Fighting for Control: Children's Embodied Interactions When Using Physical and Digital Representations

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ABSTRACT
Tabletop and tangible interfaces are often described in terms of their support for shared access to digital resources. However, it is not always the case that collaborators want to share and help one another. In this paper we detail a video-analysis of a series of prototyping sessions with children who used both cardboard objects and an interactive tabletop surface. We show how the material qualities of the digital interface and physical objects affect the kinds of bodily strategies adopted by children to stop others from accessing them. We discuss how children fight for and maintain control of physical versus digital objects in terms of embodied interaction and what this means when designing collaborative applications for shareable interfaces.

Author Keywords
Collaboration, embodied interaction, children.

ACM Classification Keywords
H5.2. User Interfaces, H.5.3. Collaborative computing.

INTRODUCTION
Much recent discussion of tabletop and tangible interfaces has focused on their putative benefits in supporting face-to-face collaboration (e.g., [4, 6, 8, 9]). However, our understanding of how people interact with one another while using different co-located technologies and how these technologies mediate the interaction is still limited. In particular, while we are beginning to uncover some details of the pro-social behaviours that people engage in [4, 9], we know less about the strategies that collaborators adopt to prevent others from accessing certain resources.

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In this paper, we detail differences in the ways that children, engaged in a collaborative design task, restricted collaborators' access to the design materials when using both a paper prototype and an interactive tabletop. Video data are presented from a series of prototyping sessions conducted during the development of a collaborative application devised to enable children to construct a classroom seating-plan. Hence, the sessions were not designed to investigate the actions used by the children to mediate competition over resources per se, but were part of an iterative development process. When running the studies it became obvious that the children competed for access to the design materials more overtly when using the interactive tabletop than when using the paper prototype and that they used various physical movements to mediate these conflicts. This observation motivated a detailed analysis of the videos to investigate how disputes over different kinds of objects are negotiated.

PROTOTYPING TASK
The task carried out by the children in the prototyping sessions involved working in groups of three to design a seating plan. The design goal was to develop a collaborative application that could run on a DiamondTouch tabletop [1] to investigate how children plan together. Since the aim was to iterate the design of an interface, small changes were made to the task and materials between groups of sessions throughout. The first 7 groups worked with a large plan of their own classroom printed out and stuck to a piece of cardboard (see figure 1 left) measuring 65 x 49cm (the same size as a standard DiamondTouch table). On the plan, 12 rectangular pieces of cardboard, representing desks were

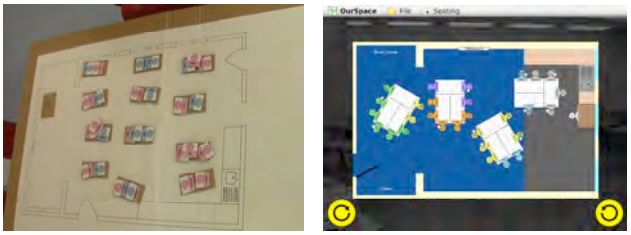

Figure 1: left - paper prototyping materials; right - interactive tabletop interface

placed along with 25 smaller cardboard tokens, with written names, representing the children in the class. The first four of the paper prototype groups worked with representations of the children in their own class, whereas the remaining three used a representation of children in an imaginary class who it was suggested might use the room next year. This manipulation was carried out because certain individuals were often left to sit on their own in the plan and there was concern that this might encourage bullying. The task was set up in a small room next to the pupils' classroom.

Four other groups worked with an interactive prototype implemented on the DiamondTouch tabletop [1] (Figure 1, right). This allows children to interact with digital content at the same time by using their fingers at the interface. The tabletop groups also worked with children from the hypothetical classroom, represented as digital icons. The children, classroom and tables were visually similar to those used in the paper prototyping sessions, but with a more colourful background. The children were able to concurrently drag and drop the digital icons on the classroom plan. All sessions lasted between 10-15 minutes.

Participants

10 groups of three pupils participated in the study (19 girls and 11 boys). They were in year 3 of a local primary school and were 7-8 years old. One of the groups took part in sessions with both the paper and multi-touch prototypes.

Analysis

As the video data used were drawn opportunistically from a series of prototyping sessions rather than a controlled experimental study, the analysis comprised a detailed iterative examination of the videos rather than a comparison using inferential statistics. The analysis progressed through repeated viewing of all of the video data to select sequences where there was a conflict over access to one of the physical or digital objects mediated through a physical action. These were then transcribed and viewed several times to reveal in detail how the children used their bodies to restrict access to either the physical or digital materials.

In the vignettes described below, square brackets are used to indicate overlapping conversational turns, descriptions of activity are enclosed with double brackets and arrows indicate where in the stream of conversation the selected screenshots occurred. All names have been changed and faces blurred. To facilitate reading, the individual on the left of the image has been given a name starting with "A", the one in the middle with "B" and the one on the right with "C". White circles have been added to the images to highlight where the important action is occurring and arrows on the images indicate direction of movement.

FINDINGS

The videos showed how two children often reached for the same physical token or digital icon at the same time. However, the majority of these were resolved without any kind of a dispute; with one child withdrawing their hand before or soon after they touched it and with little or no verbal negotiation. Children were also frequently observed taking a physical or digital object away from another child with the second child offering no resistance. However, on a few occasions neither child wanted to yield control of an object and employed various physical mechanisms to prevent the other child from reaching it; these varied qualitatively across the physical and digital settings.

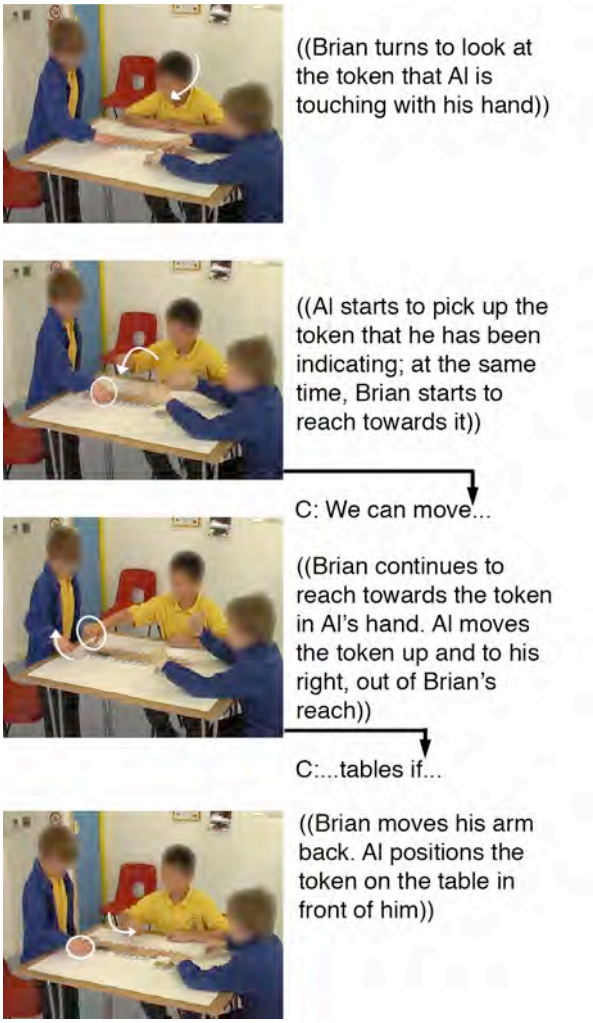

Figure 2: Moving a physical token out of reach

Moving out of reach

The most common mechanism employed by the children to prevent others from accessing the physical tokens was to move them out of reach. This occurred twice for two of the seven groups and once for three of them. The vignette in Figure 2 illustrates this: Al, Brian and Craig have a completed seating plan and are now fine-tuning the configuration. Al has just risen to his feet and touched a token with his hand, uttering "And them two talk [and therefore shouldn't sit together]". He attracts the attention of Brian, who turns to look at the token that he is touching, while Craig continues to talk about a different part of the configuration. Brian reaches out to grasp the token, but Al

picks it up at the same time while continually looking at it. As Brian's hand comes into Al's field of view, he moves his hand slightly to the right, taking the token out of Brian's reach. Brian sees that he is unable to reach it and withdraws his hand allowing Al to position the token where he wants on the seating plan.

Children using the interactive tabletop were also observed to attempt to move the equivalent digital icons away from another child when they did not want to give up control. However, as the digital icons were constrained to the edge of the interactive surface, this approach was often unsuccessful. It was noted how both children repeatedly selected and re-selected an icon, trying to move it away from the other until one eventually gave up. This happened several times in all of the DiamondTouch groups.

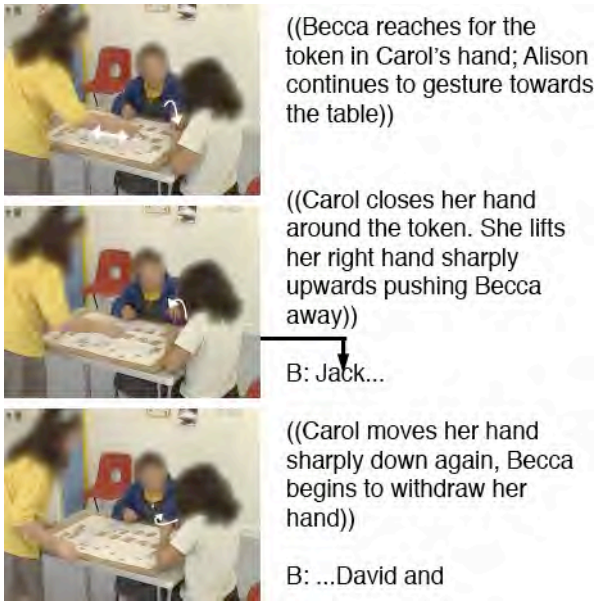

Figure 3: Closing fingers around a physical token

Blocking access to an object

A second mechanism that the children used to prevent access to a physical token was to close their fingers around it. This strategy was rare, occurring on only 3 occasions across the 7 groups: twice in one group and once in another. Figure 3 illustrates this: Becca reaches for a physical token in Carol's hand. Carol closes her fingers around it and moves her hand up and then down until Becca withdraws her hand. One possible reason that Carol closed her fingers rather than moving the object out of reach is because she was holding it in her right hand. This was next to Becca, limiting her range of movement. She continued by moving it to her left hand out of Becca's reach.

Children in one of the four tabletop groups were seen on a number of occasions to use a different kind of blocking action, where they shielded an area of the tabletop to prevent the others from moving the digital icons nearest to them. Figure 4 illustrates this strategy. Brendan first pushes Chris away with his left hand, complaining to the researcher, "He's nicking all mine". He then rests both hands on the tabletop claiming a portion as his own space.

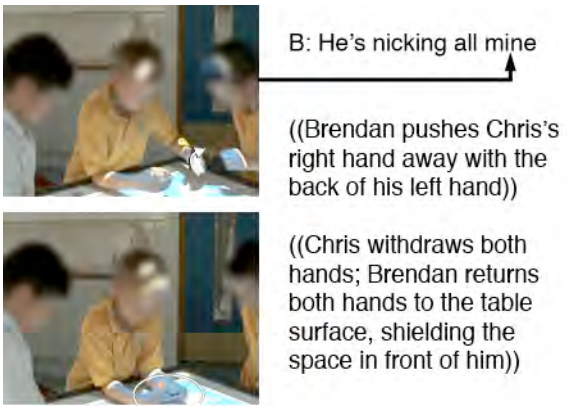

Figure 4: Shielding an area of the tabletop surface

Moving other children away

The most successful mechanism used to limit others' access to the digital icons when using the tabletop surface was to physically move the other children away, either by pushing, lifting or pulling their arm or hand. There were large differences in the prevalence of this behaviour between groups. Children in two of the tabletop groups were seen to do this only once, whereas it occurred four times in another of the tabletop groups and eleven in the group described above who used the shielding action. Figure 5 presents a vignette where Abi disputes the placement of a child icon, but Charlie positions her hand under Abi's and lifts it away.

There was only one example of a child in a paper prototype group pushing one of the others away to prevent access to a physical token. This occurred when all three of the children reached for it at the same time.

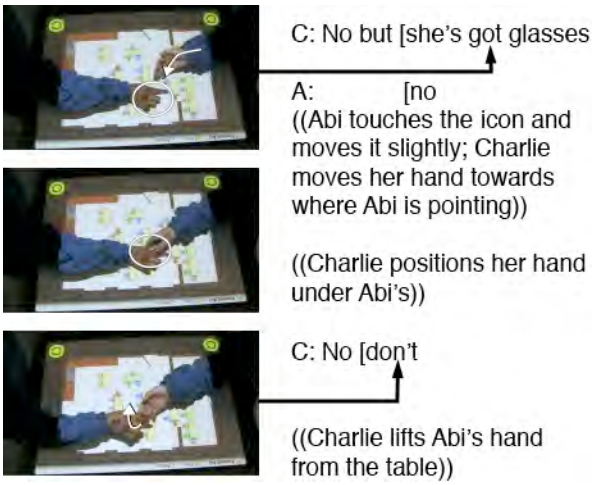

Figure 5: Lifting a hand off the tabletop surface

DISCUSSION AND CONCLUSION

Previous research with adults has shown how conflicts and competition over shared resources can occur in co-located work. Morris et al. [7], for example, describe how adult

participants stole words from each other in a poem creation task with a tabletop interface. The serendipitous finding from our prototyping studies that children will physically fight for control over shared resources provides new evidence that they will adopt highly assertive strategies to take control. In particular, our preliminary findings show the importance of bodily interaction for mediating collaboration as well as verbal mechanisms (cf., [5]).

The mechanisms that the children used to restrict others' access tended to be more subtle when using the physical cardboard prototype; they were able to use the configuration of their bodies around the table to move the materials out of reach, or the relative sizes of the small cardboard tokens and their own hands to prevent access by closing their fingers around them. These actions were not possible when using the equivalent digital icons at the interactive tabletop: since they could only be dragged or dwelled on at the surface. It is not surprising, therefore, that although the children tried to move the icons out of reach using their fingertips, this strategy was not always successful. Instead, they sometimes resorted to more forceful mechanisms such as pushing or pulling others away or (in one case) shielding off an area of the tabletop with their hands. It is notable that groups using the physical tokens could have used similarly forceful actions as those working at the tabletop, but chose not to. This suggests that while children might always try to find a way to limit others' access, they tend to choose less aggressive mechanisms first.

The finding that children use distinct physical mechanisms to restrict access when using different kinds of physical and digital materials is of relevance to recent discussion on the nature of embodied interaction (e.g., [2]). Embodied collaborative actions mediated through novel technologies such as tabletops, are beginning to be explicated, but have so far focused on pro-social behavior among adults (e.g., [6, 9]. For example, Suzuki and Kato [10] describe how tabletop and tangible artefacts allow the creation of a shared 'transactive space' through positioning of bodies in space where shared focus can be maintained though gestures and gaze direction. Similarly, Scott et al. [9] argue that tabletop interfaces need to provide support for natural interpersonal interaction through gesturing and deictic reference. Hornecker's [6] notion of embodied facilitation refers to the physical and spatial properties of an interactive artefact that can be used to encourage positive collaborative behavior. Fernaeus and Tholander have documented how physical movement is used to signal a change in attention or to spatially index an interface object [3], and how tangible artefacts can be used outside the interactive space to support social organisation [4].

The findings presented here show the subtle ways that the physical and interactive properties of an interface or object can interact with the structure and orientation of children's bodies. It also reveals how children may want to hold onto objects they wish to place in a shared design space and to prevent other children from changing their contribution. Moreover, it suggests that when moving from using physical materials to digital shared surfaces, such as multi-touch tabletops, designers should be sensitive to their different properties; for example, children may find themselves having to be more forceful when wanting to prevent other children from accessing 'their' objects. Flapping arms and arm shielding are two examples that contrast sharply with the more subtle closing of a hand around an object or the raising of a physical object out of another's reach. We plan to carry out further research to determine whether additional interface mechanisms can provide more subtle forms of access control when designing collaborative applications for interactive tabletops.

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REFERENCES

1. Dietz, P.H., Leigh, D.L., DiamondTouch: A Multi-User Touch Technology. In *Proc. UIST'01*, 219-226.
2. Dourish, P. *Where the action is: the foundations of embodied interaction*. MIT Press, 2001.
3. Fernaeus, Y. & Tholander, J. Designing for Programming as Joint Performances among Groups of Children. *Interacting with Computers*, 18, 1012-1031.
4. Fernaeus, Y. and Tholander, J., Finding design qualities in a tangible programming space. In *Proc. CHI '06*, 447-456.
5. Green, V. A. and Rechis, R. Children's cooperative and competitive interactions in limited resource situations: A literature review. *Applied Developmental Psychology*, 27, 42-59.
6. Hornecker, E. A Design Theme for Tangible Interaction: Embodied Facilitation. In *Proc. E-CSCW '05*, pp. 23-43.
7. Morris, M. R., Ryall, K., Shen, C., Forlines, C. & Vernier, F. Beyond Social Protocols: Multi-User Coordination Policies for Co-located Groupware. In *Proc. CSCW '04*, pp. 262-265.
8. Rogers, Y., Lim, Y-K., Hazlewood, W., Marshall, P. (2009) Equal Opportunities: Do shareable interfaces promote more group participation than single user displays? To appear in *Human-Computer Interaction.*
9. Scott, S.D., Grant, K.D., Mandryk, R.L. System guidelines for co-located, collaborative Work on a Tabletop Display. In *Proc. E-CSCW '03*, pp. 159-178.
10. Suzuki, H. & Kato, H., Algoblocks: an open programming language. In *Proc. CSCL '95*, 349-355.