I did that! Measuring Users’ Experience of Agency in their own Actions

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Agenda

Relevance in HCI

Background

Experimental Design

Conclusion
Relevance in HCl
Agency in interface design

“Users strongly desire the sense that they are in charge of the system and that the system responds to their actions.”

- Designing the User Interface: Strategies for Effective Human-Computer Interaction

Shneiderman’s Seventh Golden Rule of Interface Design:

Support an internal locus of control
Examples of Users’ Experience of Agency
Views of Agency in HCI

- Media Agency
- Intelligent Agent
- Design Agency
Background
Definition of Agency

“A person’s innate sense of being in control of their actions and through this control of being responsible for, or having ownership of, the consequences of these actions.”
A Little Bit of Neurology

Two theoretical positions:

• Agency is based on the sensory comparison of predicted versus actual consequences
• Agency is a reconstructive inference based on the assumption that one’s intention has caused an external event

Humans do not always perceive agency correctly

• Ouija boards
• Gambling
• Neurological disorders
Measuring Agency

Voluntary actions cause changes in our perception of time

This is termed intentional binding
Measuring Agency

Higher temporal binding indicates a greater sense of agency

Two methods:

- Libet Clock
  - Robust measurement
  - However, user must look at a clock
- Interval Estimation
  - Less robust
  - No clock
Libet Clock
Calculating Agency

<table>
<thead>
<tr>
<th>Action measurements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline error</td>
<td>Report time when button was pressed; no beep</td>
</tr>
<tr>
<td>Active error</td>
<td>Report time when button was pressed; beep</td>
</tr>
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Calculating Agency

Error = actual time – perceived time

Action binding = action error[active] – action error[baseline]

Outcome binding = outcome error[baseline] – outcome error[active]

Total binding = action binding + outcome binding

Again: greater total binding values indicate greater sense of agency.
Experiment
Goals of Experiments

• Develop methods to implicitly measure agency in an HCI context
• Determine how perception of agency is affected by different input modalities
• Determine how perception of agency is affected by varying degrees of computer assistance
• Target demographic: everyone
What’s it like to be a button?
Experiment 1: Changing Input Modalities

- **Independent variable:** input modality
  - Skininput vs MAC keyboard

- **Dependent variable:** length of binding
  - Libet clock

- **Design:** Within-subjects

- **Participants**
  - 21 right-handed individuals ages 20-40
  - Recruited via email to a University bulletin board
Experiment 1: Procedure

Trials:

- 40 trials of:
  - Action baseline error
  - Action active error
  - Outcome baseline error
  - Outcome active error

Per input modality or 320 total per participant.

Randomization: modality alternated, random order of measurements, but measured in blocks.
Experiment 1: Results

<table>
<thead>
<tr>
<th>Modality</th>
<th>Action binding</th>
<th>Outcome binding</th>
<th>Total binding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Button</td>
<td>6.81ms (45.6ms)</td>
<td>36.11ms (45.46ms)</td>
<td>42.92ms (67.43ms)</td>
</tr>
<tr>
<td>Skin-based</td>
<td>29.66ms (42.84ms)</td>
<td>79.82ms (91.23ms)</td>
<td>109.47ms (74.54ms)</td>
</tr>
</tbody>
</table>

Significance testing:
- Bonferroni corrected paired sample t-test
- H0: No difference in total binding for input modality
- t(18)=4.05, p<0.01
- Conclusion: Reject H0
Experiment 1: Analysis and Discussion

• No significant difference in baseline conditions
• Greater sense of agency for skin-based input than keyboard
• Furthermore: input modality matters in a quantifiable way
  • Possible applications: stylus vs touch
Experiment 2: Computer Assistance

• Independent variable: level of computer assistance
  • No, mild, medium, and high assistance

• Dependent variable: difference in interval estimation

• Design: Within-subjects

• Training: 12 practice trials

• Participants
  • 27 right-handed individuals ages 20-40
  • Recruited via email to a University bulletin board
Experiment 2: Procedure

Trials:

12 trials of:

- None ($\alpha = 0$)
- Mild ($\alpha = 3$)
- Medium ($\alpha = 6$)
- High ($\alpha = 9$)

Per time interval (150ms, 400ms, 700ms) or 144 trials per participant

Randomization: assistance levels blocked, interval was random
Experiment 2: Results

- Bonferroni corrected paired sample t-tests
- H0: No difference in estimation errors
- No significant difference between no and mild assistance, $p=0.97$
- No significant difference between medium and high assistance, $p=0.679$
- Significant difference between mild and medium assistance level, $p < .01$

<table>
<thead>
<tr>
<th>No Assistance</th>
<th>Mild Assistance</th>
<th>Medium Assistance</th>
<th>High Assistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>-16.78ms (70.70ms)</td>
<td>-16.32ms (82.03ms)</td>
<td>9.93ms (85.92ms)</td>
<td>4.53ms (79.54ms)</td>
</tr>
</tbody>
</table>
Experiment 2: Analysis and Discussion

• Participants were aware of all four assistance levels
• Threshold for computer assistance, before which assistance doesn’t hinder experience
• Mapping of assistance variable to agency
• Future applications:
  • More complex systems such as machine learning or AI
  • Level of agency when a computer hinders rather than helps
Final Discussion and Conclusion

• Paper provides two empirical methods for measuring agency

• Future interfaces can be evaluated based on user’s perception of agency

• Other factors to be researched:
  • Quality of feedback
  • Uncertainty
  • Differences between demographics
References


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Auto correct: http://www.freemake.com/blog/12-funny-autocorrect-mistakes/
Auto complete: http://www.esarcasm.com/13557/google-autocomplete/
Vim: http://www.celsius1414.com/tag/vim/

Slide 5:
Auto correct: http://www.freemake.com/blog/12-funny-autocorrect-mistakes/
Auto complete: http://www.esarcasm.com/13557/google-autocomplete/
Vim: http://www.celsius1414.com/tag/vim/

Slide 10: Libet clock:
http://www.informationphilosopher.com/solutions/scientists/libet/Libet_Clock.gif