Selection of Touch Gestures for Children's Applications

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Abstract— *The touch-screen revolution is not restricted to adults only. Parents find games and educational applications running on touch-screen devices and purchase them for their children. Therefore, very young children are playing with and exploring these touch-screen devices. For any one device there can be hundreds of applications for the parents to choose from, so it is likely that the selection of applications is based on advertisements and recommendations. There is a large range of gestures available on multi-touch devices and there is very little known about the relationship between the age of a child and the gestures that they can master. This research focuses on the iPad device and children aged between 2 to 4 years old and investigate which gestures the children in that age group can manage. The results of the research, therefore, could be used to form guidelines for the design of gesture-based software for very young children.*

Keywords— *Children; Gesture; Applications (Apps)*

I. INTRODUCTION

Tablets, particularly the iPad [1] are gaining popularity among adults and children. According to the survey by Nielsen, in American tablet-owning households in 2011, 77% of children play downloaded games on their tablets and 57% of children used tablets to access educational apps [2]. In this research the Apple iPad and education and games category apps from the Apple store were chosen for study. These downloaded apps have been analyzed to identify the most used gestures in children's apps.

This paper is divided into the following sections: Previous Research, Experiment Set Up, Results & Discussion, Conclusions.

II. PREVIOUS RESEARCH

A gesture, defined in [3], is any physical movement a digital system can detect and respond to without the help of a traditional pointing device such as a mouse or stylus. There are many studies on multi-touch interfaces focusing on aspects of human computer interaction techniques [4, 5, 6, 7], multi-touch programming [8, 9, 10, 11], multi-touch panel development [12, 13, 14, 15], guides for multi-touch interaction [16], multi-touch application development [17, 18] and mobile touch interfaces for the elderly [19].

There are also studies that considered children and touch-screens in general [18, 20, 21, 22,] but they have not investigated the relationship between the age of a child and the type of gestures they can master. There are also other studies that focused on children and interactivity using pointing devices but not touch screen gestures [15, 23, 24, 25, 26, 27].

The Michael Cohen Group LLC (MCG) has undertaken research to explore the perceptions of young children and their caregivers regarding the use of iPads and Apps (applications). Sixty children aged between two to eight took part. The study found that children as young as two years old could play and learn with touch screen devices. The children of that age learned to target, often press or drag hard and slowly learned to tap or swipe. Children aged four to five were found using gestures in a more directed and intentional way. Their initial press or drag quickly evolves to tap and swipe with trial and error. Children aged six to eight years quickly figured out the moves that work and if novice, they may press too hard initially but soon tap and target accurately. MCG suggested that apps need to be age appropriate to be effective that the app interface design is also critical and also that the app needs to be user friendly and support the player's intuitions. MCG concluded that the iPad alone does not guarantee engagement and learning [21].

MCG's findings are important for this research in terms of children's ability in using iPad in general. However, the study did not focus on the use of touch screen gesture in detail.

Another study by Segal [22] found that children who used a touch screen interface (iPad) performed better than children who used a mouse interface. Segal suggests that guidelines need to be set for designers and educators on how to develop effective gestural interfaces for the purposes of improving cognition and learning.

Yu et al. [18] tested the application e-Wa Sketchpad on a large multi-touch display with a group of five to six years old children (one boy and three girls). During the whole process, the children's conversation, mood and behavior were observed and recorded. The children quickly learned how to use four

typical gestures: tap, drag, rotate, zoom in and zoom out. The children would allow their hand or arm to relax causing additional contacts with the screen. The touch points generated in this way caused interference for identification of useful contacts.

Yu et al. [18] suggest that researchers need to observe children closely and show them at least once how to use gestures in applications to avoid unintended contacts in any experiment.

Harris et al. [20], evaluated the potential of using a digital touch tabletop to support children's collaborative learning interactions. Children aged seven to ten worked in groups of three on a collaborative planning task to make a seating plan for their classroom in two situations. The first situation the tabletop was configured to allow only one child to interact with the digital content at a time. In the second situation, all children could interact with the digital content at the same time. Harris et al. found that the situations did not affect how frequent or how equitable the interactions were, but influenced the types of discussions that the children had. In the first situation the children talked more about turn taking and in the second they talked more about the task in hand.

In a "Best Practises document" [28] The creators of Sesame Street discuss many aspects of designing apps for preschool children. In the short section on gestures they state that they have found tap, draw/move finger, swipe, drag and slide to be the most intuitive gestures while, pinch, tilt/shake, multi-touch, flick/fling and double tap are the least intuitive gestures. However they do not draw any distinction among children by age.

Existing research [18, 20, 21, 22], has not considered gestures in much detail except [28]. Current findings are more on the use of touch screen in general by young children. A better understanding of children's abilities in using gestures by age is crucial in designing children apps and avoiding lengthy testing [24, 29].

Our pilot study showed that only children aged two to three years have problems using certain gestures. Therefore, this study will focus on how children aged two to three years use the same seven gestures with more children participating in the experiment for each group. Children aged four years are also included in the study since it is presumed that if the children aged four years can use all the seven gestures, older children should also be able to do the same [30].

III. Experiment Set Up

This research was carried out in three phases. The first phase identified the common gestures used in children's apps. The selection of the appropriate apps for the experiment was carried out in the second phase. The third phase was the main experimental study with thirty seven children in the United Kingdom aged from two to four years.

Seven gestures were selected for this experiment: Tap, Drag/Slide, Free Rotate, Drag & Drop, Pinch, Spread, Flick.

The four selected apps are: Montessori Crosswords, AlphaBaby Free, Toca Hair Salon and Toca Kitchen Monsters.

The children were aged:
1. 2 years (11 children)
2. 3 years (11 children)
3. 4 years (15 children)

A digital video camera was used to record images and video of the gestures made by each child. Other information recorded includes:
1. child's age;
2. how well they use the apps on the iPad;
3. gestures they could use;
4. finger movements while using each gesture;
5. problems faced by the child while using gestures and apps;

The three research phases are described in detail below.

IV. Gestures Used in Children's Applications

In the first phase the Apple app store was searched under the categories of Books, Kids, and Entertainment. One hundred of the top listed iPad apps, including those requiring fee payment or free were examined. The most suitable apps for children were under the categories of education and games. Therefore 100 apps in these two categories were examined to identify the gestures commonly used in children apps.

After analyzing those 100 apps seven gestures were identified as shown in Table I [31].

TABLE I. Gestures and The Number of Apps Use it [31]

Gestures	The Number of Apps
Tap	86%
Drag/Slide	56%
Free Rotate	40%
Drag & Drop	22%
Pinch	14%
Spread	11%
Flick	9 %

The most common gesture is tap, followed by drag/slide, free rotate, drag and drop, pinch, spread and flick.

V. App Selection

This research used four apps for the experiment. The selection is based on reviews in 2012 and what was listed by iPad store as best apps in terms of popularity, fun and interest for young children, age range and gestures implemented in the apps [32, 33]. Table II shows the selected apps.

TABLE II. APPS AND GESTURES FOR EXPERIMENT

Apps	Gestures T DS FR DD P F S	Age Recommended
Montessori Crosswords	√ √ √ √ √ √ √	iTunes Preview : *age 3+*
AlphaBaby Free	√ √ √ X √ √ √	iTunes Preview : *for age 2 years old and younger kids*
Toca Hair Salon	√ √ √ √ X √ X	iTunes Preview : *age 3+*
Toca Kitchen Monsters	√ √ √ √ X √ X	iTune Preview : for kids all ages

T=tap DS=drag/slide FR=free rotate DD=drag & drop P=pinch F=flick S=spread

Table II shows four apps chosen for this study which are Montessori Crosswords - Spelling With Phonics-Enabled Alphabet, AlphaBaby Free, Toca Hair Salon and Toca Kitchen Monsters.

The selections of apps are crucial for this research to attract the young children. The children also can show their real ability in using gestures with the app that they like most. For example, if they do not like to play with Montessori app, the researcher still has an opportunity to observe their gestures capability in AlphaBaby Free app.

Table II also lists the gestures used in each app based on seven gestures, which have been identified after analyzing the 100 iPad children applications under education and games categories as shown in Table III.

Montessori Crossword app uses all the seven gestures similar to the most used gestures in children applications as identified in Table I. Toca Hair Salon app also uses all gestures except pinch and spread gestures. AlphaBaby Free app uses all gestures except drag and drop. The two Toca apps use all gestures except pinch and spread.

Table II also shows the age recommended for each app. The age recommendations by iTunes Preview are generally based on the app's content and not the review of the gestures used inside it.

All four applications discussed above are selected based on the gestures found in each app, their popularity, their ability to provide fun and interest for young children, suitability for the age group and also recommended by Apple or other reviewers.

VI. EXPERIMENT

The main experiment focused on investigating the ability of children aged two to three in using the seven gestures. Children age four were also considered to confirm that they could use all the gestures. Thirty seven children age two to four in the United Kingdom took part in the experiment. The study prepared a comfortable environment for the children to use the iPad one at a time. A digital video camera was carefully placed to record images and video of the gestures made by each child. The researcher together with the parent/teacher guided the child to play with each application at least once. The items recorded were the child's age, their prior experience with touch screen device and how well they use the apps on the iPad. The details include the gestures they could use, the finger movements while using each gesture and the problems faced by the child while using them.

VII. RESULTS AND DISCUSSION

In order to discuss the results in detail, this section is divided into the following sub-sections: Gestures that can be used by Children, Additional Criteria for the use of Gestures and Interface Design Components.

A. Gestures that can be used by Children

The video recorded during experiment with eleven children aged 2 years and aged 3 years and fifteen young children aged 4 years has been analyzed. Table III summarizes the results.

TABLE III. GESTURES THAT CAN BE USED BY CHILDREN AGED TWO TO FOUR YEARS

Gestures	Age 2	Age 3	Age 4
Tap	100%	100%	100%
Drag/Slide	100%	100%	100%
Free Rotate	55%	91%	100%
Drag & Drop	36%	100%	100%
Pinch	55%	82%	100%
Flick	36%	73%	100%
Spread	11%	36%	100%

The first column in Table III shows the list of gestures and the following columns show the percentages of children aged two to four years who can use the gestures. This research considers the percentage lower than 60% indicates that the children are struggling in using gestures. Meanwhile the higher percentage indicates they are successful in using the gestures.

The result shows that all children from aged two to four years can use tap and drag/slide gestures. This maybe because the children found these gestures is easy and natural as what they see and do in their real life. Therefore, this research suggests that app designer can use these two gestures in their apps.

It is shown that only 55% children from aged two years can use the free rotate gesture. This indicates that children aged two years old are struggling doing free rotate gesture. This occurs because the free rotate gesture requires the children to twist their fingers and is difficult for a child aged two years maybe because their motor skill is not yet fully developed. 91% of children aged three years and all children aged four years can use free rotate gestures. Therefore, it is appropriate to use this gesture in games for children aged three upwards.

Only 36% of children aged two years can use drag & drop gestures. This indicates that the drag & drop gesture is not appropriate for apps for two years old. All children of aged

three and four years were successful in using drag & drop gesture.

The result also shows that only 55% of the children aged two years can use pinch gesture. This indicates that children aged two years are also struggling doing the pinch gesture like drag & drop and free rotate gestures. Perhaps they lack the capability to perform pinch gesture (motor skill) or do not understand how to do the gesture (cognitive level). Meanwhile, 82% children aged three years and all children aged four years can use the pinch gesture. The app designer can use this gesture for children aged three upwards.

With the flick gesture, only 36% of the children aged two years can use it. This indicates that children aged two years old are struggling doing the flick gesture. The reason may be they do not understand how to flick and why they have to use the flick gesture. This gesture is not obvious to them because they normally never use flick gesture in the real world if they are sorting letters, numbers or shape. However, 73% children aged three years and all children aged four years can use flick gesture. The app designer can use this gesture for children aged three and four years.

With the spread gesture, 11% of the children aged two years and 36% of the children aged three years can use it. This also indicates that children aged two and aged three years are struggling to do the spread gesture. Like pinch and flick, it is assumed the reason for the struggle is caused by their motor skill which is not yet developed and they also do not understand how and why they have to do the gesture. The result shows that all children aged four years can use spread gesture. The app designer can use this gesture for children aged four years.

The selection of gestures needs to be appropriate to the children's age for app design and this experiment shows a strong relationship between age and the gestures used.

B. Additional Criteria for the use of Gesture

This research also identified additional criteria for the use of gesture. The criteria are 'one gesture - one task', simultaneous gestures, consistent gesture and natural gesture. Table IV summarizes the identified gestures criteria.

TABLE IV. GESTURES CRITERIA

	Gestures criteria	**Description**
1	Unique gesture	One gesture implemented to achieve any given task on a particular component
2	Simultaneous gestures	a) The set of all gestures used in all tasks on all components b) The ability to apply a gesture to more than one component at once
3	Consistent gesture	Similar gesture for different task and component for different screen
4	Natural gesture	The use of gesture is consistent with its use in the real world

Gestures criteria 1 and 2 in Table IV are related to one another. Children's applications come with components which are touchable such as shapes, letters, numbers or objects. Unique gesture is at most one gesture implemented to achieve any given task on a particular component. Observation shows that too many gestures for a task have no meaning to young children aged two and three years. Children only use one unique gesture for each task even though they are taught to use other gesture by the researcher or their teacher. For example, children will use tap gesture only to cut the character's hair in Toca Hair Salon app even though they also have different choices of gestures such as drag/slide and free rotate. Therefore designing one gesture for a task is highly suggested.

Observation also shows that simultaneous gestures for different task and different components at the same screen also make children confused. For example, children get confused when they try to move the letter "A" and at the same time they also accidentally moved another letter in the Montessori Crossword app. The app allows the children to move many letters at the same time in one screen. Hence, designing a unique gesture for a component is highly suggested.

The third gesture criterion as shown in Table IV is consistent gesture. Consistent gesture can be defined as whenever a certain task is to be done then the same set of gestures are available whatever the component.

Our observations indicate that children are able to use the app smoothly if the app's designers use consistent gesture for the whole app. In the Toca Hair Salon app, three screens were designed for almost similar gesture; unfortunately the last screen was designed for totally different gesture. Inconsistent gestures from one screen to another make the children confused. The app designer can use similar gesture for different screen for children apps development.

A natural gesture as shown in Table IV is a gesture used in a children's app that is similar to our gesture in the real world. Observation also shows that children always use natural gesture at the beginning of their interaction with apps. For example using pinch gesture for picking any object. Unfortunately those apps in this experiment use drag/slide or drag & drop to pick object such as in Toca Hair Salon and Toca Kitchen Monsters app. Therefore the appropriate selection of gesture is crucial for young children and this research highly suggests the use of gesture in children's app must be consistent with its use in the real world.

C. Interface Design Components

In this experiment, children's interactions with the app's interface design components were also observed. This section discusses the interface design components which are touchable, e.g. a shape, a letter, a number or any object in a children's app. Table V summarizes the findings.

TABLE V. INTERFACE DESIGN COMPONENTS

	Components Criteria	**Suggestions**
1	Number of components	Reduce the number of components for each page to enable children to focus Reduce the number of components for each page to enlarge the space between components
2	Selection of components	The selection of images must be consistent with their use in the real world Select appropriate (cute) characters for young children
3	Arrangement of components	The arrangement of components must be consistent and simple for the whole app

The first components criterion as shown in Table V is the number of components. The number of components is crucial when designing app interface. Observation shows that too many components for every page will keep children busy sorting the components (numbers/letters/object) rather than answering the question given on that page. There is still a lack of studies related to components and children's app design. Therefore, while this study suggests reducing the number of components for each page to enable children to focus more research is needed to find out the appropriate number of components per page for children apps.

Observation shows that children found it difficult and got confused when using gestures on crowded interface design such as in Montessori Crossword and AlphaBaby app. There are too many letters on one page in Montessori Crossword app and too many components (letter, number, shape) appear on the same page in AlphaBaby app. Meanwhile, the size of the components become smaller and the distances become closer. Hence, enlarging the space between components by reducing the number of components for each page is suggested to the app designer.

The selection of components is the second criteria as shown in Table V. The selection of image must be consistent with its use in the real world. Observation shows that children also relate the image or item they see on the app to what they usually see in the real world. Any still image on the interface which is used as a background should be omitted from the screen. Children will try to interact with the image because they think they can interact with it like other images on the screen. Therefore designing apps for young children really needs special attention and understanding in children's characteristics and what they learned in the real world.

The selection of characters for young children is also crucial. Observation also shows that a few children did not like to play with certain cartoon characters and hid behind their mothers when researcher showed the application. Therefore, before using any image, especially a cartoon character, the app's designers have to test it on young children to ensure the character does not scare them.

The last criterion as shown in Table V is the arrangement of components. The arrangement of components must be consistent and simple throughout the whole app. For example, if all items on the panel are placed at the bottom of every interface from the beginning, the app's designer should not arbitrarily put them the other way around or add complicated design. This will confuse the children. Therefore the arrangement of components must be consistent and simple for the whole app.

An overall observation indicates that the components criteria are also related to gestures criteria. This means that the number and the size of components influence the number of gestures to be used in every screen.

VIII. CONCLUSION

This research has important implications for developing application software for young children aged two to four years. Table VI summarizes the results from successful gestures that can be used by young children aged 2 to 4 years.

TABLE VI. SUCCESSFUL GESTURES THAT CAN BE USED BY YOUNG CHILDREN AGED 2 TO 4 YEARS

Age 2	**Age 3**	**Age 4**
Tap Drag/Slide	Tap Drag/Slide Drag & Drop	Tap Drag/Slide Drag & Drop Free Rotate Pinch Flick Spread

Table VI shows that children aged two years successfully use tap and drag/slide gestures. App designer can use these two gestures in children's app aged two years.

This study also finds that children aged three years do slightly better than children aged two years. They are successful in using drag & drop gesture other than tap and drag/slide gestures. Therefore the app designer can use these three gestures in children's app for children aged three upwards.

The app designer can use all seven gestures in a children's app aged four years and above.

Apart from the ability of children to use gestures, the way that an app designer chooses and arrange the gestures also must be appropriate. The app designer should use a unique gesture for a given task, consistent gesture across different screens and natural gestures for the whole app.

When designing an interface, a designer is encouraged to reduce the number of components for each page, enlarge the space between components, select appropriate images/characters for young children and arrange the components in a consistent and simple way for the whole app.

This research suggests future investigations in 1) using simultaneous gestures for each task to observe children's appropriate gesture, 2) designing natural gesture for young children's interface design and also 3) using the appropriate number of components per screen for children apps. We would also like to look at the needs of children who have problem with motor skill or other disabilities like dyspraxia, to see whether using apps with certain gestures because might beneficial.

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