History

Your Last Trades

<table>
<thead>
<tr>
<th>Time</th>
<th>Price</th>
<th>Direction</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>69</td>
<td>41</td>
<td>sell</td>
<td>0</td>
</tr>
<tr>
<td>66</td>
<td>40</td>
<td>sell</td>
<td>-3</td>
</tr>
<tr>
<td>57</td>
<td>59</td>
<td>sell</td>
<td>2</td>
</tr>
<tr>
<td>54</td>
<td>41</td>
<td>sell</td>
<td>1</td>
</tr>
<tr>
<td>45</td>
<td>50</td>
<td>sell</td>
<td>-2</td>
</tr>
<tr>
<td>48</td>
<td>41</td>
<td>sell</td>
<td>-3</td>
</tr>
</tbody>
</table>

Your Holdings
Cash: 80
Shares: 20
Integrating Live Biofeedback into Information Systems
• Providing users with live biofeedback on their arousal level supports self-monitoring the emotional state
• Use serious games with real-time biofeedback to provide users with an engaging learning environment
• With the serious game effective emotion regulation can be actively practiced and rewarded.

Application in Electronic Auctions
• Provide market participants with live biofeedback
• Train emotion regulation to investigate whether the impact of arousal on behavior can be actively regulated

“sound and rational decision making, in fact, depends on prior accurate emotional processing” (Bechara & Damasio, 2005)

**Design Guideline 1:** Choose measurements which are adequate for the environment of the users; e.g., use ECG recording with dry electrodes and wireless data transmission for providing users in fast-paced environments with live biofeedback in an unobtrusive way.

**Design Guideline 2:** Present biofeedback in an intuitive and meaningful way. Reduce complexity and use salient visual, auditory, or tactile cues (e.g., colors, arousal meter), while taking into account the contextual and situational circumstances of the users.

**Design Guideline 3:** Biofeedback is to some extent processed unconsciously; include objective measurements (e.g., eye tracking) during demonstration sessions in order to evaluate and iteratively redesign the way in which biofeedback is presented to users.

**Design Guideline 4:** Use serious games with real-time biofeedback and arousing game elements in order to provide users with an engaging learning environment in which effective emotion regulation can be actively practiced and rewarded.

➔ Real-time biofeedback based serious game to improve emotion regulation.
Thank you!

**Figure 2** Modified mouse device with developed printed circuit board.