Ability of children to perform touchscreen gestures and follow prompting techniques when using mobile apps

Running title: Ability of children to use mobile apps

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Abstract

Background: Nowadays, children get access to smartphones at an early age. However, their ability to use mobile apps has not yet been studied in detail.

Purpose: The purpose was to study the ability of children aged between two and eight years to perform touchscreen gestures and follow prompting techniques, i.e. ways used by apps to provide instructions on how to use them.

Methods: We developed a mobile app to test the ability of children to perform various touchscreen gestures and another mobile app to test their ability to follow various prompting techniques. We used these apps to perform our experiment with 90 children in a kindergarten and a primary school in New Delhi in July 2019. We noted the touchscreen gestures that the children could perform and the most sophisticated prompting technique that they could follow.

Results: Two and three year old children could not follow any prompting technique and only a minority (27%) of them could tap the touchscreen at an intended place. Four to six year old children could perform simple gestures like tap and slide (57%), and follow instructions provided through animation (63%). Seven and eight year old children could perform more sophisticated gestures like drag and drop (30%), and follow instructions provided in audio and video formats (34%). We observed a significant difference between the number of touchscreen gestures that the children could perform and the number of prompting techniques that they could follow (F=544.0407, P<0.05). No significant difference in the performance of female and male children was observed (P>0.05).

Conclusion: Children gradually learn to use mobile apps beginning at two years of age. They become comfortable in performing single-finger gestures and following non-textual prompting techniques by eight years of age. We recommend that these results be taken into consideration while developing mobile apps for children.
**Key words:** Child, Smartphone, Touchscreen gesture, Prompting technique.

**Graphical abstract**

**Key message**

**Question:** At what age children develop skills necessary for using mobile apps?

**Finding:** Four to six year old children can perform single-finger touchscreen gestures and follow non-textual prompting techniques, while some seven and eight year old children can also perform multi-finger gestures and follow textual instructions.

**Meaning:** Mobile apps for young children should make minimal use of text and only single-finger touchscreen gestures should be required to operate them.
Introduction

Children are attracted to smartphones more than other household gadgets and such a new form of media can affect their wellbeing. Smartphones invoke curiosity and interest among children. By the age of two years, children can hold a smartphone firmly in their hands and scribble and draw using a simple drawing app. Children explore different types of mobile apps as they grow up. Mobile apps with age appropriate and engaging content and an interactive interface can be used to foster informal learning among young children. However, Chau found that many mobile apps marketed for children are not actually suitable for them. Mobile apps for children should have a user interface that takes into consideration the physical and cognitive capabilities of children, and use appropriate ways for providing instructions to children on how to use them. Children acquire skills necessary for using mobile apps gradually as they grow up. If the capabilities of children belonging to different age groups are known to software developers, then they can develop suitable mobile apps for them. Ability to perform touchscreen gestures and follow in-app instructions are two important skills necessary for using mobile apps. In this study, we evaluate these two skills of children.

Users interact differently with personal computers and smartphones even when they are using the same software, and their interaction with smartphones is strongly influenced by their ability to perform various touchscreen gestures. Preliminary studies found that two and three year old children can perform gestures like tap, slide and flick, while four to six year old children can perform more complex gestures like drag and drop and pinch and zoom. Nacher et al. experimented with interface designs that allow children to perform touchscreen gestures with more ease.

Mobile apps typically use text, audio and animation to provide instructions to users on how to use them. Young children cannot follow in-app prompting techniques used by mobile
apps and need an adult to guide them when using mobile apps. Hiniker et al.\textsuperscript{13} observed that children start following the instructions provided by mobile apps around the age of five years and can then operate a smartphone alone. McKnight and Fitton\textsuperscript{14} observed that children often have problem in understanding the language of the instructions provided by mobile apps.

The objective of our study was to understand the ability of two to eight year old children to perform touchscreen gestures and follow in-app prompting techniques.
Methods

1. The apps

We developed a mobile app named Baby’s Touch to assess the ability of children to perform various touchscreen gestures (Fig. 1A). The app displays four simple geometric figures, viz. a circle, a square, a triangle and a star, on a simple background. A child is asked to perform a particular touchscreen gesture on all the four geometric objects. The time taken by the child to do so is noted. If the child can perform the touchscreen gesture on all the four geometric objects within a predefined time limit, then we say that the child is able to perform that touchscreen gesture successfully. We say that the child has failed to perform that touchscreen gesture, otherwise. The app can identify seven gestures, viz. tap on a stationary object, tap on a moving object, tap and hold, slide, drag and drop, pinch and zoom, and pinch and rotate.

We developed another mobile app, named Toddler’s Tiles, to assess the ability of children to follow various in-app prompting techniques (Fig. 1B). The app is in the form of a game. The app can provide instructions on how to play the game using several prompting techniques. The app displays six tiles each of which is hiding a fruit. Tapping on a tile reveals the fruit it is hiding. A child can score a point by tapping on two tiles hiding the same fruit in consecutive moves. The time taken by a child to understand the instructions and then discover two fruits is noted. If a child is able to discover two fruits within a predefined time limit, then we say that the child is able follow that prompting technique successfully. We say that the child has failed to follow that prompting technique, otherwise. The background of the app has been intentionally made complex to simulate commercially available apps. The app can provide instructions to a user on how to play the game in five formats, viz. text, on-the-fly textual prompts, audio, video and animation.
We developed Baby’s Touch and Toddler’s Tiles for studying the interaction of children with smartphones. Both of these apps can be downloaded for free from Google Play.

2. Study design

We performed our experiment with 90 children in a kindergarten and a primary school in New Delhi in July 2019. We performed our experiment on children of three age groups, viz. two and three year old children, four to six year old children and seven and eight year old children. We included 15 female and 15 male children of each age group in our study. The experiment was conducted with the permission of the principals of the kindergarten and the primary school.

We asked the children to perform the different touchscreen gestures using Baby’s Touch. Each child was given two minutes to perform a particular gesture on a set of four objects. We noted which gestures the children could perform within the stipulated time.

We then asked the children to use Toddler’s Tiles. We arranged the prompting techniques in a decreasing order of their level of difficulty: instructions in textual format, on-the-fly textual prompts, instructions read out loud, video demonstration and demonstration using an animated hand symbol. The children had to understand the instructions provided through the prompting techniques and play the game. We started with the textual prompting technique. Each child was given two minutes to discover at least two fruits hidden behind the tiles. If a child was successful, then we assumed that the child was able to follow the prompting technique. Otherwise, we provided the next easier prompting technique to the child. If a child was not able to follow any of the five in-app prompting techniques, then an observer gave an in-person demonstration on how to use the app to that child. We noted the most difficult prompting technique each child was able to follow and assumed that the child will be able to follow the easier prompting techniques.
We did not apply for, or receive, any approval from any board or committee for this research because of the following reasons. First, this was a techno-behavioral general pediatric study. The study was non-medicinal, non-intrusive and non-clinical in nature. Second, all the authors are affiliated to a technology university. There is no department or study program related to human subjects in the university. Consequently, there is no internal committee related to research on human subjects in the university.

3. Data analysis

We studied the effects of age and gender of the children on their ability to perform touchscreen gestures and follow prompting techniques. We used one-way ANOVA to evaluate the relationship between the age of the children and the number of touchscreen gestures they could perform and the number of prompting techniques they could follow. We used independent samples t-test to evaluate the relationship between the gender of the children and the number of touchscreen gestures they could perform and the number of prompting techniques they could follow. All analyses were performed using IBM SPSS Statistics ver. 26.0 (IBM Co., Armonk, NY, USA) at the 5% significance level.
Results

Children aged two and three years could hardly perform any touchscreen gesture (Fig. 2). Only 27% children in this age group could tap on an intended place on the touchscreen. Alternatively, children aged four to six years were more proficient in using smartphones. A majority of children in this age group were able to perform simple touchscreen gestures. Among the children in this age group, 57% could tap on an intended place on the touchscreen, 37% could tap on an object moving across the screen and 20% could tap and hold at an intended place on the touchscreen. It was observed that most children learn to perform single-finger touchscreen gestures by the age of seven years. Children aged seven and eight years could perform tap (83%), tap on a moving object (73%), tap and hold (60%), slide (40%) and drag and drop (30%). However, only a few children in this age group could perform two-finger touchscreen gestures like pinch and zoom (13%) and pinch and rotate (10%).

Children aged two and three years could not typically follow any in-app prompting technique (Fig. 3). They can use an app only if someone explained it to them in person. However, children typically develop skills to follow in-app prompting techniques by the age of four years. A majority of children aged four to six years (63%) could follow one or more in-app prompting techniques. The most difficult prompting technique that children in this age group could follow was instructions in audio format (17%), instructions in video format (17%) and instructions using animation (37%). Almost all children (97%) aged seven and eight years could follow one or more in-app prompting techniques. The most difficult prompting technique that the children in this age group were able to follow was textual instructions (17%), textual instructions on-the-fly (17%), instructions in audio format (20%), instructions in video format (33%) and instructions using animation (10%).

We observed a significant difference between the number of touchscreen gestures that the children could perform and the number of prompting techniques that they could follow.
(F=544.0407, P<0.05). However, we did not observe a significant (P>0.05) difference in the number of touchscreen gestures that could be performed by female and male children in any of the three age groups (Table 1). Similarly, we did not observe a significant (P>0.05) difference in the number of prompting techniques that could be followed by female and male children in any of the three age groups (Table 1).
Discussion

Nowadays, parents and teachers often use smartphones to entertain and educate young children. However, smartphones can facilitate child development only if the apps are designed suitably. Moreover, children should use mobile apps in conjunction with their academic activities and play in the physical world.

Aziz et al. and Hiniker et al. studied the ability of children to use mobile apps and a foreknowledge of their findings helped us to design our study. We designed our experiment to be more systematic and involved more children. We observed that children learn to perform various touchscreen gestures and follow in-app prompting techniques between four and eight years of age. Two and three year old children typically require help from their caregivers for using mobile apps. Apps for children in this age group should work with little intervention from the children and may ignore accidental touches on the screen. Four to six year old children can use mobile apps independently. However, using apps meant for children in this age group should require only simple touchscreen gestures like tap and slide. Instructions may be provided through animation which can be understood by a majority of children in this age group. More sophisticated mobile apps may be developed for seven and eight years old children. Seven and eight year old children can perform single-finger touchscreen gestures and follow instructions provided in the forms of animation, and audio and video clips. We observed that some children could perform more touchscreen gestures and follow more prompting techniques than other children of their age. We found that children who use mobile apps frequently could perform more touchscreen gestures and follow more sophisticated prompting techniques. The ability to perform touchscreen gestures or follow prompting techniques is not an appropriate measure of children’s development.

Smartphones may be used to foster child development. However, the apps to be provided to children should be developed according to their physical and cognitive
capabilities. Children learn to perform single-finger touchscreen gestures and follow non-textual prompting techniques between four and eight years of age. Apps for children aged eight years or less should not use textual prompts and using such apps should not require performing multi-finger gestures like pinch and zoom and pinch and rotate.
References


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15. Yadav S, Chakraborty P. Smartphone apps can entertain and educate children aged two to six but should be used with caution. Acta Paediatr 2018;107:1834-1835.
Table 1. Comparison of performance of female and male children.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Average number of touchscreen gestures performed by children</th>
<th>Average number of prompting techniques followed by children</th>
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<tr>
<td></td>
<td>Female</td>
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<tr>
<td>Two and three years</td>
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<td>Four to six years</td>
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<tr>
<td>Seven and eight years</td>
<td>2.87</td>
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*Insignificant difference between female and male children (P>0.05).
Figure Legends

Fig. 1. The two apps used in the study. Here, (A) Baby’s Touch is being used to study children’s ability to perform drag and drop, and (B) Toddler’s Tiles is being used with animation prompting technique.

Fig. 2. Touchscreen gestures performed by children of different age groups. Each age group was represented in the study by 15 female and 15 male children.

Fig. 3. Prompting techniques that children of different age groups could follow. The most difficult prompting technique that a child was able to follow has been shown here and it is assumed that the child will be able to follow the easier prompting techniques.
Toddler's Tiles

00:01  Score:

End Game
Fig 2

- 83% could perform single-finger gestures
- 13% could also perform multi-finger gestures

27% could tap on an intended place

57% could perform single-finger gestures

Number of children

<table>
<thead>
<tr>
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<tr>
<td>Four to six years</td>
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<td>5</td>
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<td>Seven and eight years</td>
<td>13</td>
<td>12</td>
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Fig 3

63% could follow non-textual prompts
97% could follow non-textual prompts
34% could also follow textual prompts

Number of children

<table>
<thead>
<tr>
<th>Female</th>
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<td>Four to six years</td>
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<td>Seven and eight years</td>
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<td>4</td>
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Legend:
- Text
- On-the-fly textual prompts
- Audio
- Video
- Animation
- In person