

# Analyzing interaction techniques using mouse and keyboard for preschool children

Bettina Grünzweil, Michael Haller

Media Interaction Lab

Upper Austria University of Applied Sciences

{bettina.gruenzweil|michael.haller}@fh-hagenberg.at

## Abstract

Nowadays, even very young children begin to use software applications – mostly playing games. Not surprisingly, both skills and abilities of preschool children differ not only from adults, but also from older children. In this paper, we analyzed preschool children in the kindergarten to show the most effective ways of interacting with an application. In contrast to related work, we mainly focus on how preschool children interact with applications using various interaction metaphors and devices.

## Introduction

In the past years, a lot of research has been done in the field of improving interfaces for children [11]. Growing up is a process of learning and during the first fifteen years the abilities and skills of children are changing rapidly [1]. Therefore, we cannot use software design guidelines designed for children ranging in age from about 10 to 12 for preschool kids.

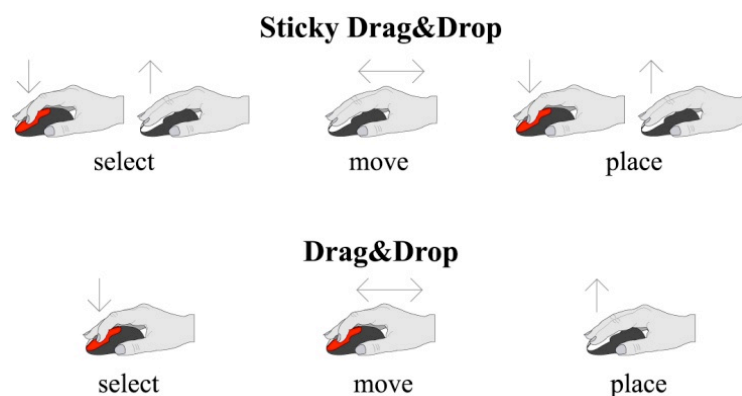


Figure 1 Sticky Drag-and-Drop vs. Drag-and-Drop.

As children today start using software in a very early age, the present study tests some of the most frequently used interaction techniques on preschool children, e.g. different dragging techniques (Drag-and-Drop vs. Sticky Drag-and-Drop [7]) using different devices such as keyboard and mouse. In the Sticky Drag-and-Drop interaction technique users click first on the object then move it without pressing the mouse button and finally they click again when the object reached the target (see Figure 1). Further results of our user test (e.g. detecting important regions of the screen, preferred colors etc.) can be found in [6]. Our key question during our test was to find out in which way desktop applications have to be designed so that preschool children can use them easily and efficiently.

## Related work

Several studies discuss the usage of input devices for children [2, 5, 8]. Inkpen conducted a study with children aged between 9 and 13 who already had experiences in using computers to compare Point-and-Click with Drag-and-Drop interfaces [11]. The Point-and-Click style to move an object was realized by Sticky Drag-and-Drop. The performance of children using Sticky Drag-and-Drop was significantly higher and the error rate was lower. In the same way, Hourcade tested kindergarten children [8, 9, 10]. In contrast to Inkpen and Hourcade, we wanted to test interaction techniques using mouse and keyboard *with children without any computer experience*.

A study of Donker and Reitsma compared mouse usage of preschool children, 7-year-old children and adults [3]. The results of this study showed that preschool children were able to aim and click with the same accuracy as adults, but they needed much more time. This result corresponds with the recommendations of the “Sesame Workshop” [13]. This non-profit education organization is developing media for education for more than 40 years. The experience-based guidelines indicate that the fine motor skills of preschool children are still developing. Kail developed a formula for predicting the performance of children in these tasks depending on the performance time of adults [12]. According to Kail, the younger children are, the higher the difference between their time and the time, adults need for a certain task. The values decrease very rapidly between the first and the sixth year. After that, the negative slope of the curve gets less steep. This indicates that there is not only a difference between the performance of children and adults, but also a big difference between younger and older children.

## User study

In our user study, we wanted to test the performance between different devices (mouse vs. keyboard) and between two different interaction metaphors (Drag-and-Drop vs. Sticky Drag-and-Drop). We also evaluated the devices under two different setups, resulting in an overall of three different experiments. In the first experiment, the participants had to select objects, in the second, they had to choose horizontal

movements, and finally, in the third experiment we measured the performance and error rate using Drag-and-Drop and Sticky Drag-and-Drop.

The study was conducted with 42 children from a local kindergarten, who used a computer for their very first time. 55% of all participants were girls and 45% were boys, 96.34% were right-handed and 3.67% left-handed. The average age of the children was 4.53 years (SD=0.76). 14 children operated each experiment. A repeated measure within-subject design was used in our user study. Moreover, the order of the experiments was counterbalanced among participants. Before starting the user study, all children were able to try the device to make sure that they understood what they have to do.

### Apparatus

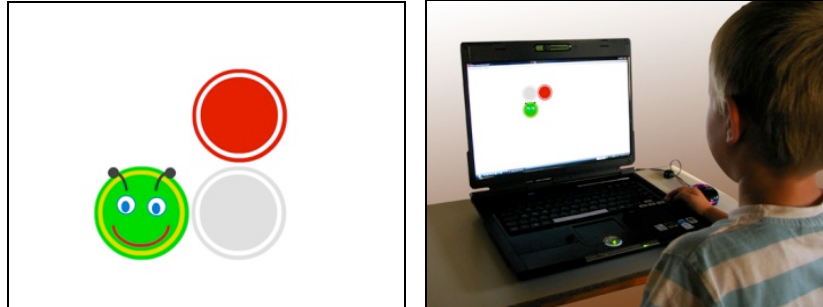
For all three experiments, a 15.4" laptop with a resolution of 1440 × 900 pixels has been used. As depicted in Figure 2, the arrow keys and the space bar were the only keys that have been used in the experiments. For a quick identification, these keys were highlighted in color.



Figure 2: (left) The keyboard and the mouse (right), that have been used in the first two experiments.

### Experiment 1: Object selection

In the first experiment, children had to select one part of an object that consisted of three sub-objects (see Figure 3).



**Figure 3: Participants had to select the face of the object by using the key arrows and the space bar and the mouse.**

The sub-objects were linked together horizontally or vertically. One of the objects was the source object and another circle the target object (marked with a face). Using the keyboard, at the beginning of the experiment, the sub-object was active and highlighted by a colored ring. The participants had to move to the target object using the arrow keys and log in the target object by pressing the spacebar. Using the mouse, children had to move the mouse cursor to the target object and confirm the selection with a mouse-click. After a completed trial, all three objects were rearranged randomly.

### Design and Procedure

All children were encouraged to move to and select as many target objects as possible. We tracked the number of correct and wrong selected target objects. While using the keyboard, the number of correct and wrong selected directions was stored. While using the mouse, the cursor movements were stored. The experiment stopped automatically after one minute.

### Results

Using the mouse, averagely 14.77 objects were selected ( $SD=9.25$ ) during the experiment, while the number of selected objects using the keyboard was 3.38 objects in average ( $SD=1.98$ ). We also found a high significant difference using both devices ( $F_{2,12}=18.84, p<0.001$ ).

81.36% of all target objects that were logged in correctly were selected by using the mouse, only 18.64% by using the keyboard. Altogether, 54.96% of all selected objects – right and wrong – were logged in by mouse, in contrast to 45.04% by keyboard.

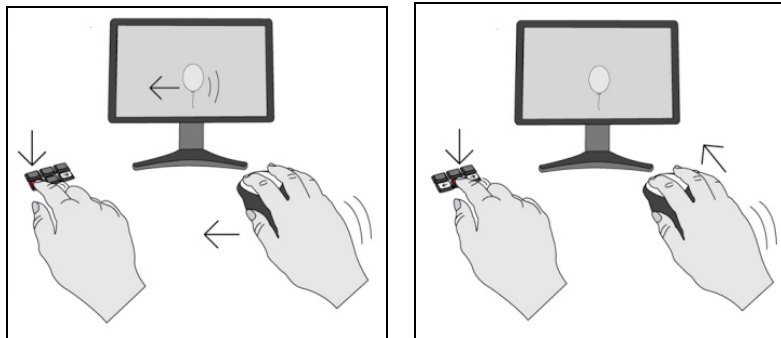
An overall error rate of 36.73% occurred during the experiment. Errors are defined by selecting the wrong object or pressing the spacebar while the target object was still not activated. From these errors, 90.51% happened using the keyboard and only 9.49% occurred using the mouse. Again, we found a high significant difference ( $F_{2,12}=23.79, p<0.001$ ).

### Experiment 2: Horizontal Movement

In the second experiment, the object (a balloon or fish) had to be balanced (by moving to left and right). At the beginning the object was placed at the bottom of the screen. Using the keyboard, participants had to press the left and right arrow keys. In contrast, while using the mouse, the object was placed on the mouse cursor's position. During the experiment, vertically moving objects tried to collide with the balloon and the task was to not collide with those objects.

### Design and Procedure

During the trials, the number of collisions, the duration of collisions and the path of the controlled object on the screen were tracked. The experiment was automatically stopped after passing ten collision objects.



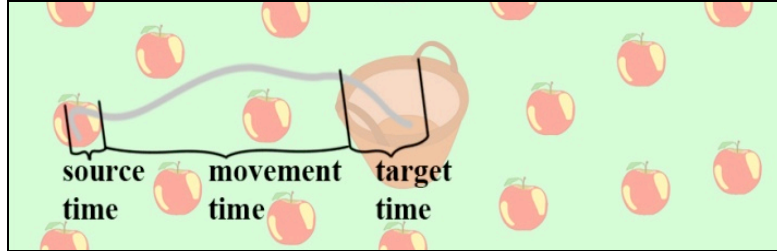
**Figure 4: Participants had to avoid collisions in the experiment 2. The balloon was controlled by using the key arrows and the mouse.**

### Results

The balloon collided on average with 4.62 objects ( $SD= 1.55$ ) using the keyboard and with 3.15 objects using the mouse. We found a significant difference between the two devices ( $F_{2,12}=5.31, p<0.05$ ).

### Experiment 3: Object movement

In this experiment, children had to pick up 26 objects and to put them into a basket (see Figure 5). The source objects had a size of  $2 \times 2$ cm on the used laptop screen, the target object measured a size of  $6.5 \times 5$ cm.



**Figure 5: Participants had to move the apples into the basket. The grey line shows a movement path.**

The apples had a distance of 3 to 13 cm to the target object. Under the Drag-and-Drop condition, the selected objects moved back to their original position when the mouse-button was released before it reached the target object. To provide a visual feedback using Sticky Drag-and-Drop, the selected apple appeared transparent while moving the mouse. Notice that in this experiment, we only used the mouse device.

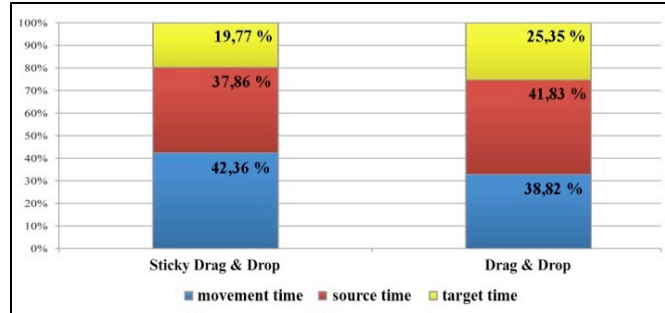
### Design and Procedure

The task was to move as much apples as possible to the target object within 60 seconds. During this, we captured the mouse cursor as well as the number of source objects moved. An error occurred in the Drag-and-Drop scenario if the mouse button has been released *before* reaching the source object. An error occurred in the Sticky Drag-and-Drop scenario whenever children were clicking anywhere else than on the source objects to select and the target object to assign.

### Results

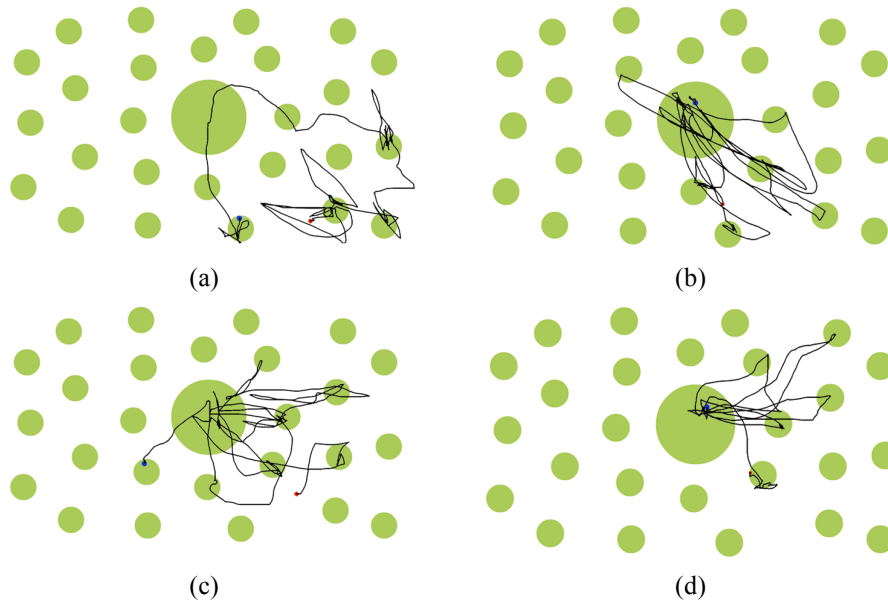
On average 5.96 (SD=3.36) objects have been moved with the Sticky Drag-and-Drop interaction technique and 6.67 (SD=4.48) objects using the Drag-and-Drop technique. However, there was no significant difference between the mean of both methods,  $F_{2,11}=0.38$ ,  $p=0.54$ .

A higher difference could be found comparing the error rates. On average 2.33 (SD=2.9) source objects selected by Drag-and-Drop did not reach the target, because the mouse button was released before the cursor reached the target object. This means that 28.57% of all objects selected with Drag-and-Drop did not reach their target. In contrast, using the Sticky Drag-and-Drop method, all children completed the task without any mistake. We measured a high significant difference between both methods ( $F_{2,11}=7.59$ ,  $p<0.01$ ).



**Figure 6: Composition of time spent during the movement task.**

To get a better understanding, we also tracked all mouse movements. Analyzing this data, we found out that the time children spent during the experiment can be classified in three categories: the source time, which is the time the cursor was placed on the source object, the movement time, which is the time between the source objects and the target object, and the target time, which is the time the cursor was placed on the target object (see Figure 6). Analyzing these traces, it becomes clear that by using Drag-and-Drop, the mouse cursor spent more time at the source and target objects than on the way between the objects; on average 41.83% of the time was spent for the movement from the source to the target and only 25.35% of the overall time was spent for the target time. In contrast, using the Sticky Drag-and-Drop method resulted in an overall of 37.82% total time spent for the movement and 19.77% of the overall time was spent for the target time. This results in a movement time of 42.36 %.



**Figure 7: These plots depict the movement of two different children using the Drag-and-Drop (a, c) and the Sticky Drag-and-Drop (b, d) metaphor.**

Although the children have to press and release the mouse button selecting and placing an object, it takes less time than by simply pressing and releasing the button as it is the case by using the Drag-and-Drop technique. Even children that were able to move more objects by using Drag-and-Drop achieved a higher percentage of source and target time than by using Sticky Drag-and-Drop (cf. Figure 7).

## Discussion

The differences in performance and error rate between mouse and keyboard indicated that the mouse is preferred to the keyboard while designing applications for preschool children. The reason for this could be found in the steep learning curve of mouse usage. Children left their hand on the mouse all the time, but they release the keyboard immediately after pressing a key.

They watched the mouse only at the beginning, but after some minutes, they managed to keep their eyes on the screen and were able to click automatically when the cursor reached the target. Using the keyboard, they always put their fingers away from the keys shortly after clicking. Therefore, before they were able to press a key, they had to look to the keyboard. For many children, identifying the meaning of the used keys was hard as well, although the keys were highlighted and only a very limited amount of keys has been used. Some children just tried all the keys one after another. Because of the problems in identifying the keys and the fact that children release their hands from the keyboard, the children focused alternately the screen and the keyboard as seen in Figure 8. This took much longer than just clicking the mouse and was less intuitive as well.



**Figure 8: Using the keyboard, the participants focused alternately the keyboard and the screen.**

Problems in using the mouse arose when children had to stop a movement precisely. This comes because the fine motor skills are still developing within preschool age. For the same reason, the standard deviations for the average selected or moved



objects and collisions were relatively high; some children were already able to move their hands precisely and click accurately while others needed more time.

Unlike the assumption that preschool children would perform similarly to older children, significant differences in the amount of moved objects by Drag-and-Drop and Sticky Drag-and-Drop could not be found. Although children did not have any experience in using a mouse, they were able to move the objects with Drag-and-Drop. However, due to the error rate of Drag-and-Drop and the time children needed for selecting and placing the objects, Sticky Drag-and-Drop has more advantages than Drag-and-Drop – this was different with older children [11]. While all the objects selected with Sticky Drag-and-Drop reached their target, only 71.26% of the objects selected with Drag-and-Drop did. Additionally, even children that moved more objects using Sticky Drag-and-Drop needed more time for selecting and placing the objects with Drag-and-Drop than they did using Sticky Drag-and-Drop. This could be caused by the fact that keeping the mouse button pressed demands more concentration than simply moving the mouse.

## Conclusions & Future Work

In this paper, we presented the results of three experiments that analyzed interaction techniques for preschool children. We showed that mouse interaction can be preferred to keyboard interaction, because of performance and error rate. Comparing mouse interaction styles, we found that Sticky Drag-and-Drop can be favored over Drag-and-Drop. Next, we want to analyze the behavior using interactive large surfaces (e.g. interactive tables) and develop design guidelines, which should help developers creating applications for preschool children.

## References

1. Bruckman, A. and Bandlow, A.: Human-computer interaction for kids, 2003, 428 - 440.
2. Crook, C.: Young children's skill in using a mouse to control a graphical computer interface. *Comput. Educ.* 19, 3 (1992), 199- 207.
3. Donker, A., Reitsma, P.: Drag-and-drop errors in young children's use of the mouse. *Interact. Comput.* 19, 2 (2007), 257-266.
4. Druin, A., Inkpen, K. 2001. When are Personal Technologies for Children? *Personal Ubiquitous Computing* 5, 3 (2001), 191-194.
5. Druin, A.: A place called childhood. *Interactions* 3, 1 (1996), 17-22.
6. Grünzweil, B.: *Richtlinien für die Erstellung von Applikationen für Kinder im Vorschulalter*, Master Thesis, Digital Media, Upper Austria University of Applied Sciences, 2008.
7. Hanna, L., Risden, K., Czerwinski, M., and Alexander, K. J. 1998: The role of usability research in designing children's computer products. In *the Design of Children's Technology*, Morgan Kaufmann Series In Interactive Technologies. Morgan Kaufmann Publishers, San Francisco, CA, 3-26.

8. Hourcade, J. P., Bederson, B. B., Druin, A.: Preschool children's use of mouse buttons. *CHI '04 extended abstracts on Human factors in computing systems* (2004), 1411-1412.
9. Hourcade, J. P. 2006. Learning from preschool children's pointing sub-movements. In Proceedings of the 2006 Conference on interaction Design and Children (Tampere, Finland, June 07 - 09, 2006). IDC '06. ACM, New York, NY, 65-72.
10. Hourcade, J. P., Crowther, M., and Hunt, L. 2007. Does mouse size affect study and evaluation results?: a study comparing preschool children's performance with small and regular-sized mice. In Proceedings of the 6th international Conference on interaction Design and Children (Aalborg, Denmark, June 06 - 08, 2007). IDC '07. ACM, New York, NY, 109-116.
11. Inkpen, K: Drag-and-Drop versus Point-and-Click Mouse Interaction Styles for Children. *ACM toChi*, 8 (2001), 1-33.
12. Kail, R: Developmental Change in Speed of Processing During Childhood and Adolescence. *Psychological Bulletin* 109, 3 (1991), 490-501.
13. Revelle, G.: Education via entertainment media: the Sesame Workshop approach. *ACM Computers in Entertainment* 1, 1 (2003), 16.