The Effect of Interacting with Two Devices When Creating the Illusion of Internal State in Passive Tangible Widgets

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Abstract. This paper investigates whether the illusion of internal state in passive tangible widgets is stronger when using one touchscreen device or two devices. Passive tangible widgets are an increasingly popular way to interact with tablet games. Since the production of passive widgets is usually cheaper than the production of widgets with internal state, it is much more cost-efficient to induce the illusion of internal state in passive widgets than to use tangible widgets with an actual internal state. An experiment was conducted where the participants' belief in the illusion was determined by means of an interview with questions regarding the functionality of the tangible widgets. The results show that using two devices is significantly better at inducing the illusion of internal state.

Keywords: Illusion of internal state · Internal state illusion · Tangible widgets · Internal state on touch screen devices

1 Introduction

Touchscreen devices, such as tablets and smartphones, have become common household objects and therefore new interaction methods for these devices are more interesting than ever. Tangible Widgets (TW) offer new forms of interaction and are gaining popularity, especially for tablet games. TWs are physical tokens that lead conductivity from the user or through electronic signals to the touchscreen. Companies such a LEGO [9,10] and Disney [5,6] have produced and sold games utilising different types of TWs: TWs without electronic equipment — and therefore not requiring a battery — are henceforth referred to as *Passive Tangible Widgets* (PTW). TWs that can store information, e.g., in a memory chip, are henceforth referred to as *Internal State Tangible Widgets* (ITW). Since the production of PTWs is usually considerably cheaper than the production of ITWs, it is much more cost-efficient to induce the illusion of internal state in PTWs than to use ITWs with an actual internal state. Therefore, this project researches whether it is possible to create an illusion of internal state in PTWs, with the focus on whether using two touchscreen devices enhances the illusion when compared to the use on only one touchscreen. To this end, an experiment was conducted with

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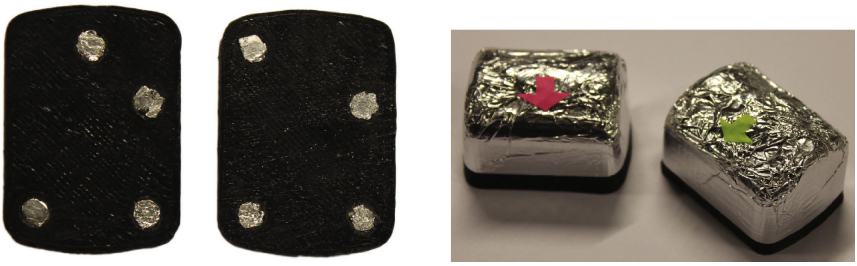
two different versions of a tablet game involving imitation of storing and transferring data with a PTW. One version imitates data transfer within one device, and the other imitates data transfer between two separate devices. This paper describes the process and results of the conducted experiment.

2 Related Work

Yu et al. [12] described methods for creating passive tangible widgets that can be uniquely identified. The widgets use conductive touch points in a pattern to register on a touchscreen. The pattern consists of a coordinate system made by three points forming a 90-degree angle. Additional touch points are placed in a unique pattern inside the coordinate system to represent the ID of the widget.

Bock et al. [2,3] researched the use of PTWs in games and concluded that using these was an interesting and entertaining way of interaction with games on touchscreen devices. In addition, movement in their game was easier and more intuitive with PTWs compared to finger touch. For their research, they developed a detection algorithm for PTWs and implemented it to be used with the Unity game engine. The algorithm required PTWs with four touch points; three touch points forming a 90° angle, similar to Yu et al. [12], and with a fourth point for a unique ID. This pattern can be seen in Fig. 1(a). The implementation by Bock et al. was used in order to identify the created PTWs in this research.



(a) (b)

Fig. 1. Passive tangible widgets: *(a)* The bottom of the PTWs shows their touch pattern. *(b)* The top of the PTWs is covered with conductive material.

3 Materials and Methods

This section describes the design and implementation of the widgets and the game; in particular, how the game was designed to induce the illusion of internal state.

3.1 Widget Design

Two unique PTWs were designed with three detection points and a unique ID. The PTWs were designed and modelled in Maya and 3D-printed. Holes were made for conductive material and filled with tinfoil. The top of the PTWs were wrapped with conductive tape, as seen in Fig. 1(b), which allowed for better conductive flow between touch points. Using tinfoil ensured that the widget's bottom and touch points were flattened and thus more stable.

3.2 Game Design

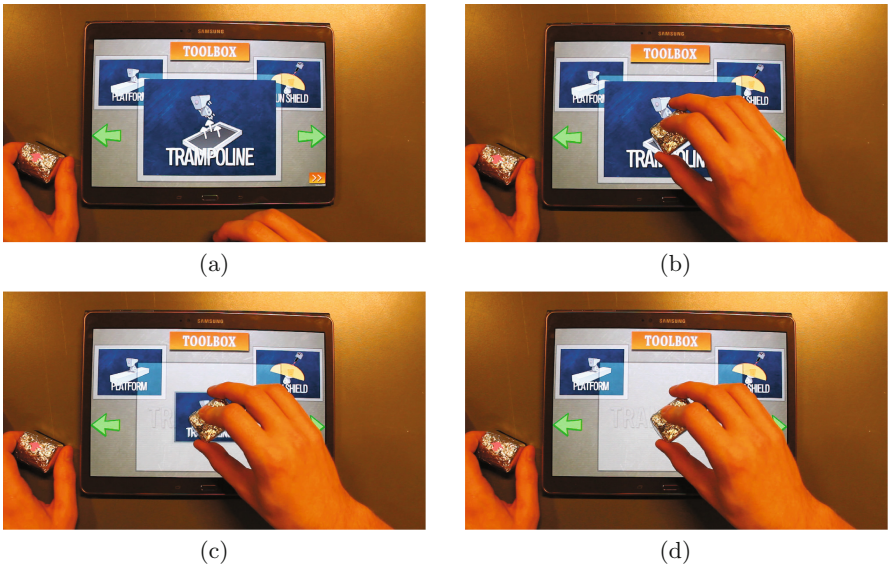
A Lemmings-style game was designed, where the player had to guide a number of non-player characters through levels containing obstacles. The player had access to several virtual tools in a virtual toolbox to overcome the traps and complete four levels. Two PTWs were used to pick up and control the tools. When a widget was placed on the screen, the selected tool followed its movement and rotation. The tools could be picked up and changed freely using the widgets and the toolbox. Two versions of the game were made, one where the toolbox was integrated as a window on a tablet, see Fig. 2(a), and one version where it was displayed on a separate device next to the tablet, see Fig. 2(b). Wireless networking was used to create communication between the tablet game and the separate device. The toolbox was able to identify which widget was used to pick up a tool and the game controlled which widget contained which tool.

(a) (b)

Fig. 2. Game versions: *(a)* The one-device version with the integrated toolbox. *(b)* The two-device version with the toolbox on a separate smartphone.

3.3 Illusion of Internal State

For the participants to believe in an internal state in PTWs, they must see the widgets as being independent from the game. In order to create a perception of them being separate systems, such as seen with the ITWs used in e.g. Skylanders [1], data transfer was imitated between the toolbox and the game. The toolbox was designed to give visual and auditory feedback to the player when saving and placing tools with the PTW, to imitate the tools being stored in the widget. The toolbox contained three tools set up in a horizontal menu, where all of the images



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

Fig. 3. The progress of scaling the image of a tool when picking it up. *(a)* The "trampoline" tool is ready to be picked up. *(b)* The user places a widget on the image of the tool. *(c)* The image of the tool is scaled down and *(d)* it disappears from the screen.

were visible at the same time. The tool in focus had its image scaled up and was the only interactive object, while the others were placed in the background. Buttons were used to scroll through the different tools. When tools were picked up, the image of the tool scaled down underneath the widget, creating a visual effect of the tool being sucked into the widget, this effect is depicted in Fig. 3. Once a tool had been picked up, it would no longer be visible in the toolbox. It was possible to place a tool back into the toolbox by placing the widget on an empty space, or by placing it on top of another tool. In both cases the tool image appears at the initial location of the specific tool and scales back to its initial size. All widget interaction was accompanied by auditory feedback.

4 Experiment Design

The experiment used a between-group [7] design with 15 participants playing the one-device game version and 15 participants playing the two-device game version. When the experiment began, the participants were introduced to the game, the widget and the toolbox in order to ensure that they understood the concept. In order to prevent bias in the introduction of the widgets, no hints to the functionality of the widget were given. If the participants asked about the functionality of the widget during the interview, they were told that they would be informed after the interview was done. This was because if the participants were told of the functionality before the end, such as that the pattern underneath

was read by an algorithm in the game, it would bias their belief in the illusion of internal state.

After the playthrough of the game, a questionnaire [8] was given to gather demographic information about the participants such as their background and technical knowledge. It was also used to gather quantitative data, in the form of Likert scale questions, regarding the widgets' stability, interaction, etc. After the questionnaire, a semi-structured interview [4] was conducted asking the participants questions about the functionality of the widget. Four interview questions were designed to determine whether the participants believed in the illusion:

- "If you should describe the widget in your own words, how does it work on a technical level?"
- "In your own words, how did the tools come from the toolbox to the game?"
- "In the toolbox, you have registered the trampoline to one widget. What do you think would happen if you placed a completely identical widget in the game?"
- "What do you believe is inside the widget?"

An interobserver evaluation was used, and four of the authors used these four questions and video recordings of the interviews as the base of determining whether a participant believed in the illusion [11]. After individual evaluation, each participant was discussed as to whether they believed in the illusion. A third option, *inconclusive*, was chosen if less than three observers agreed on a participant's belief. In these cases, not enough information was available from the interview questions to clearly determine a belief. Strong indications to a belief in the illusion were, for example, when the participants stated that there was a memory chip inside the widget, or strongly indicated that the widget was storing tools inside of it. Indications towards not believing in the illusion were if participants thought the tablet stored the data, that the screen registered the pattern of touchpoints or that nothing was inside the widget.

5 Results

The experiment was conducted on participants with different areas and levels of university experience. It was assumed that the participants had varying levels of technical knowledge, which would be beneficial when trying to determine whether this had an effect on the illusion of internal state. The participants consisted of 18 males and 12 females, in the ages of 20–26 years. On a Likert scale ranging from 1 (very bad) to 5 (very good), the participants rated their general abilities with using tablets on average as 3.53. For the statement "I have advanced knowledge of tablets and smartphones", the participants rated 2.78 on a scale from 1 (totally disagree) to 5 (totally agree).

When asked the question "If you should describe the widget in your own words, how does it work on a technical level?", some participants misunderstood the question and answered about the interaction and advantages with the widget. In these cases, the question was rephrased or elaborated to try to get a valuable

answer. In most cases it was possible to get the participant to understand the question and give their explanation.

When asked the question "In your own words, how did the tools come from the toolbox to the game?", participants in the one-device sample group had difficulties understanding it. This could be because the toolbox was integrated into the game environment and therefore the toolbox and the game was seen as a whole, whereas it was considered separate in the two-device sample group. This confusion about the question led to the question being omitted from the rest of the participants in the one-device sample group, which meant that there was less information available to determine their belief in the illusion for the interobserver evaluation. The expected feedback from the question was that they either thought the widget or the tablet controlled the storing of data. Since there were several questions asking about the functionality of the widget, it was not an issue to omit the question, as the same information could be deduced from these.

When asked the question "In the toolbox, you have registered the trampoline to one widget. What do you think would happen if you placed a completely identical widget in the game?", the participants' answers ranged from "nothing" to "it would show the trampoline". These questions indicated their belief in whether the widget actually stored the data, as if containing a memory chip. Participants were presented with an identical widget, but not all participants got a hands-on look at it, but had it lying in front of them on the table. This meant that they did not see the identical pattern underneath the widgets. It was, however, stated by the presenter that they were completely identical. Some participants who noticed the pattern underneath would in some cases change previous statements in favour of less strong indications of the widgets having internal state.

When asked the question "What do you believe is inside the widget?", the most common answers were "a memory chip", "magnets" and "I don't know". When the participants answered "magnets", it often seemed like a random guess, as they had no other ideas. These cases were not used as determining factors in the interobserver evaluation, as they are vague and can have several meanings.

The interobserver evaluation made it possible to determine the belief in the illusion for everyone except four participants, two from each of the groups. These four participants were categorised as inconclusive, as they gave contradictory answers or no answers with any indication towards a belief or not. Table 1 shows that a total of 6 participants believed in the illusion for the one-device sample group and 13 in the two-device sample group. A Wilcoxon ranked sum test determined that the belief of internal state in the two sample groups were significantly different from each other with a p-value of 0.0042.

No significant correlation was found between the participants' belief in the illusion and their answers to different Likert scale questions, such as their knowledge of tablets and smartphones, reliability of widgets, etc.

Table 1. Results of the interobserver evaluation.

Version	Believers	Non-believers	Inconclusive
One-device	6 (40%)	7 (46.7%)	2 (13.3%)
Two-device	13 (86.7%)	0 (0.0%)	2 (13.3%)

6 Discussion and Conclusion

It was not possible to determine the belief in the illusion of internal state of all participants. During the interview, the participants whose believes were not determined gave contradictory answers indicating that these participants both believed and did not believe in the illusion of internal state. Some participants would give a lot of different options, but stating that they were complete guesses and they did not know the answer. Others would not guess at all and simply stated that they did not know, despite attempts at rephrasing the questions and trying to make the participants elaborate on their answers.

Nonetheless, the results showed that using two devices was significantly better at inducing the illusion compared to one device. To achieve this result, the two devices had to resemble separate systems that were capable of functioning with the widget as the communication tool between them. In the experiment it was found that there was no correlation between the technical knowledge of the participants and their belief in the illusion of internal state, however, the participants assessed their own technical knowledge. Thus, future work should include less subjective assessments.

It would also be interesting to investigate if changing the appearance of the PTWs, such that the touch points at the bottom are indistinguishable, would impact the illusion of internal state. Furthermore, it remains to be discovered whether a system using PTWs with predefined game objects affects the illusion of internal state. Predefined PTWs would resemble the existing ITWs where their ID is bound to a game tool or character.

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