"You switch, and I press": Comparing Children's Collaborative Behavior in a Tangible and Graphical Interface Game

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Abstract: In this study, we examine collaborative differences between children's interactions with a tangible user interface and their interactions with an isomorphic digital interface. We observe pairs of children interacting with both interfaces and trace how their body language, verbal communication, and collaborative behavior differ across their interactions. Our preliminary findings indicate that the tangible interface supports greater collaboration between participants through affordances such as greater visibility and multiple access points.

Introduction and Background

Recent research on labor markets has argued that the most stable and well-paying jobs of the coming decades will require not only high levels of technical skills, but also high levels of *social skills* (Deming, 2015). The argument is that collaboration in teams of specialized individuals will be essential—those who bring real skills *and* an ability to work together will be the most successful. In other words, it is not enough for young people to learn skills like computer programming. They also need to know how to collaborate effectively. In this study, we investigate the collaboration of young children playing a computer programming game called Osmo Coding (see Hu, Zekelman, Horn, & Judd, 2015). The game uses the front-facing camera of a tablet computer to track physical programming blocks on a tabletop surface (Figure 1a). These blocks control the motion of a character who roams about a virtual world in search of strawberries on the screen of the tablet computer.

We are particularly interested in the role of tangible interaction in shaping children's collaboration and learning. Tangible interfaces have been shown to support collaborative learning by building on the cultural familiarity of everyday objects (Horn, 2013), multiple access points to prevent interaction bottlenecks, and greater visibility and legibility than digital counterparts (Shaer & Hornecker, 2010). While prior work has demonstrated that tangible interfaces can promote collaborative engagement (Horn, Crouser, & Bers, 2010), few studies have explored how tangible interactions shape the ways in which young children collaborate around shared interfaces. To better understand these factors, we have created a comparison condition that allows children to play the same game using a touchscreen interface containing digital representations of the programming blocks (Figure 1b).

(a) (b) (c) (d)

Figure 1. a) The tangible condition uses physical programming blocks; b) screen shot of the screen-based condition; child pair interacting in the tangible (c) and screen-based (d) conditions.

Methods

We recruited fourteen children between five and eight years old from a local community center (nine girls, five boys). Children were paired by their teacher (seven pairs), and the pairs played with each version of the game for approximately twelve minutes each (Figures 1c, 1d). To reduce order effects, some pairs started with the screen-based interface, while other pairs started with the tangible interface. All sessions were video recorded.

To analyze session videos, we are combining qualitative, inductive coding (Strauss & Corbin, 1998) with quantitative analysis. First, we created categories of nonverbal communication such as body posture, hand and arm position, and visual attention and coded these categories by watching the videos without sound. Through this coding, we hoped to gain insight on the nature of nonverbal cues within our sessions and how they

relate to collaborative behavior. We then created a second set of categories describing collaborative actions between participants. These included actions such as proposing taking turns using the interface or preventing a partner from using the interface. The videos were then viewed again, this time with sound, and coded for collaborative actions. With both sets of categories coded, we then computed the aggregate duration and number of occurrences of each code and then compared them across our conditions. We will continue to refine this coding scheme with the ultimate goal of better understanding collaborative behaviors within the sessions.

Preliminary Analysis & Findings

We have fully coded two of the seven pairs using the current coding scheme. Of these two pairs, one pair started with the digital interface, while the other started with the tangible interface. In this paper, we present some of our preliminary quantitative analysis. Since our current sample size for comparison is low, we state notable characteristics of the data, while continuing to look for evidence that contradicts these trends. In the sessions studied thus far, we observed that participants seem to assume either an "active" or "passive" role that remains fairly consistent across both conditions. Generally, the active user spends more time physically interacting and is more likely to interrupt the other user and assume control over the interface. The "passive" user, while engaged and attentive, seems to have overall less direct physical contact with the interface.

Keeping the distinction between active and passive participants in mind, we analyzed our coded data while looking for overall themes in how these roles change across the tangible and digital implementations. Analyzing the nonverbal communication codes, in the digital interface active users were more likely to orient their bodies straight towards the tablet, whereas in the tangible interface they were more likely to exhibit a slight directional tilt towards their partners. In the tangible implementation, passive participants spent more time looking at the game screen and coding blocks, held more open arm postures, and spent more time interacting physically. The findings in our collaboration codes helped explain some of our findings in the nonverbal communication codes. For example, passive participants had more options to interact with the tangible interface—they could manipulate blocks that the active participant did not hold control over, and pass blocks over to the active participant. Consequently, the passive participants were more physically active in the tangible implementation. Consistent with the theory that tangible interfaces enhance legibility due to the visibility of physical objects, and thus promote more group awareness and coordination (Shaer & Hornecker, 2010), passive participants were more verbally active in the tangible interface and provided more suggestions to the active participant. In terms of the active participants, while there was little change in their quantity of physical actions across both interfaces, they were more likely to engage in *defensive* action in the digital implementation than in the tangible one. For example, they might swipe their partners hand away or place their arms around the interface. Interestingly, passive participants were more likely to engage in defensive action in the tangible condition. Lastly, we note that in the digital interface, participants tended to suggest taking turns using the interface, whereas in the tangible interface, they were more likely to suggest dividing responsibilities, such as one participant changing the direction of movement and the other participant deciding when to execute commands. Our preliminary results indicate that the tangible user interface supports greater collaboration between participants through affordances such as greater visibility and multiple access points. In order to ground our findings in statistical analysis, we plan on creating a more efficient means of quantifying comparisons and increasing our sample size.

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