A research in optimizing

Touchscreen Interaction for Children and their Development

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Abstract

Children nowadays get in touch with technology at a very young age. A lot of the interaction we have with electronic devices goes via touchscreens these days. But most touchscreen devices are not designed user specific and they are often too difficult for children to handle. How can we optimize touchscreen interaction for young children? How can we make it stimulate their cognitive development? And what adaptations should we do to existing touchscreen interaction devices to optimize them for children? This paper will try to answer these questions by consulting other papers and combining their results.

Keywords --- touchscreen; touch screen; children; interaction; development; young.
Introduction

Touchscreen devices such as smart phones and tablets have got extremely popular and the use of them has grown rapidly the past few years and will keep on growing [6]. Not only phones and tablets use touch-interaction as the default but also computers are starting to converse from mouse and keyboard interaction to touch-interaction.

Children these days grow up in the middle of all kinds of electronic devices and they start using touchscreen devices at very young age. And even if they don't have their own smart phone or tablet they can often still use the phone or tablet from their parents.

The early use of this technology has a lot of benefits [1][9][10], but the question remains how we can optimize devices for children because nowadays the same touchscreen interaction is used for children and adults, but the way they interact with touchscreens is different.

This paper will investigate the difficulty of different kind of interactions with touchscreens for children, research the differences between the usage of touchscreens between adults and children, research what kind of interactions stimulates children their cognitive development and finally search for answers to the question what kind of interactions with touchscreens make devices suitable for young children and their development.
Method

Starting off with the fascination of touchscreens and their influence on children the research question formed into: "What kind of interactions with touchscreens make devices suitable for young children and their development?". Searching on this topic gave logically a lot psychological and biological related papers. To purely focus on technical papers the IEEE search seemed a logical place to start. Searching on:

IEEE - "Children, touch screen, interaction, development"

gave just one result; it seemed that touchscreen should be written as one word. Now searching for:

IEEE - "Children, touchscreen, interaction, development"

gave 15,653 hits, automatically sorted by relevance. Among the first papers there was a paper called "A field study of understanding child's knowledge, skills and interaction towards capacitive touch technology (iPad)" [1]. This was already highly relevant for the research. Another hit on these search terms was the paper "Interaction design of children's mobile phone for enhancing cognitive ability" [2]. Though there were some good and useful papers between all the results, the majority was not relevant. For example the word autistic came up in the papers really often. Excluding this term by searching for:

IEEE - "(((Interaction) AND children) AND touchscreen) AND development) NOT autistic)"

decreased the number of hits to 8. One of these search results now was the paper "An Analytic Process Schema for Collaborative Multi-Touch Applications" [4]. Since this search term gave so little results now Scopus should give new possibilities. Using the following search terms 54 results came up:

Scopus: (((Interaction) AND children) AND (touchscreen OR touch screen)) AND NOT autism)

Defining the subject area into engineering and computer science lessened this to 46 results. These results lead to finding the paper: "An examination of touch screen tablets and emergent literacy in Australian pre-school children". This paper was unfortunately not available for free. A few other papers came out of this search; among them was the paper: "Understanding child-defined gestures and children's mental models for touchscreen tabletop interaction" [5]. In the references of this article was
another useful paper listed: "Interaction and recognition challenges in interpreting children's touch and gesture input on mobile devices" [3].
Summary of chosen articles and conclusion

Most of the selected articles seemed not to be useful for the research since they focused on the interaction between children through touch screens rather than the interaction with the device itself and the way the child handles it. Two other articles were left out because they focused on touch tables rather than portable devices.

One article about understanding child's knowledge, skills and interaction towards capacitive touch technology [1] seemed very useful. It described a study on what children know about touch technology, what kind of interaction children find easy and what kind of interaction they find hard, and how children feel about using touchscreens.

In addition to this an article was chosen on interaction design for enhancing cognitive ability [2], that described new methods of interaction design of children's mobile phone for enhancing cognitive ability. It did this by analyzing children, draw conclusions from this and form them into new methods of interaction design.

Combining these two articles with an article on interpreting children's touch and gesture input [3] made the selection of articles complete. This third article described the difference between adults and children performing touch interaction tasks, and draw conclusions on how devices can be made more suitable for children.

The three articles together form a nice diverse set of information on the research in how children interact with touch devices and how these devices could be made more suitable for them.

**Article [1],** "A field study of understanding child's knowledge, skills and interaction towards capacitive touch technology (iPad)", discusses a study done with 20 Malaysian children of 8 years old on knowledge, skills and interaction towards capacitive touch technology. For this study 20 iPad's were used. The research was divided into two sessions; each participant played four types of games. After these games the participants answered a questionnaire. The research shows almost all participants of just 8 years old recognize the devices and most of them have already experience with them. Surprisingly, as the article calls it, they can also mention features and applications that are contained in the device. Another interesting observation the researchers make is that some children tend to interact with the device using one hand and others using two hands.

While testing the skills on the device some touch gestures seemed to be easier for children than others. Rotating objects seemed to be very difficult for them; while pressing was done correct in all tests. The results of this test can be seen in figure 1.
The research also concludes that almost all (19 out of 20) children enjoy using the touchscreen, and that the feature they like the most are games installed on the device. Furthermore the article concludes that we don't need to worry about the technological development particularly to children, if all parties, especially parents, teachers and the community together monitor the requirement and uses. So that it can be leveraged to produce more creative, innovative and competitive future generation.

**Article [2]**. "Interaction design of children's mobile phone for enhancing cognitive ability", explored new methods of interaction design, mainly focusing on enhancing the cognitive ability of children. The paper states that a good designed interactive products can enhance children's abilities including exploration, reflection, imagination, creativity and collaboration. They emphasize that children their demand of telecommunication is simpler from adults. Their social area is smaller: the persons children contact are only acquaintances in their daily life, such as their parents. Children mainly use electronic products for learning and entertainment.

The paper also discusses the different phases in a child's life, and states that in the 'concrete operational stage' (age from 6-7 to 11-12) children can perceive more complex graphics, and they can think from multiple perspectives. According to the paper children on this age have difficulties with some language skills. Children of this age also begin to conduct demanding hand-eye interactive activities.

Than the paper goes deeper into the interaction design, and discusses the fact that more and more researchers find that the means of interaction in the lab will meet with difficulties in practice, and users will spend much time on the process of designer's interaction. They state that users will become the more important part in interaction design.

The paper comes up with new design methods for interaction. They propose more actions, memory strategies and social interaction. More actions would stimulate more working memory; memory
strategies would ensure the modifying of production memory and create new production memory; social interaction should be the context of improving cognitive ability. See figure 2.

![figure 2 - new methods based on cognitive ability](image)

The paper is concluded with the statement that interacting in experience and experiencing in interaction are the key factors to enhance cognitive ability. But to apply the new methods into commercial designs the researchers state that there should be deeper research of children's cognitive psychologies and specific usage contexts.

**Article [3]**, "Interaction and recognition challenges in interpreting children's touch and gesture input on mobile devices", focuses on interpreting children's touch and gesture input and how they do this different from adults. Since touchscreen devices become increasingly commonplace, touchscreen interactions are quickly overtaking other interactions. But children probably need another way of interaction with devices than adults since children have smaller fingers, weaker arms, less fine motor control and less experience with technology than adults. According to the article these differences have not yet been examined thoroughly for design implications.

From one of their previous researches [7] they already found that children missed targets 50% more often than adults, and had more trouble with smaller targets. Also, children exerted less pressure on the screen than adults did.

For the new tests they had 30 participants among who were 16 children aged 11.5 years on average and 14 adults from 22 years old on average, all 18+. From this tests they concluded that children are likely to accidentally touch the screen on the borders while holding devices. Children are also likely to cause so called 'holdovers'. Holdovers are touches located within the vicinity of the previous target (see figure 3). In the test 96% of those holdovers were caused by children.
This test also showed that children missed their target 23.1% of the time on their first attempt, while adults just missed 16.9%. In figure 4 you can see the effect of target size on the misses both for children and adults.

**figure 3 - holdovers from target (a) to target (b) [3]**

**figure 4 - average proportion of misses by target size [3]**
Also gesture recognition seems to be more difficult for children than for parents. When drawing characters using the popular $N$-Protractor recognizer [8], children's gestures were recognized more poorly (81% of the time) than adults' (90% of the time). Especially the "+" and the "X" were confused a lot by children's input. See figure 5 for all frequent confusions.

Concluding the test the paper states that holdover touches should be ignored in a smart way, especially for children. There should also not be targets close to borders but not touching them, since this causes a lot of misses placed in the 'gutter' between the target and the edge of the screen. Furthermore they propose training an age-specific recognizer to improve accuracy on kids' gestures.

**Discussion**

The three papers all answer other aspects of the research question. Paper [1] investigated the knowledge and skills children have with touch screens. This made clear that children definitely enjoy using touchscreens. The paper also investigated in different kinds of touchscreen gestures and what gestures were hard for children. This made clear that in order to make a device suitable for children the difficult gestures like rotating (see figure 1) should either be very well explained or left out.

Paper [2] was focusing on cognitive development and how this could be stimulated by means of capacitive touch technology. The article shows the importance of users (children in this case) being part of the interaction-design process. The fact that children have a smaller social life is something to keep in mind while designing a child-suitable device. The researchers from paper [2] emphasize the importance of more actions, memory strategies and social interaction to improve children's cognitive ability which seems to be an answer to the question how the cognitive development of children is
stimulated by means of touchscreen-interaction, although these three new interaction design methods are not touch-screen specific.

Paper [3] described and investigated the challenges in interpreting gestures on touch screens. In order to make a touchscreen device suitable for children it should be optimized to interpret a child's gesture. This article showed where the difficulties lie and how children interact with touchscreens different from adults. For example; children need larger 'touch targets' than adults do and children need a target group specific gesture recognizer in order to recognize their input better. This helps answering the research question what kind of interactions with touchscreens make devices suitable for young children and their development.

It is important that parents and teachers support and monitor the use of touchscreens by children [1]. Also, children should not get addicted to their devices so the apps should be child friendly and not be too addictive: playing outside and having social contact should not suffer from smart touch devices.

All discussed papers are peer reviewed and all use a lot of references, so you could assume that they are all reliably source. However, paper [1] did research using 20 participants which is a rather small group to determine which gestures are hard for them. Paper [3] also had a low number of participants, but the tasks they perform are repeated a lot of times; so that test is way more reliable.

**Ideas for further investigation**

Although this research answers a lot on the research question, more research has to be done in order to formulate complete answers to it, especially research in the psychological domain. This paper mainly focused on different kind of interactions and which ones are most suitable for children and their development. It does however not investigate how to implement them in devices and apps. Research on how to implement the findings in this article to touch devices and apps would be a great addition to this research. A research purely on apps would be necessary to be able to start implementing the findings of this document, since the content of an app determines the child-suitability the most. This would however be a more psychological related research.
List of references

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