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Paper Prototyping As A Graspable Medium: An Analysis

Eva Hornecker
Forschungszentrum artec, Universität Bremen, Germany
eva@artec.uni-bremen.de

Research on graspable (or tangible) user interfaces (Ishii & Ullmer, 1997) has up to now focused on implementation, categorisation, and usability issues. Little has been published on co-operative use, although many applications are based on co-operative scenarios. My research (Hornecker, 2001) contributes to an understanding of the positive effects of graspable interfaces on co-operative use, so that these can be consciously exploited in system design. To achieve a deeper understanding of co-operative modelling processes, I started analysing videos of groups working with graspable media. This example focuses on interaction in a situation of working with graspable material only (without virtual/digital elements).

1. Designing using Paper as Graspable Medium

In a seminar on PD methods a group of six women used the design game PICTIVE (Muller, 1993). PICTIVE is a low-tech prototyping method, using paper, pens, scissors and transparent foil. Thus it can be considered a graspable medium. The group designed the user interface for the local transportation ticket vending automata. All participants thus were familiar with the perspectives of end users. Six people (all women) sat around a table, while the centre of the table was reserved as design space and was captured on video. The moderator had prepared some materials as potential elements for the user interface of the automata. I transcribed about 40 minutes of 50 minutes session, including gestures.

1.1. Types of activity and frequency distribution

In comparison with prior studies of face-to-face design sessions which used paper for writing and drawing (Tang, 1991; Neilsen & Lee, 1994; Bekker, 1995), there are additional types of actions. These additional actions are due to the possibility of manipulating the material (cp. Robertson, 1997). There are *gestures*

- *on the rim* (rarely mentioned till now): cutting, writing, searching, sorting.
- *referencing the design space* (mostly identical to interaction with sketches): simulating interaction with the interface, pointing, indicating an area.
- *manipulating the design space* (rare when using paper as drawing surface): laying scraps, removing, fastening with glue, rearranging or shifting.

I analysed frequencies and types of gestures. As gesture function is not always evident or gestures serve several purposes, the analysis was restricted to the three categories mentioned above. I counted as gesture every movement which could be interpreted as meaningful action and occurred in one flow of movement.

After ten minutes of low activity, frequency of gestures referring to objects rises rapidly. During quiet phases discussion centres on more general topics (requirements, colours, text). There are four phases with a “burst". In longer discussions with many deictic gestures ideas are formed, discussed, and interface elements created. When a shared vision is produced. there results a rush of activity implementing design. In gesture rich phases, the group rearranges the interface.

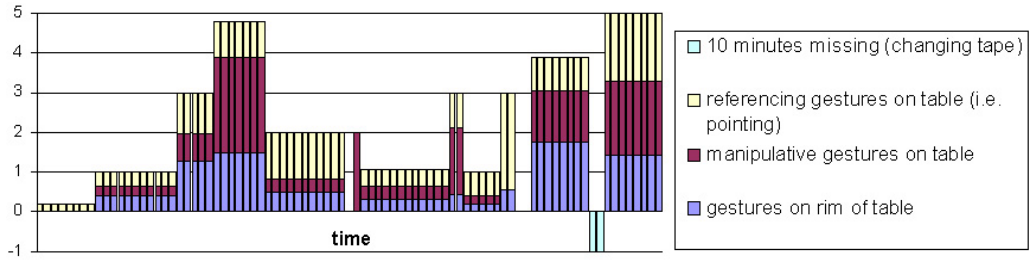

Figure 1. Frequency of gesture types over time
(1bar = 30seconds, 10 minutes tape change are shown as negative value).

1.2. Orchestration of parallel activity

The horizontal workspace promotes parallel activity, because actors’ bodies remain on the periphery while only arms and hands reach into the middle. Working on a blackboard would require more proximity. Researchers working on interactive whiteboards (informally) report no problems although touch-sensitive whiteboards can only be manipulated by one person at a time. They rarely noticed an impulse to work interactively. This may be due to the higher threshold of intruding into other peoples personal space in front of a wall-blackboard.

Fascinating are several scenes with highly “orchestrated” almost parallel manipulative actions. One has to look closely, frame-by-frame, to observe that these

are not parallel, but alternating manipulations. Seven scenes show truly parallel manipulation. Four times two persons interacted in rearranging paper scraps, manipulating highly interactive and synchronised. Three times persons independently, but synchronously manipulated objects in different areas of the interface. If the technology used in implementation of graspable interfaces prohibits parallel manipulation, this fast and effective manipulation is endangered, as there is no guarantee for social synchronisation to work out.

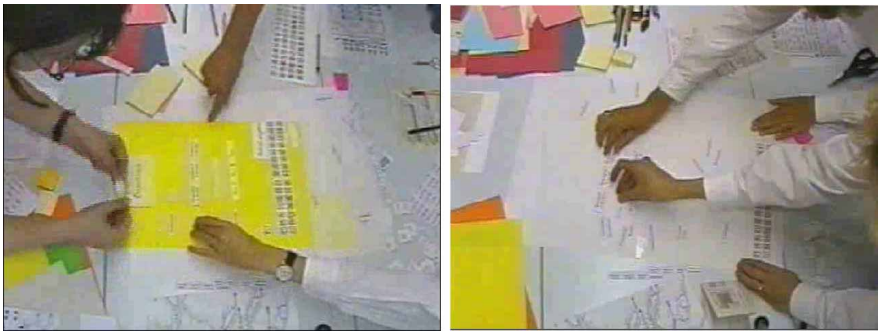

Figure 2. Parallel work: left: parallel pointing and arranging scraps, right: parallel, interactive manipulation of rearranging.

1.3. Gesture and talk in interaction

Interaction is very quick. When someone states an idea or requirement and there is no objection, others look around for material, start cutting and laying scraps into the design space, while discussion proceeds. This reaction takes place often immediately after an idea/suggestion has been stated, usually within 10 seconds, no more than 20 seconds. This seems extremely quick and effective. Often decisions are pragmatic. E.g. orientation of the two sheets serving as “screen” is decided implicitly and pragmatically by use. Sharon simulates typing on a virtual keyboard, then she points to the lower edge and says “down here”. Three minutes later, the scraps - thus the screen - are oriented facing her. The group as well pragmatically accepts the first definition of orientation for the second screen.

Regarding non-verbal action, quiet persons are as active as talkative ones. They react by searching material or information, cutting, writing, and laying down, all on their own accord. They thus participate and express their opinion non-verbally. The activity of preparing “buttons” kept Ruth thinking about what is needed on the interface. This can be deduced from the very concrete question she asks: “Is it the same fare for a bicycle regardless of being adult or student?”

Gestures, visible representation and talk augment each other. When the design space is yet void, gesture and talk produce a first vision how elements could be arranged: “We could make a box, where we say – keyboard” (makes two-handed gesture of a square bracket, indicating area, size and form). This area is later referenced with this meaning. Verbal and non-verbal suggestions together produce a

vivid image. Simulating user interaction with the system serves either as summary of results or for clarification. The first summary both simulates usage and references icons, delivering a concrete summary of design results. The other simulations serve as clarification (“Do we agree, that...”, “Did I understand correctly, that...”), summarising and producing a vivid image. In simulations, misunderstandings quickly get obvious. Instantly seeing designs results leads to concrete questions. Visibility and concreteness of design offer irritations, evoking questions and objections (“When I already said I’m adult, I don’t want to see this stuff for pupils!”) and stimulate imagination of the use situation.

2 Conclusion

These empirical findings stress the importance of parallel manipulative activity. Gestures, talk and visible artefacts interact in producing meaning and shared understanding. Graspable media promote quick, pragmatic interaction and fast trial of ideas. Visibility and concreteness evoke irritation, questions and objections, enforcing focus and clarification. Searching, cutting and scribbling in a group fosters involvement and shared activity. Non-verbal activity keeps people involved, allows parallel action and supports active participation. The group developed a reasonable proposal within 50 minutes, while often returning to requirements discussion. This indicates for the effectiveness of modelling with graspable material. These results can be transferred to graspable interfaces. In the future I will look at different scenarios and domains, especially graspable interfaces, integrating real and virtual system elements.

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