When Output meets Input…

Matthias Rauterberg
Department Industrial Design
Technical University Eindhoven
The Netherlands, 2005
Most Important Design Constrains

- Information
- Attention
- Matter
- Energy
- Access
- Gravity

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Visual Output Space and Input Space

Output Space (system’s view)
- The physical space where the user’s \textit{visual} attention is.

Perception Space (user’s view)

Input Space (system’s view)
- The physical space where the user’s \textit{motor} actions are.

Action Space (user’s view)
How to design visual Output Space and Input Space in 2D?


MSc Thesis (1993) from Christian Cachin
Signal Detection Experiment (SDE)

N = 19; 11 women and 8 men took part in the experiment (mean age: 33 ± 14 years). 12 subjects were students of computer science at the ETH.

Dual task approach: (1) count circles, (2) detect signal X (given a distractor [])
SDE Results: primary task

‘Circle Deviation’ CD as a measure for task accuracy:

\[ CD = \frac{\left| \text{#CIRCLES}_{\text{counted}} - \text{#CIRCLES}_{\text{presented}} \right| \times 100\%}{\text{#CIRCLES}_{\text{presented}}} \]

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD=6.1%</td>
<td>CD=6.8%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD=6.9%</td>
<td>CD = 4.4%</td>
</tr>
</tbody>
</table>

Main Results:
Quadrant IV outperforms all others
SDE Results: secondary task

Signal Detection Table:

<table>
<thead>
<tr>
<th>answer of the subject</th>
<th>NO</th>
<th>a</th>
<th>b</th>
<th>X SIGN or square</th>
<th>X SIGN PRESENTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>YES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

‘Error Ratio’ ER:
ER = (b + c) / (a + d) * 100%

![Error Ratio Graph]

**Distance (inch)**

- [X] vs [no signal or square]
- [X] vs [no signal]
Eye Recording Experiment (ERE)

How to determine automatically the actual position of the user’s visual attention focus on a computer screen?

Subjects:
N=6: 2 women and 4 men
5 subjects were students of computer science at the ETH. 1 subject studied psychology at Uni Zurich.

Tasks:
(1) Computer game;
(2) Text formatting;
(3) Hypertext navigation.
ERE Results

fixation region :=
circle around fixation point with $r = 3$ inch

(1) without mouse operations:
Mouse position in fixation region for 25% - 70%

(2) with mouse operations:
Mouse position in fixation region for 49% - 97%
Design Recommendations

(1) Place e.g. the message left above the actual user’s focus of attention;
(2) Place this message maximal 3 inch away of actual mouse position.

\[ \alpha \sim 135 \text{ grad} \]
\[ \Delta |\text{OS-IS}| < 3 \text{ inch} \]
The Digital Desk
from Pierre Wellner in 1991
How to design Output Space and Input Space in 3D?

- **Output Space**
  - The physical space where the user’s visual attention is.

- **Input Space**
  - The physical space where the user’s motor actions are.

- **Design Principle:**
  - output space and input space must coincide! [\Delta =0]
  - “Interlacing the display and manipulation space” (Djajadiningrat, 1998, TU Delft)
Tic-Tac-Toe with four interaction styles
Empirical Results: game playing time per dialog technique

Cell Line Chart for "playing time"
Grouping Variable(s): Interface type
Error Bars: ± 1 Standard Deviation(s)
Empirical Results: winning chance per dialog technique

Cell Line Chart for "winning chance"
Grouping Variable(s): Interface type
Error Bars: ± 1 Standard Deviation(s)

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Design Recommendations

(1) Output space and Input Space should maximally intersect.
(2) Tangible interaction props do not interfere with primary task.

\[ \text{OS} := \text{Output Space} \]
\[ \text{IS} := \text{Input Space} \]
\[ \text{WS} := \text{Work Space} \]

Result:
\[ \text{WS} = \text{OS} \cup \text{IS} \quad \text{with max} \left[ \text{OS}_{\text{visual}}^3 \cap \text{IS}_{\text{visual}}^3 \right] \]
The Build-It System
Fjeld, Bichsel & Rauterberg 1997

Build-It: tangible interaction props

2D

3D

E.P. Elektro Projekt
TELLWARE

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Interaction Props: user study

Props design factors:
form, size, material and metaphor:

• An experiment was carried out to explore different design strategies.

• Tasks were based on initial planning of an interior architecture.

• Focus of the experiment was subjective opinion (n=12) about the bricks.

• The bricks were ranked by user performance before (first number) and after (second number) task solving activity.
Build-It: Spin-outs in Europe, Canada & Japan

IPO → TU/e → VIP-3

OMRON, Japan (2004)
Build-It: The PlanningTable in Japan by OMRON Inc.
Interaction Models
Brygg Ullmer & Hiroshi Ishii, 2000

INPUT

physical

digital

OUTPUT

control

view

model

Non graspable representation

graspable representation

model

INPUT / OUTPUT

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How to design interaction props for 3D navigation?

2D interaction:

3D interaction:

VIP-3: Tangible Interaction Props

Aliakseyeu, Subramaniam, Martens & Rauterberg 2002
Trends in Interactive System Technology

Mobile computing

Transport

Ambient rooms and Cooperative buildings

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Design Metaphors

Channel

Substitute

Tool

long time ago 2000 history
Trend in Interface Design

SW controls
HW controls
Design Styles

- Mechanical style
- Electronic style
- Mechatronic style

Time:
- 1900
- 2000
Design Forms

1900

mechanical style

dedicated forms
(e.g. typewriter, etc)

1900-2000

mechatronic style

active forms
(smart memory alloys)

connected forms
(ambient intelligence)

given forms
(ubiquitous computing)

electronic style

channel forms
(e.g. PC, TV, Radio, etc)
HomeLab: The Memory Browser
van den Hoven, Eggen & Rauterberg, 2003

RFID tagged souvenirs
Interaction Props with Active Form

unloaded state  Nitinol tubes  loaded state
If Output meets Input: interactive holography might be the final solution

smoke curtain (e.g. FogScreen)
Thank you for your attention.