2014

Study of Touch Gesture Performance by Four and Five Year-Old Children: Point-and-Touch, Drag-and-Drop, Zoom-in and Zoom-out, and Rotate

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By

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A Thesis Submitted in Partial Fulfillment of the

Requirements for the Degree of

Information Technology

In

Computer Information Science

Minnesota State University, Mankato

Mankato, Minnesota

July 2014

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Abstract

Past research has focused on children's interaction with computers through mouse clicks, and mouse research studies focused on point-and-click and drag-and-drop. However, More research is necessary in regard to children's ability to perform touch gestures such as point-and-touch, drag-and-drop, zoom-in and zoom-out, and rotate. Furthermore, research should consider specific gestures such as zoom-in and zoom-out, and rotate tasks for young children. The aim of this thesis is to study the ability of 4 and 5 year-old children to interact with touch devices and perform tasks such as: point-and-touch, drag-and-drop, zoom-in and zoom-out, and rotate. This thesis tests an iPad application with four experiments on 17 four and five-year-old children, 16 without motor impairment and 1 with a motor impairment disability. The results show that 5-year-old children perform better than 4-year-old children in the four experiments. Results indicate that interaction design for young children that uses Point-and-Touch gestures should consider distance between targets, and designs using Drag-and-Drop gestures should consider size of targets, as these have significant effects in the way children perform these gestures. Also, designers should consider size and rotation direction in rotate tasks, as it is smoother for young children to rotate clockwise objects. The result of the four different touch gestures tasks shows that time was not an important factor in children's performance.

Acknowledgments

This research study could not be completed without the support of so many people. I would like specifically to thank each one of them.

Special thank to my dad Husain who empowered me to reach my goals, and my mom Sakina who has been so supportive and caring throughout my life. I also extend my thanks to my siblings, Isra, Ahmed, Alaa, and Ali who I could not make it this far without counting on them, and to my aunt Mariam who has been supportive throughout my educational journey.

I express gratitude to my advisor Dr. Salivia for mentoring me through each step in this research, and the committee members Dr. Veltsos and Dr. Bertsch for their time and meaningful feedback. Furthermore, I sincerely appreciate the help I had obtained from the IT department by providing me with the hardware I used during the experiment. I also thank Joshua Wuollet for helping me in the statistical analysis part of this study.

I am very thankful for the parents/guardians who allowed their children to be part of this educational research, and all children for their enthusiasm to be part of the experiment. A special thank to South Elementary School in Saint Peter for allowing us to recruit children and use their facilities for this study.

Also, I would like to express gratitude to Layla Fakhro organization, and Mr. Ubaydli for their support. I thank Mohammed Almahdi for designing the graphics used in the application. Finally, I would like to thank all my family and friends who believed in me to accomplish this research.

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Chapter 1: Introduction

Children are using technology more and more everyday, and children start developing their fine motor skills as they start writing as young as 3 years old (Makopoulos & Bekker, 2003). A research study indicates children are able to use technology such as mouse computers before their ability to read and write (McKenny & Voogt, 2010). Nowadays, touch devices, especially tablets are introduced to children through learning applications and games. "There has been a rapid growth in recent years in the range of non-keyboard input devices (NKID) utilized with computer systems (e.g. trackball, touchscreen, touch pad and trackpoint)" (Woods, Hastings, Buckle, & Haslam, 2003, p.511). The ability of children to deal with non-keyboard input devices (NKID) and touch devices is dependent on their skills on specific NKID tasks, and within the touch devices, there are different skills that can be performed by a child. Children interaction style with computers is usually through mouse clicks. The main interaction gestures are point-and-click and drag-and-drop. However, touch devices have introduced more interaction styles to perform the same task that a mouse performs such as zoom-in and zoom-out, and rotation.

Different technologies introduce different interaction styles to perform specific tasks, which are used by children. For instance computer mouse introduced point-and-click and drag-and-drop tasks, while touch devices introduced zoom-in and zoom-out, and rotate. Inkpen (2001) note that children get used to any interaction style that is introduced to them. However, there might be some issues in introducing interaction styles that may result in difficulties or uncomfortable situations for the children.

Research on human interaction with technology input device has focused on adult mouse interaction or adult compared to child interaction (Inkpen, 2001), while research has also focused on children's interaction with computer software focusing on mouse interactions. On the other hand, little research has been done related to children's interaction with touch devices, especially for children between 4 and 5 years old. Also, there is little research analyzing children's ability to perform specific touch interaction movements such as point and touch, drag and drop, zoom-in and zoom-out, and rotation. Current touch research studies with children focus on helping children with specific needs use specific touch gestures. For instance, Hourcade, Williams, Miller, Huebner, and Liang (2013) used touch devices to enhance the social interaction of children with autism. Hourcade, Driessnack, and Huebner (2012) used touch devices to interact with children and used the strategy of zoomable draw and tell to understand children's headache and identify specific symptoms for a better treatment.

Children's fine motor skills are highly related to their ability in dealing with input devices, and mouse interaction styles has been thoroughly studied compared to touch interaction style (Hourcade, 2008). According to Hourcade that children adapt to the touch interaction style very well, but not much research has been done in this regard (2008). While research (Inkpen, 2001) shows the point and click interaction style is faster than drag and drop, and the target distance and target size affects the interaction style significantly, most previous research has been focusing on point and click, and drag and drop tasks performed by adults. This research will focus on four different tasks that are performed by children using touch devices.

This research will study the ability of 4 and 5 year-old children to interact with touch devices such as the iPad. It will observe, compare, and analyze the ability of young children to perform tasks on touch tablets. In particular the study will look at touch gesture performance for children while performing the following tasks: Point-and-Touch, Drag-and-Drop, Zoom-in and Zoom-out, and Rotate. This study attempts to have a better understanding of children between 4 and 5 year-old while performing touch movements on tablets. As children nowadays have early contact with technology, they understand how to deal with devices faster than adults who grow up in less technological environment (Bay & Ziefle, 2005). As children are highly adaptive to any kind of technology given to them, in this research study we did not provide any training or test trials before we start the experiment. So it is important to understand the difficulties that the child encounter for the first time in dealing with a technology, and study the first-time problems that a child will have during performing specific tasks (McKnight & Cassidy, 2010).

The study observes touch gestures on an iPad application that is designed for this study, and the children will be testing the application by performing a total of 100 task which took around 30 minutes per child to complete. The research population is children who are 4 to 5 year-old, 16 are without any motor impairment and one child with motor impairment disability. The iPad application saved the touch coordinates for each test for analysis, four sections are presented in the application which are: point and touch the colored block to a frame, drag and drop a colored box to a frame, zoom-in an zoom-out a colored box to fit in a frame, and rotate a colored box to fit in a frame.

We expect all children to have different touch behavior and difficulties based on the touch interaction style performed. Also, we expect some difficulties in performing zoom-in and zoom-out, and rotation tasks more than point-and-touch and drag-and-drop tasks. Some of the limitations for this study were recruiting children for the experiment. Also, less research was found on touch devices and children interaction with different touch gestures compared to adult's research. And in same context less research was found in zoom-in and zoom-out, and rotate gestures.

This study consists of several chapters to have a complete understanding of the research. Chapter one is introduction and general concept of the study which consists of: introduction to the problem, background of the study, statement of the problem, purpose of the study, research question, nature of the study, significance of the study for touch devices designers with young children, and limitations that can be avoided for future research. Chapter two is literature review about children interaction styles, touch devices, and children motor impairment disabilities with technological devices. It presents previous research done in this field with the focus on touch interaction styles, which this study builds on previous research findings. Chapter three discuss the methodology used to perform the experiment in this study, the application is tested on 4-5 years old children. This chapter includes detailed description of participants, tasks, procedure, design, and analysis. Chapter four includes the results of all experiments and a discussion of the results. At the end, chapter five concludes the research and has recommendations for future research.

Chapter 2: Related Research

Touch technology and the shift towards mobile touch devices have been growing rapidly in the recent years, and many companies are starting to compete with the touch mobile devices and tablets such as: Microsoft, Apple, Nokia, etc. (McKnight & Cassidy, 2010; McKnight & Fitton, 2010). Nowadays, mobile devices with touch usability are spreading rapidly, and most people have used or own a touch device. Due to the growth of touch screens, it is replacing the traditional methods of interaction with computers. The shift towards touch screens is replacing mouse and keyboard interaction methods with technology, and it is replacing the user experience in dealing with technology from an indirect (mouse and keyboard) to more direct (iPad and iPhone touch screens) method (Anthony, Brown, Nias, Tate, & Mohan, 2012).

There is not much research regarding the usability of touch technology, and research regarding children's interaction with touch devices and children's application designs is limited (McKnight & Cassidy, 2010; AbdulAziz, Batmaz, Stone, & Chung, 2013). Most research is based on children and mouse interaction capabilities or other interaction methods such as: joysticks and stylus (Strommen, Revelle, Medoff, & Razavi, 1996).

Children at a young age have limited ability to deal with technology due to developing cognitive and fine motor skills, and children interface design should be based on the age target. For example, research has found children in the age range of 5 to 7 have some difficulties in understanding complicated designs; therefore, designs for this age group should be simple, direct, the child's age should be highly considered, and there should not be the use of abstractions in order to have an effective design (Revelle & Reardon, 2009;

McKnight & Cassidy, 2010). Also, handedness and gender affect children's aiming capabilities. Barral and Debu (2002) found 5-year-old girls performed better than boys at aiming and right-handed children performed better than left-handed in completing the tasks (Barral & Debu, 2002). However, Sackes, Trundle, and Bell (2011) found that boys had better computer skills than girls in kindergarten.

As the technology improves on a daily basis, and children interact with these new technologies, the influence and pressure increases to adopt and use them and be part of the normal daily life (Yu, Zhang, Xue, & Zhu, 2010). However, research primarily focusing on mouse skills and limited research on touch technology may result in technology that is too challenging for young children to use effectively. This literature review will focus on outlining research regarding children's skills in using input technology.

The ways that interaction styles are designed create different obstacles or difficulties for the child as a user. A study expects difficulties for children that basically depend on gesture interaction style versus using stylus (McKnight & Fitton, 2010). As mouse interaction style with devices showed many difficulties for children (Agudo, Sanchez, & Rico, 2010).

2.1 Children's Use of Computer Mouse

Children's fine motor skills vary a lot compared to adults, and children's fine motor skills start developing mainly while the child learns how to read and write (Donker & Reitsma, 2007). But, children are able to use technology such as computers prior their ability to read and write (McKenny & Voogt, 2010). Also, the fine motor skills of children differ at different ages, and there may be a huge difference in their gesture abilities (Donker & Reitsma 2007). For example, a child that is 4 year-old may have completely different abilities

than a child who is 5 year-old that can read and write. Research shows that young children can use the mouse and perform some tasks such as pointing and moving; however, they will take time to accomplish those basic tasks (Dennerlein & Yang, 2001) or need additional adult assistance (McKenny & Voogt, 2010). Additionally, research indicates that while it is more difficult for children compared to adults to accomplish basic mouse clicking tasks (Donker & Reitsma 2007) children prefer mouse technology over touch technology due to developing fine motor skills (McKnight & Cassidy, 2010). Overall, these research studies show that it is hard on young children to use the mouse and perform task and it is hard for children to use touch technology in an efficient way, but at the same time basic tasks performed by mouse are feasible.

In order to evaluate the usability of the mouse interaction style and the challenges children face in performing mouse tasks, it is important to test interfaces and perform usability tests on young children. A research study concludes that after performing usability tests on children, interfaces need to be different for adults compared to children (Joiner, Messer, Light, & Littleton, 1998). It is important to keep in mind that a main difficulty for a child to use a mouse is the relative size of the mouse compared to the child's hand in order to control it to perform mouse tasks such as clicking and dragging (Donker & Reitsma, 2007; Hourcade, Bederson, Druin, & Oisguimbretie're, 2004). It is hard to consider the mouse as the most efficient way for children to interact with technology as it has many difficulties. The mouse has relied on gesture movements that the touch interaction style uses. Moreover, a research study titled *Slow and steady wins the race? Three-year-old children and pointing*

device use compared different interaction styles such as trackball, mouse, and joystick to perform specific tasks and difficulties encountered with children (Strommen al., 1996).

As the mouse can be a very useful input method to perform tasks on a computer, it is important to highlight the difficulties that a child would face the performance of mouse tasks. Even though the general perspective that the mouse is the most efficient input method for children compared to the joystick and the track ball. Research results show that the mouse tasks can be complicated for young children. Training is needed for children in order to be able to use the mouse, especially for the children that have little or no experience in using the mouse as an input method (Agudo al., 2010).

2.2 Children's Use of Touch Devices

Touch technology is the most recent technology that is closest to a natural interaction with mobile, computer, and tablet interfaces. Natural interaction allows children to deal with a technology with their hands, and without any medium such as pen or stylus. As it is described by Yu, Zhang, Xue, and Zhu (2010) touch interaction is "new era of more natural, more direct human-machine interaction"(p.4). Multi-touch technology and direct interaction are becoming more familiar to organization, because they use flexible touch gestures to interact with the screen (Holzinger, 2003; Yuet al., 2010), there is no other medium to interact with the screen and perform tasks, the child interacts directly with his or her finger. However, touch devices are made for the mass market, general audience, and mostly for adults as they are the target customer (Anthony, Brown, Nias, Tate, & Mohan, 2012). Also, the touch interaction style has changed the way that users interact with devices. The interaction style has changed to overcome the most common ways of dealing with

technology, because "it also provides an excellent alternative to the use of other hardware such as mouse, stick pointer, digital pen, touch button and keyboard" This has brought new concepts of touch gestures such as: point-and-click, drag-and-drop, zoom-in and zoom-out, and rotate (Ibrahim, Borhan, & Yatim, 2013, p.1).

Children's interaction with technology differs, because children's arms and fingers are smaller and weaker than adults. Also, children's way of controlling their hands and fine motor skills are weaker than adults. Those are some of the main elements that a child can differ in his or her way of dealing with touch technology and performing gestures tasks compared to adults (Anthony et al., 2012; McKnight & Cassidy, 2010) as the design of adults may not be the most appropriate design for children use. Anthony et al., (2012) indicate that there has not little research on how young children interact with touch devices, how they perform using touch gestures, and in the investigation of young children's difficulties with touch devices; however this research is needed because the target of touch devices is extending not only to adults but to children as well.

Research on touch gestures shows that children can learn how to deal with touch devices and perform touch gestures such as point-and-click, drag-and-drop, zoom-in and zoom-out, and rotate with some difficulties (Yu al., 2010; AbdulAziz al., 2013). However, the age of the child plays an important role in determining the capability of the child in using touch devices. Young children (2 and 3-year-old) can perform specific touch gestures such as tap and drag, but starting at age 4 years can perform all touch gestures such as: tap, drag-and-drop, pinch, spread, and rotation (AbdulAziz al., 2013). The children can learn how to use touch devices easily as they can learn rapidly with no need for previous experience to

perform specific skills on touch devices (Couse & Chen, 2010; McKnight & Cassidy, 2010). Most children are exposed to this technology at a young age. Especially because parents give their touch devices to their children, the children have the ability to deal with touch gestures with touch screens by themselves (Ibrahim, Borhan, & Yatim, 2013). Touch devices need some operational skills in order to perform touch gestures tasks, operational skill is the skill needed to process or function a task through mouse or touch screen (Plowman, Stevenson, Stephen, & McPake, 2012). In addition to that, operational skills usually need fine motor skills in order to complete the tasks.

Research studies shows that young children have difficulties performing touch gestures tasks (Yu al., 2010, Abdulaziz al., 2013). Difficulties include touching the edges of the screen, and method of holding the device. These are linked to the child's age and previous experience with technology (Chang, 2008; Revelle & Reardon, 2009; McKnight & Cassidy, 2010; Couse & Chen, 2010).

It is important to study the difficulties that children face the first time they use touch interfaces versus the difficulties after using them for a while. At the same time it is important to have the children enjoy using the technology to perform the tasks, because if the child does not enjoy it he or she will not perform the task correctly (McKnight & Cassidy, 2010). Research shows when comparing touch-based interaction to gesture based interaction with a camera, most 5 year-old children preferred to use the touch interaction style (Jong, Hong, & Yen, 2013). Additionally, when comparing computer mouse to touch based interaction children with autism preferred touch based learning and adapted to the new technology more easily (Sitdhisanguan, Chotikakamthorn, Dechaboon, & Out, 2012). This research

shows that touch interaction styles is becoming the dominant form children prefer among interaction styles.

There are different types of touch screens, but mainly the concept of touch screen is having a screen that records the touch point of a finger or stylus. A study by McKnight and Cassidy describes the resistive touch screen as "two thin resistive layers that are separated from each other, when pressure is applied, the layers are connected and the location of the touch is registered, ant pressure on the screen will be registered"(p.2) compared to capacitive touch screens which are "mostly glass coated in a conductor, when a part of the screen is pressed by a part of the body, such as finger, the electric field on the screen is disrupted" (p.3). The capacitive touch screens basically are used in apple devices such as iPad and iPhone. This study will be using iPad as the touch gestures recorder. The main focus of interaction styles with children consist of point-and-click or point-and-touch, and drag-and-drop that will be based on literatures that are described in the following sections.

2.2.1 Point and Touch

Point-and-click is most commonly used for mouse interaction style with computers, while point-and-touch is used for touch interaction style with touch devices such as touch laptops, touch mobile phones, and touch tablets. Dennerlein & Yang (2001) define pointing in their research as three steps, which are: "rushing towards the target, reducing speed, and aiming precisely" (p. xxx). While this research focuses on mouse interaction, it can be applied point-and-touch as well.

Point-and-click research with young children, indicates that speed and accuracy in aiming are two important elements in order to complete point-and-click task using the

mouse (Donker & Reitsma, 2007). The children try to be fast and as accurate as they can in order to achieve the task with least amount of errors. However, while errors always occur while performing the tasks, research shows that the larger the tasks, the fewer the errors children make. Also, as the target gets larger, children aim and select a target faster (Donker & Reitsma, 2007; Chag, 2008). Moreover, Donker & Reitsma (2007) found that after 27px for mobile phone applications or games, the accuracy of pointing and clicking does not differ much and is stable. However, Hourcade et al. (2004) state that children aged 4 and 5-years-old will have more difficulties if the target is smaller than 64 pixels, and as shows in figure 2.2.1 4 years old children needs 64px targets and 5 years old children need 32px targets.
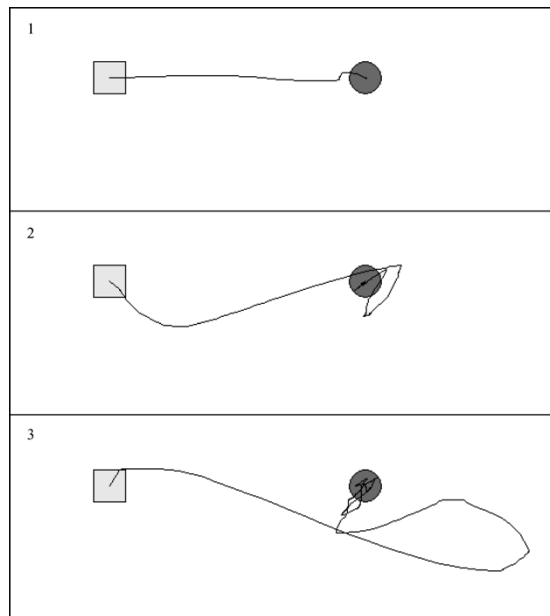
Figure 2.2.1 Plots of three participants' mouse motion towards a 32 pixel circular target 256 pixels away from the home position. Participant in (1) was a 21 year-old female. Participant in (2) was a 5 year 8 month old female. Participant in (3) was a 4 year 6 month old female. Adopted from "Differences in Pointing Task Performance Between Preschool Children and Adults Using Mice", by J.P Hourcade, B.B Bederson, A. Druin, and F. Guimbretiere, 2004, *ACM Transactions on Computer-Human Interaction (TOCHI), ACM*

In addition to the size of the target, the number of objects on the screen may also influence children's point-and-touch accuracy. In most applications or games there are different objects in the same screen. Most educational applications that are designed for young children have various objects positioned on the screen at the same time, and the reason to that is due the number of errors will decrease if there is only one object positioned on the screen (Donker & Reitsma 2007; Chag, 2008). Also, it is important to decrease the children error rate in the application (Donker & Reitsma, 2007). However, if only one object is position on the screen, the child will finish the task successfully after several attempts as the designer have more control on the test environment. Donker & Reitsma (2007) found that the size mattered in designing application interfaces for children, but the shape of the object or the distracting objects did not effect the experiment results (2007).

Another important element that can effect the target selections for young children is distance, which is the distance between objects to be selected. While some research recommends large distance between targets for young children (Donker & Reitsma, 2007) other research suggests that distance does not have much relationship with the accuracy of a target for children, and size instead affects the accuracy as shown in figure 2.2.2 (Hourcade et al., 2004). Most research on distance has focused on point-and-click with one object on the screen, or compared point-and-click with drag-and-drop.
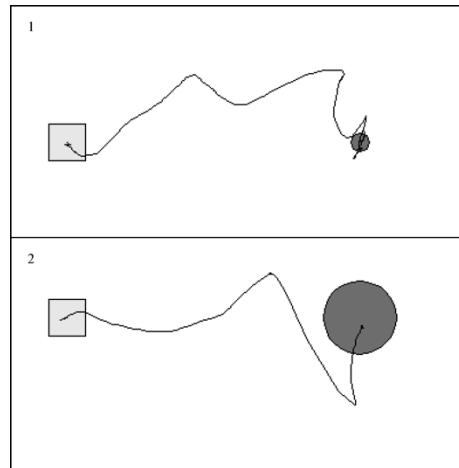
Figure 2.2.2 Mouse paths by a 4 year 3 month old male; (1) when clicking on a 16 pixel target 256 pixels away; and (2) when clicking on a 64 pixel target 256 pixels away. Adopted from "Differences in Pointing Task Performance Between Preschool Children and Adults Using Mice", by J.P Hourcade, B.B Bederson, A. Druin, and F. Guimbretiere, 2004, *ACM Transactions on Computer-Human Interaction (TOCHI), ACM*

Several problems occurred in touch screens using point-and-touch strategy compared to point-and-click. Children touch the screen and their fingers slightly slide before raising their finger off the screen, this action converts the touch-and-point to drag-and-drop action in touch screens (McKnight & Cassidy, 2010) so the software takes the action as drag-and-drop unless the software limits dragging action to the initial touch point and ending touch point to position the item. Another problem with touch screens is related to the technical hardware/device itself. Young children tend to repeat a task if it was not performed instantly. For instance, some of the touch screens are slow in response, so children tend to repeat the task resulting in unintentional touch points (Anthony et al., 2012). This can also result in the interface moving on to another scene before the child realizes the change with his/her repetitive touch.

Children perform differently with touch interfaces based on their level of fine motor development. 4 and 5-year-old have more developed fine motor skills as they have more experience with fine motor movements used in writing compared to their 3-year-old counterparts who cannot write yet (Donker & Reitsma 2007; Agudo al., 2010). Research has defined a usable size for children using touch devices. If objects are too small, young children find problems in pointing and touching the target. However, some research defined the best size for square objects to be 27px (Donker & Reitsma 2007; Anthony al., 2012). Young children increase their speed in performing similar tasks, and as they repeat a task over and over. However, they decrease the speed as they make errors, so they try to be more accurate by decreasing the speed.

2.2.2 Drag and Drop

Drag and drop is the process of selecting an object by clicking a mouse and then moving the mouse and releasing it on another position (Donker & Reitsma 2007). The same process is used for drag-and-drop for touch devices. Drag-and-drop on touch devices requires the user to use a finger to position on the target, slide the finger while pressing on the screen, then lifting up the finger on the required ending position. Young children can perform drag-and-drop task by themselves or with a little help in directions of how to use drag-and-drop in both mouse and touch interaction styles, even though children have some difficulties in accomplishing drag-and-drop task (Joiner al., 1998; Inkpen, 2001; Donker & Reitsma 2007; Agudo al., 2010). Difficulties are related to the set up of the experiments or touch/click skills of the young children, which can be studied further to find out main difficulties with the children.

Young children's main problem with drag-and-drop is mainly drop errors, as young children are still developing their fine motor skills the release point which is dropping may be earlier than the targeted release point. Some researchers suggest dragging an object for long distances requires more time for the child to hold the mouse or fingers over dragging for short distances (Joiner et al., 1998; Chag, 2008). However, other research (Chag, 2008) found that the average speed of moving an object on long distance compared to short distance is faster. Also, the speed differs between drag-and-drop compared to click-move-click in touch devices. Young children are faster in using click-move-click than drag-and-drop (Donker & Reitsma, 2007). Moreover, a research by Joiner, Messer, Light, and Littleton indicated that children performing the task by pointing took less time and were more accurate compared to children used dragging (1998). Lastly, Inkpen's (2001) research with girls age 9-13 confirm that click-move-click shows better achievement, better performance, and more accuracy which is faster and has less errors.

Inkpen (2001) states that children prefer to perform point-and-click tasks over drag-and-drop tasks (2001). Objects in Inkpen study were used point-and-click by clicking the object once, position the mouse to the desired destination, and then clicking the mouse again on the target position (2001). That research had different object accompanied the selected target with a game environment for the child to play the game and at the same time the child perform the tasks. Those research results were for mouse interaction method with computers.

Age is another important element that affects the drag-and-drop performance for the children, and it is related to fine motor skill development. Young children have more errors

when they used drag-and-drop compared to point-and-click (Joiner al., 1998), as this difficulty occurred only with younger (5 – 6 years old) children and no major difference with older children (8 – 9 and 11 – 12 years old). Research also concluded that as age increases the children become more accurate in using mouse and perform better (Lane & Ziviani, 2010).

The point within the drag-and-drop also provides evidence for the skills that may make drag-and-drop challenging. As drag-and-drop is a process of three actions, picking up an object by clicking or touching, holding the click and moving the mouse cursor or finger touch, and releasing the object, errors can occur during any of these steps. Most experiments find more error in dropping an object compared to picking up an object (Inkpen, 2001; Donker & Reitsma 2007). Younger children drop the object before they reach the target resulting in increased dropping errors (Joiner al., 1998). Researchers agree that fine motor development of 3, 4, and 5-year-olds makes continued pressing on the device or holding a specific object with their fingers to drag it challenging (Agudo, Sanchez, & Rico, 2010; Donker & Reitsma, 2007; Chag, 2008).

Another problem in drag-and-drop is the way the children hold the device itself. McKnight and Cassidy (2010) note that many errors happen because of touching the edges of the device, as the touch devices usually record the first or/and second touch, so if the child's finger is on the edge of the screen it will be considered as the first touch even though it was perhaps not the intended touch.

Research suggests children perform better on drag-and-drop tasks with guidance, hints and clues. Moreover, it would be good to have some hints and clues for the child to

when to select or release an object (Donker, Reitsma, 2007). Also, guiding the child helps, as young children do not move an object in a straight line, they usually tend to have some errors till they get to the target and release the object (Donker, Reitsma, 2007).

With all of the errors and difficulties in drag-and-drop for young children, the children would be frustrated at the end, as they would struggle in completing drag-and-drop task (Agudo al., 2010). As these skills consider being more advanced or complex skills compared to point-and-click. Moreover, distracting items on the screen may affect accuracy of children performing drag-and-drop task, and more research need to be done on this point (Donker & Reitsma 2007). In general if speed is not required, it is possible that young children are accurate in drag-and-drop tasks. Some children focus on speed and want to finish some tasks as fast as they can which affects their performance and accuracy which depends on the interaction styles used to perform the task (Strommen al., 1996; Donker & Reitsma 2007).

2.2.3 Zoom-in, Zoom-out, and Rotate

Zoom-in and zoom-out, and rotate gestures are highly related to touch technology, and other interaction styles research studies such as the mouse do not deal with these gestures. For instance, mouse interaction styles do not have zoom-in and zoom-out which touch gestures can perform it by two fingers spreading or pinching. A research study by Yu, Zhang, Xue, and Zhu has indicated that children can perform normal touch gestures such as one direct touch, but no experiment was done in rotation gesture with children (2010). So we did not found any research that has actually tested the pinch or spread gesture and rotation for young children with touch devices. However, research has suggested that it is

important to understand and analyze young children's ability to perform those gestures (McKnight & Cassidy, 2010). Moreover, the same research suggests that it is important to understand the current technology that we have in the market before a new interaction style comes to the market.

Ibrahim, Borhan, and Yatim (2013) observed 8-year-old children while using touch devices. The research results showed "The touch gesture that quite difficult for respondents are zoom-out (45% of respondents) and rotate (35%of respondents) where respondents are not able to make contact with the touch gesture successfully" (p.4). Rotation was the hardest interaction for children with touch devices, however no statistical measurements were identified for this research. Zoom-in and zoom-out gestures in touch devices have not been tested on young children specially 4 and 5-year-old children, and as previous studies indicated more research is needed with these two gestures as they are related with recent technology (McKnight & Cassidy, 2010; Yu al., 2010; Ibrahim al., 2013).

2.3 Disability Research

Little research has been done with children with fine motor impairment and touch technology interaction. Fine motor skills disabilities can result in a wide range of skill differences and be part of many different disabilities. Children with and without cognitive disabilities may have fine motor difficulties. A research study that has been done on Apple devices such as iPods, iPhones, and iPads indicates that touch technology can be used for people with disabilities (Kagohara et al., 2013). Moreover, a research study has stated that mobile touch devices can actually help students with disabilities based on specific

application, and may be resources of developing motor skills for disabled students as well as developing other skills (Lopez, Fortiz, Almendros, & Segura, 2013). Touch technology is used for development disabilities in the education fields or even for communication (Kagohara, Meer, etc., 2013). Touch gestures can be used for children and adults with disabilities, as it requires fewer fine motor skills compared to mouse style interaction. Research needs to be done in order to know the difficulties for young children with disabilities.

Cerebral palsy is an example of a disability that affects the fine motor skills of children, and thus which would effect the children's interaction with touch devices. Various physical and cognitive disabilities would result in different abilities in fine motor skills and thus varying skill in using technology (Raya et al., 2010). When completing research with children with cerebral palsy Ray and colleagues (2010) note that young children with cerebral palsy can perform basic gestures such as pointing, however, have some difficulties when fine motor skills are necessary with some other tasks. It is important to understand the fine motor skills abilities young children with disabilities have and how this influences their interaction with touch devices (Raya et al., 2010).

2.4 Fitts' Law

Human Computer Interaction research that is aimed at pointing skills uses Fitts' Law in order to calculate the relationship between speed and accuracy for a pointing task. As Fitts' Law is a model that relates the distance with movement time for calculating the results of an ongoing activity using fine motor skills (Fitts, 1954), the formula is counted as the base for most of previous mentioned research studies which is as follows:

$$MT \text{ (seconds)} = a + b \times ID$$

Where: MT is movement time, a is the constant, and b is the slope coefficient.

Then in order to calculate the ID that is the index of difficulty, we use the following formula:

$$ID = \log_2 (A/W + 1)$$

Where: A is the amplitude or distance between targets, and W is the width of the target.

Moreover, in order to calculate the capacity of a human when performing motor tasks (Fitts & Peterson, 1964) we use the following formula:

$$C \text{ (bits/seconds)} = ID/MT$$

Many research studies has proven Fitts' Law and applied it in calculating the accuracy of pointing tasks for adults and children. The relationship for this formula shows that the smaller the object, the slower in the movement time. Moreover, the larger the object, the faster in the movement time for performing interaction with a button (Agudo al., 2010). Also, as stated in a research study it is important to understand how Fitts' law matches the height of the target as well as direction of the task and investigate more on the accuracy, speed, size, and aiming precision for the young children (Donker & Reitsma 2007).

Errors are expected while children use touch devices, and children tend to do unintentional and intentional touches on the screen that will not result in achieving the application goal. Sometimes accidental touches go to the screen while holding the device,

when their finger slip by mistake on the surface, or when the palm of their hand touches the surface of the screen while performing a task (McKnight & Cassidy, 2010; Anthony al., 2012). These touches can be around the target or far from the target, and all these touches can effect the child result and sometimes increase the error rate in some experiment. Moreover, age has a positive effect on child interaction with mouse interaction style. In addition, it has a positive effect on touch devices and performing touch gestures (Agudo al., 2010; Anthony al., 2012). Children as young as six years can perform task with different touch gestures, and they can differentiate between touch gestures (McKnight & Cassidy, 2010). As children grow up they can have better accuracy and better control over their fine motor skills.

Touch devices will accept any touch as the touch point is within the surface of the screen and will perform an action as long as the touch is within the targeted touch point. Another point that accidental touches usually cause is to perform unwanted tasks and get wrong answers if the child is playing games that can result in dissatisfaction (McKnight & Cassidy, 2010). Children always need some kind of instruction while playing games, and a demonstration is more helpful than giving instructions. As children are not familiar with technical terms used with new technologies, sometimes it is good to simplify works for children to understand the gesture required to be performed (Revelle & Reardon, 2009).

Some of the touch devices try to eliminate the errors by providing more advanced technology rather than just touch surface. Another way to reduce the errors for using touch screens is to have a direct clear feedback when a user touch the screen, so the child will know specifically where did he or she touched the screen (McKnight & Cassidy, 2010). The

same research suggests that it would be good to customize the touch device and make it less sensitive to touches, as young children make more unintentional errors than adults.

Timing did effect the children's performance with interaction styles, as children tried to keep holding objects in drag-and-drop as they kept pressing the mouse instead of releasing it on the target position (McKnight & Cassidy, 2010; Agudo al., 2010). In conclusion the design interface for children in screens should include large icons, avoid sensitive position on the screen such as edges of the screen, and have a simple design with basic interaction skills (Revelle & Reardon, 2009). As research actually stated that mouse can be effectively used by 5 year-old children (Lane & Ziviani, 2010), it is important to check the effectiveness of touch technology with 4 and 5 year-old children.

Chapter 3: Methodology

3.1 Participants

4 and 5 year-old children from different backgrounds of different areas in Minnesota in the United States have been recruited as participants for this research. Some main demographic data were asked for the parents / guardians before starting the test as displayed in figure. These data are mainly about the child's gender, date of birth (month and year), hours per week of child's use of iPad, hours per week of child's use of touch devices, age of first use of touch device, handedness, and disability status (if any). Participants were given numbers while signing the consent form, so no names are used in this research. The demographics are as follows based on each category and total of 17 participants: 16 non-disabled and 1 disabled, 10 males and 7 females, 12 4-year-old and 5 5-year-old, and 15 right handed and 2 left handed. Table 3.1.1 explains the demographic information for each participant

Table 3.1.1: Participants Demographic Information

P_ID	Gender	Age	Hours/week - iPad	Hours/week Touch devices	Age of first use	Handedness	Disability
P1	Male	4	2	4	2	Right	No
P2	Female	4	10	13	2	Right	No
P3	Male	4	3	3	2	Right	No
P4	Female	5	5	5	2	Left	No
P5	Male	5	0	0	1	Right	Yes
P6	Male	4	3	0	1	Right	No
P7	Female	4	0	0	1	Right	No
P8	Male	5	2.5	2.5	4	Right	No
P9	Female	4	2.5	2.5	3	Right	No
P10	Male	5	7	2.5	3	Right	No
P11	Female	4	1	1	3	Right	No
P12	Female	4	0	3	1.5	Right	No
P13	Male	5	0	5	2	Right	No
P14	Male	4	14	14	3	Left	No
P15	Male	4	30	0	1	Right	No
P16	Male	4	0	14	3	Right	No
P17	Female	4	7	0	1	Right	No

3.2 Hardware

The children played a touch based interaction game that is designed for this research study. The game is designed for the iPad air, which is the most current iPad as of the research date. Three iPads were used for the test, and all of them are property of the IT Department of Minnesota State University, Mankato. The iPad air specifications' are: width of 6.6 inches (169.5 mm), height of 9.4 inches (7.5 mm), depth of 0.29 inch (7.5 mm), and weight of 1 pound (469 g). The iPad air is a retina display that has a 9.7-inch (diagonal) LED-backlit Multi-Touch display with IPS technology. Also, it has 2048 by 1536 resolution at 264 pixels per inch (ppi) fingerprint resistant oleophobic coating that protects the screen from printing fingerprints on the iPad surface ("iPad Air," 2014).

We have used several programming language for this research, we have used objective c with Xcode 5.1.1 to design the iPad application. And all the touch points are saved in csv file on the iPad that we used Excel to organize the data. Python 3.4.1 is used to reorganized the excel data. And SPSS 20.0.0 is used to statistically analyze the data. Also, c# and visual studio 2012 is used to reproduce the touch points performed by the children on graphs.

3.3 Research design

Demographic information about the child was saved on the iPad before the child starts the test (see figure 3.3.1), then the child chose a color to be his or her color block through the four different tests. A colored block without any frame, and a dotted frame with a dot in the middle of the frame was used as a target in first (point-and-touch) test and second (drag-and-drop) test. A colored block with any frame, and a dotted frame was used

as a target in the third (zoom-in and zoom-out) test and fourth (rotate) test. A screen with a sticker showed for the child indicating the end of each test (see figure 3.3.2). The experiment was designed on a vertical basis, and the child held the iPad vertically to perform the tests. A screen with "Thank you" message showed after completing the four tests indicating its end of the experiment (see figure 3.3.2).

Figure. 3.3.1 Demographic information page before starting the game

Figure. 3.3.2 Game separation screen, and end of the game screen

3.3.1 Point-and-touch

In the point-and-touch task as it shown in figure 3.3.1.1 the child is asked to move a colored block to a frame. To move the colored block the child touches the block to activate it and then touches the destination to move it. So its basically one touch to activate the block in order the child will be able to move it, and another touch to move the block to a specific target. In the experiment touch is considered as the placing the finger on the screen which is (touch started) and then lifting the finger off the screen which is (touch ended), in this experiment all the results were taking based on touch ended which is where did the child left their finger from the screen. After the first block touch, there no limit in number of moving the target without the need to touch the colored block, so its one time block activation. There are three different sizes of blocks which are: 64px, 128px, and 256px, and two distances which are: 128px, and 512px. Each child performs total of 30 tasks selected randomly from combination of number of repetition, size, and distance as follow: ten tasks

of 64px block with 128px distance, five tasks of 64px block with 512px distance, five tasks

of 128px block with 128px distance, five tasks of 256px block with 128px distance, and five

tasks of 256px block with 512px distance.

Figure 3.3.1.1 Point-and-Touch game (size of 64px, and 128px distance).

Distance is calculated as 128px or 512px from the lower edge of the frame to the

upper edge of the colored block, and the block and the frame anchor points are centered and

positioned from center. The frame is positioned on the upper part of the screen and the

block is positioned on the lower part of the screen based on the distance and size. The goal

for the child is to match the block with the frame, which is moving the colored block by

point-and-touch and then point-and-touch the frame center. A 32px square is given for the

child to reduce errors, and this 32px square is in the center of the frame, which is the target

for a successful task. Once the tasks is completed and child touch ended on the 32px target, a sound feedback saying "yay" is given to the child indicating this task is completed successfully. However, if the child touch is off the target a sound feedback saying "ops" is given for the child indicating a wrong touch location.

3.3.2 Drag-and-Drop

In Drag-and-Drop test as it shown in figure 3.3.2.1 the child is asked to move a colored block to a frame similar to the first test. However, to move the colored block the child touches the block and drag the block while holding the finger touch on the screen and then release the touch or lift up his or her finger to stop the block movement. The starting touch should be on the block to activate the block. However, if the touch started that is positioning the finger on the screen should follow up by touch moved which is not lifting the finger off the screen after the initial touch. The block will be positioned on the dragging touch location, and once the finger is lifted up the block will be positioned on the point that they left their finger, which is the last (touch moved) position. In this experiment all results were taking based on touch ended which is where did the child left their finger from the screen. The child can drag-and-drop the block as many as they want before reaching the frame target. There are three different sizes of blocks which are: 64px, 128px, and 256px, and two distances which are: 128px, and 512px. Each child performs total of 30 tasks selected randomly from combination of number of repetition, size, and distance as follow: ten tasks of 64px block with 128px distance, five tasks of 64px block with 512px distance, five tasks of 128px block with 128px distance, five tasks of 256px block with 128px distance, and five tasks of 256px block with 512px distance.

Distance is calculated as 128px or 512px from the lower edge of the frame to the upper edge of the colored block, and the block and the frame anchor points are centered and positioned from center. The frame is positioned on the upper part of the screen and the block is positioned on the lower part of the screen based on the distance and size. The goal for the child is to match the block with the frame, which is moving the colored block by touching the block and dragging it through moving their finger and then releasing the block by lifting their finger. So it is a process of three steps with the child's finger. A 32px target is given for the child in order to detect the collision between the colored block and the frame. However, once the colored block collides with 32px target, it will move on to the next task. The 32px square is positioned from the center of the target frame. A sound feedback saying "yay" is given to the child indicating this task is completed successfully and the block collided with the 32px target square. However, if the child colored block is off the 32px target a sound feedback saying "ops" is given for the child indicating wrong touch ended and wrong block position.

Figure. 3.3.2.1 Drag-and-Drop game (size of 256px, and 512px distance).

3.3.3 Zoom-in and Zoom-out

In Zoom-in and Zoom-out test as it shows in figure 3.3.3.1 the child is asked to

zoom-in or zoom-out a colored block to match a frame. Zoom-in in this experiment is

considered as spreading out with two fingers that is starting two fingers to touch the screen

and then moving them further to increase the distance between the two fingers to larger the

colored block. Zoom-out in this experiment is considered as pinching in with two fingers

that is starting with two fingers to touch the screen in a wide position and then starting to

reduce the distance between the two fingers to smaller the colored block. No negative

feedback is given to the child while performing this test, because it is one of the new touch

gestures which children are not used to perform it with other interaction styles. There is no

specific position on the screen to perform the zoom-in and zoom-out tasks, which the child

can pinch-in or spread-out any position on the screen to zoom-out or zoom-in. The child

has only one trial for each task, once they lift one of their fingers from the screen the task will end and a new task will show on the screen.

There are three different sizes of blocks which are: 64px, 128px, and 256px and three sizes for the frame which are: 64px, 128px, and 256px. Each child performs total of 40 tasks selected randomly from a combination of number of repetition, size of the block, and size of the frame as follow: for zoom-in there is ten tasks of 64px block with 256px frame, and ten tasks of 128px block with 256px frame. For zoom-out there is ten tasks of 256px block with 64px frame, and ten tasks if 256px block with 128px frame. The block and frame anchor points are centered and both of them are positioned from the center. Both of them are positioned in the center of the iPad screen. The goal for the child is to either zoom-in or zoom-out the colored block to match the frame size. However, there is no negative feedback for the child and they are allowed to have only one pinch in or spread out for each task. One finger touch on the screen does not consider a pinch or spread. A pinch or a spread must be two finger touching the screen, then two fingers or one finger lifting up from the screen to perform the task. After each task completed a positive sound feedback saying "yay" is given to the child indicating this task is completed, whether they matched the block size with the frame target or not.
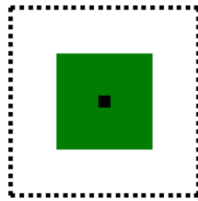
Figure. 3.3.3.1 Zoom-in (256px frame size, and 128px).

3.3.4 Rotation

In rotation test as it shows in figure 3.3.4.1 the child is asked to rotate a colored block to match a frame. Rotation in this experiment is considered as two fingers rotation, which is two fingers to touch the screen and then moving both of them or one of them in clock wise or counter clock wise to rotate the object to the left or right. No negative feedback is given to the child for this experiment, which is similar to the zoom-in and zoom-out test. Also, this test is one of the new or unfamiliar touch gesturer compared to other interaction styles such as mouse, and children are not used on performing it with any other interaction styles. There is not specific position on the screen to perform the rotation tasks, which the can position the two fingers on any position on the screen and start moving their

fingers to perform the rotation action. The child has only one trial for each task, once they lift one or both their finger off the screen the tasks will end and a new task will show on the screen.

There are three different sizes of blocks that are: 128px, 256px, and 512px and the frame sizes are same as the block size. Each child performs total of 30 tasks selected randomly from a combination of number of repetition, size of the block, and initial rotation degree as follow: ten tasks with block and frame size of 128px which five of those tasks will have 90degree initial rotation and the other five will have 270degree initial rotation. Ten tasks with block and frame size of 256px which five of those tasks will have 90degree initial rotation and the other five will have 270degree initial rotation. Ten tasks with block and frame size of 512px which five of those tasks will have 90degree initial rotation and the other five will have 270degree initial rotation. 90degree initial rotation requires the child to rotate counter clock wise, and 270degree initial rotation requires the child to rotate clock wise to reach to the target. Both the colored block and the frame are positioned in the center of the screen. One finger touch on the screen does not consider rotation, and a rotation must be two finger touching the screen, then two fingers or one finger moving clock wise or counter clock wise from the screen to perform the task. After each task completed a positive sound feedback saying "yay" is given to the child indicating this task is completed, whether they matched the block rotation with the frame target or not.
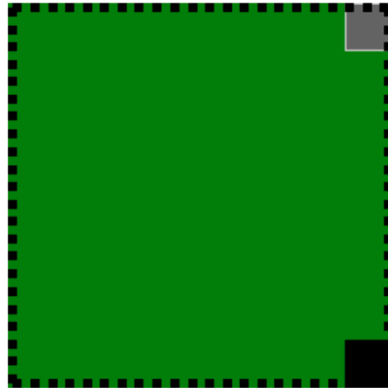
Figure. 3.3.4.1 Rotation (512px with clock wise rotation).

3.4 Procedure

The children performed the tasks either in quiet room at South Elementary School in Saint Peter, a room at Minnesota State University Mankato, Saint Cloud State University library, or University of Saint Thomas library in Minnesota. The order of the four tests was the same for all children (point-and-touch, drag-and-drop, zoom-in and zoom-out, and rotate). However, we randomized the tasks for each test for each child to avoid fatigue. A short explanation before each test was presented for each child before starting the test. We did not tell the child anything about speed of performing the tasks or timing. However, we mentioned the required accuracy for each test as best as they can to aim and target for the goal of the task.

3.5 Independent and dependent variables

Table 3.5.1 Dependent and independent variables for each experiment

Experiment	Independent Variables	Dependent Variables
Point-and-Touch	Size and Distance	Distance to target (first release) Frame misses Time
Drag-and-Drop	Size and Distance	Distance to target (first release) Time
Zoom-in and Zoom-out	Image size and fame size	Initial distance and release distance Time
Rotate	Size and initial rotation	Release distance Rotation side Rotation degree Time

As per table 3.5.1 shows each experiment has two independent variables and analyzed several dependent variables for each test based on the two independent variables. As all of the dependent variables are interval values and parametric test has been used for all of the dependent variables, we have used one-way independent measure ANOVA to analyze all the variables listed in the previous table.

Chapter 4: Results

As the number of participants for the four experiments was small n=17 and only 16

participants' data were used to analyze the four experiments, most of the data was not

normal, so we have performed data transformation in order to normalize the data. Keene

(1995) suggests that using Log transformation for positive data is the most recommended

data transformation. Also, Keene research study suggests that it is good to be consistent in

the data transformation (1995). We have used a data transformation for the data that is not

normal based on the *Using Multivariate Statistics* book that suggests the best transformation to

be used based on the data distribution (Tabachnick & Fidell, 2007). All of the data

transformation is used the Log of the data or Log of the data plus one if it has zero values.

4.1 Point-and-Touch

Table 4.1.1 Movement time and index of difficulty for point-and-touch experiment

Distance to Target (Amplitude)	Size of Target (width)	Movement Time	Index of Difficulty
512	256	621000	1.58
128	256	464000	0.58
128	128	489000	1.00
512	64	493000	3.17
128	64	825500	1.58
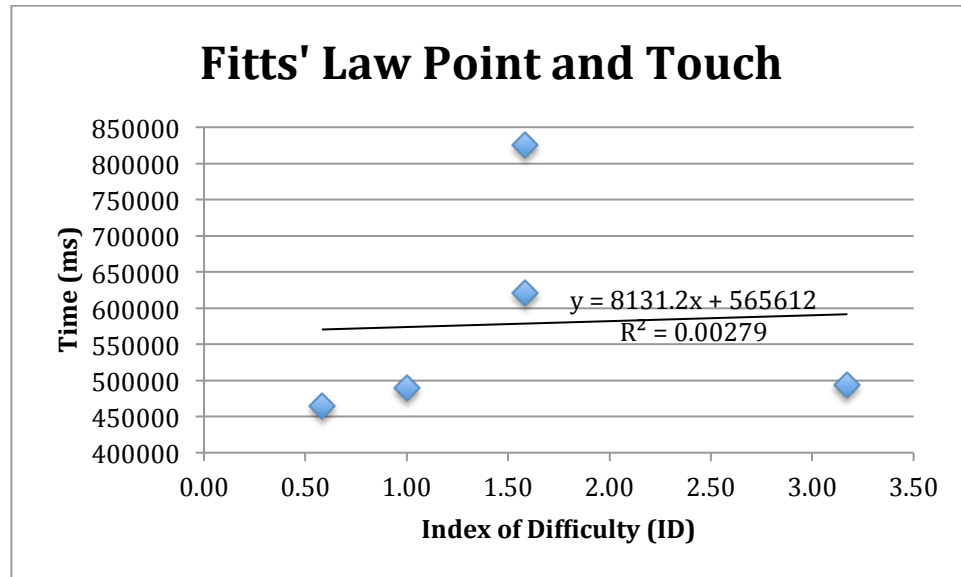
Figure 4.1.1 Fitts' Law Point-and-Touch experiment
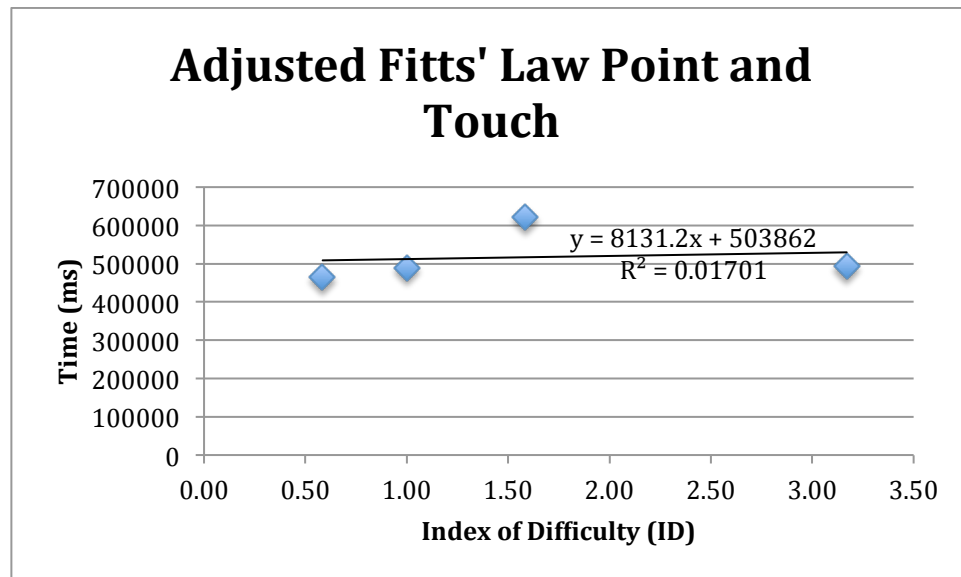
Figure 4.1.2 Adjusted Fitts' Law point-and-touch experiment

This research tried to model Fitts' Low for point-and-touch as it shows in table 4.1.1

it compared the Index of Difficulty for all task in comparison with movement time. The

results in figure 4.1.1 showed that it is hard to model Fitts' Law in point-and-touch

experiment. However, we have adjusted the regression analysis for this experiment due to an outlier. Figure 4.1.2 shows the adjusted Fitts' Law model after taking the outlier point, but after adjusting the regression line the value of R Square is 0.01701 that is still low.

4.1.1 Distance to target (first release) variable

Table 4.1.1.1 N of independent variables: distance and size

		N
Size	64	32
	128	16
	256	32
Distance	128	48
	512	32

Table 4.1.1.2 Effect of Size and Distance on Log_distance results

Dependent Variable: Log_distance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.798[a]	4	.700	2.470	.052
Intercept	319.506	1	319.506	1128.109	.000
Size	.005	2	.002	.009	.991
Distance	2.157	1	2.157	7.617	.007
Size * Distance	.303	1	.303	1.070	.304
Error	21.242	75	.283		
Total	354.548	80			
Corrected Total	24.040	79			

a. R Squared = .116 (Adjusted R Squared = .069)

Distance to target variable is the distance between center of the block and center of the target after the first touch one the block is activated. Table 4.1.1.1 shows n value for each

independent variable as we have three sizes: 64px, 128px, and 256px, and two distances

128px, and 512px. The model is close to be significance 0.052 and distance has a

0.007<0.05 significance, which is a factor in initial release distance variable. However, as

table 4.1.1.2 shows that size and size and distance did not give any significant result.

4.1.2 Time variable

Table 4.1.2.1 Effect of Size and Distance on LogTime results

Dependent Variable: LogTime

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.264[a]	4	.066	.472	.756
Intercept	1004.941	1	1004.941	7192.961	.000
Size	.158	2	.079	.566	.570
Distance	.135	1	.135	.970	.328
Size * Distance	.034	1	.034	.240	.626
Error	10.478	75	.140		
Total	1066.974	80			
Corrected Total	10.742	79			

a. R Squared = .025 (Adjusted R Squared = -.027)

The time variable is the average time each participant took to complete the five

different tasks for the first experiment. Log of the time was used to analyze the size and

distance, and it was used in data transformation. The independent variable did not show any

significant effect on variable studied, size and distance did not have a significance effect on

completion time. As table 4.1.2.1 shows distance has a 0.328>0.05 significance, which does

not consider to be a factor in time used to complete the task. Also, size has a 0.570>0.05

significance, which does not effect the time variable.

4.1.3 Frame misses variable

Table 4.1.3.1 Effect of Size and Distance on LogFrameMisses results

Dependent Variable: LogFrameMisses

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.312[a]	4	.078	.848	.499
Intercept	20.663	1	20.663	224.318	.000
Size	.235	2	.117	1.274	.286
Distance	.082	1	.082	.887	.349
Size * Distance	.005	1	.005	.053	.819
Error	6.909	75	.092		
Total	28.584	80			
Corrected Total	7.221	79			

a. R Squared = .043 (Adjusted R Squared = -.008)

The number of frame misses' variable is the average numbers each participant missed the frame after activating the block. Log of the time was used to analyze the size and distance, and Log of the time used in data transformation. The independent variable did not show any significant effect on variable studied, size and distance did not have a significance effect on number of frame misses after activating the block. As table 4.1.3.1 shows distance has a 0.349>0.05 significance, which does not consider being a factor in number of frame misses to complete the task. Also, size has a 0. 286>0.05 significance, which does not effect number the misses for a frame.

4.2 Drag-and-Drop

Table 4.2.1 Movement time and index of difficulty for drag-and-drop experiment

Distance to Target (Amplitude)	Size of Target (width)	Movement Time	Index of Difficulty
512	256	198000	1.58
128	256	169200	0.58
128	128	172000	1.00
512	64	256500	3.17
128	64	424000	1.58
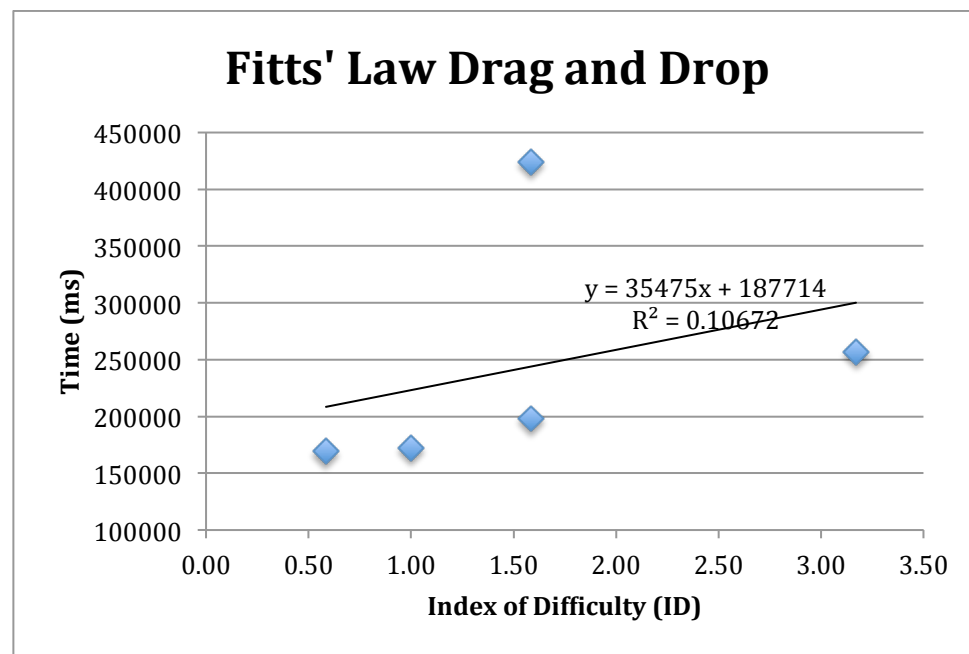
Figure 4.2.1 Fitts' Law Drag-and-Drop experiment

This research tried to model Fitts' Law for drag-and-drop experiment, as it shows in table 4.2.1 it compares the index of the difficulty for all tasks in drag-and-drop experiment to movement time. The results in figure 4.2.1 showed that it Fitts' Law cannot be modeled for drag and drop. However, we have adjusted the regression analysis for this experiment due to an outlier in the points. Figure 4.2.2 shows the adjusted Fitts' Law model after taking out the

outlier point, we found out that Fitts' Law can be almost a perfect model for drag and drop

with a R square value of 0.985.
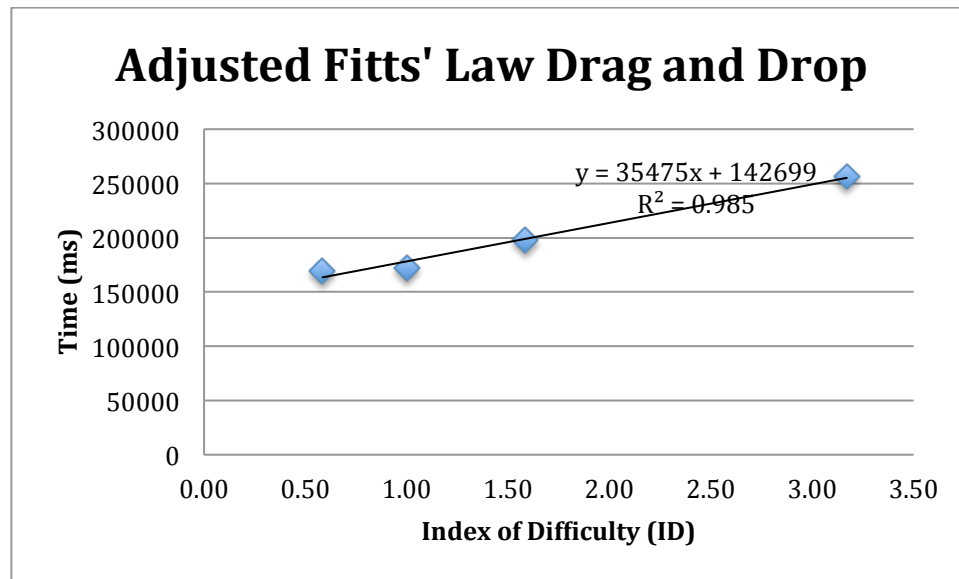
Figure 4.2.2 Adjusted Fitts' Law Drag-and-Drop experiment

4.2.1 Distance to target (first release) variable

Table 4.2.1.1 N of independent variables: distance and size for drag-and-drop experiment

		N
	64	32
Size	128	16
	256	32
Distance	128	48
	512	32

Table 4.2.1.2 Effect of Size and Distance on LogDistance for drag-and-drop experiment

Dependent Variable:
LogDistance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.007[a]	4	.252	3.505	.011
Intercept	218.614	1	218.614	3044.888	.000
Size	.638	2	.319	4.441	.015
Distance	.038	1	.038	.526	.471
Size * Distance	.246	1	.246	3.432	.068
Error	5.385	75	.072		
Total	238.202	80			
Corrected Total	6.391	79			

a. R Squared = .157(Adjusted R Squared = .113)

Distance to target variable is the distance between center of the block and center of the target after the first drag and drops that is first release of the block. Table 4.2.1.1 shows n value for each independent variable as we have three sizes: 64px, 128px, and 256px, and two distances 128px, and 512px. The independent variable size has significant effect on variable studied, distance did not have a significance effect on first release distance. Size has a 0.015<0.05 significance, which is a factor in initial release distance variable. Also, both size and distance is marginally significant with 0.068 significance. However, as table 4.2.1.2 shows that distance with a significant of 0.471 is not significance and does not effect the dependent variable.

4.2.2 Time variable

Table 4.2.2.1 Effect of Size and Distance on LogTime results for drag-and-drop

experiment

Dependent Variable: LogTime

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.512[a]	4	.128	2.261	.070
Intercept	833.346	1	833.346	14726.342	.000
Size	.312	2	.156	2.761	.070
Distance	.082	1	.082	1.449	.232
Size * Distance	.056	1	.056	.992	.322
Error	4.244	75	.057		
Total	884.895	80			
Corrected Total	4.756	79			

a. R Squared = .108 (Adjusted R Squared = .060)

The time variable is the average time each participant took to complete the five

different tasks for the second experiment. Log of the time was used to analyze the size and

distance, and it was used in data transformation. The independent variable size is marginally

significant and effect the variable studied, distance did not have any significant on

completion time. As table 4.2.2.1 shows size has a 0.07>0.05 significance, which it might

consider to be a factor in time used to complete the task. Also, distance has a 0.232>0.05

significance, which does not effect the time variable.

4.3 Zoom-In and Zoom-Out

Table 4.3.1 Movement time and index of difficulty for zoom-in and zoom-out experiment

Size	Amplitude (d)	Movement Time	Index of difficulty
128	90.50966799	227700	0.771553303
64	135.764502	256500	1.64215643
256	90.50966799	200000	0.436751795
256	135.764502	170000	0.61384287
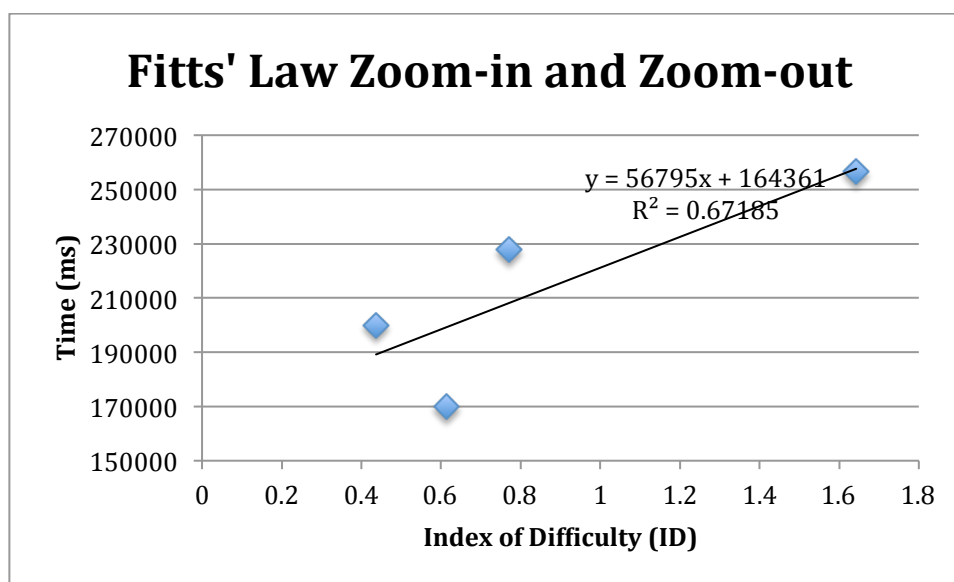
Figure 4.3.1 Fitts' Law Zoom-in and Zoom-out experiment

As per figure 4.3.2 Fitts' Law can be used to model Zoom-in and Zoom-out experiment. The model suggests that the size (W) of the target has positive relationship with the Distance to the target (D), as in figure 4.3.1 shows the size decreases the tasks will be more difficult for children to accomplish. Moreover, as the size (W) of the block increases the time used by the child to reach the frame target decreases.

4.3.1 Initial Distance Variable

Table 4.3.1.1 N of independent variables: distance and size for drag-and-drop experiment

		N
	64	16
ImageSize	128	16
	256	32
	64	16
FrameSize	128	16
	256	32

Table 4.3.1.2 Effect of Size and Distance on InitialDistance results for zoom-in and zoom-out experiment

Dependent Variable: InitialDistance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	122647.003[a]	3	40882.334	2.883	.043
Intercept	1269265.828	1	1269265.828	89.514	.000
ImageSize	4397.142	1	4397.142	.310	.580
FrameSize	33726.403	1	33726.403	2.379	.128
ImageSize * FrameSize	.000	0	.	.	.
Error	850769.712	60	14179.495		
Total	2242682.543	64			
Corrected Total	973416.714	63			

a. R Squared = .126 (Adjusted R Squared = .082)

Initial distance to target variable is the distance between the first initial touch of the two fingers for zoom-in and zoom-out experiment. Table 4.3.1.1 shows n value for each independent variable as we have three sizes: 64px, 128px, and 256px, and three frame sizes: 64px, 128px, and 256px. The independent variable did not show any significant effect on

variable studied, image size and frame size did not have a significance effect on initial

distance. Table 4.3.1.2 shows image size with a 0.580>0.05 significance and frame size with a

0.128>0.05 significance, which does not consider factors in initial release distance variable.

4.3.2 Release Variable

Table 4.3.2.1 Effect of Size and Distance on LogRelease results for zoom-in and zoom-out

experiment

Dependent Variable: LogRelease

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.454[a]	3	.818	15.032	.000
Intercept	311.895	1	311.895	5732.310	.000
ImageSize	.020	1	.020	.376	.542
FrameSize	.011	1	.011	.208	.650
ImageSize * FrameSize	.000	0	.	.	.
Error	3.265	60	.054		
Total	317.613	64			
Corrected Total	5.718	63			

a. R Squared = .429 (Adjusted R Squared = .401)

Release distance to target variable is the distance between the release touch of the

two fingers for zoom-in and zoom-out experiment. Table 4.3.2.1 shows that the image size

with significance of 0.542 and frame size with significance of 0.650 does not consider as

factors for release distance variable.

4.3.3 Time Variable

Table 4.3.3.1 Effect of Size and Distance on LogTime results for zoom-in and zoom-out

experiment

Dependent Variable: LogTime

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.153ᵃ	3	.051	.736	.535
Intercept	608.712	1	608.712	8794.642	.000
FrameSize	.013	1	.013	.186	.668
ImageSize	.011	1	.011	.154	.696
FrameSize * ImageSize	.000	0	.	.	.
Error	4.153	60	.069		
Total	613.018	64			
Corrected Total	4.306	63			

a. R Squared = .036 (Adjusted R Squared = -.013)

The time variable is the average time each participant took to complete the five different tasks for the third experiment. Log of the time was used to analyze the size and distance, and it was used in data transformation. The independent variable did not show any significant effect on variable studied, image size and frame size did not have a significance effect on completion time. As table 4.3.3.1 shows the frame size has a 00.668>0.05 significance and image size has a 0.696>0.05 significance which both do not consider to be a factor in time used to complete the task.

4.4 Rotate

Table 4.4.1 Movement time and index of difficulty for Rotate experiment

Amplitude	Width	Index of difficulty
71.08612701	64	1.077735711
142.172254	128	1.077735711
284.344508	256	1.077735711
568.6890161	512	1.077735711
71.08612701	64	1.077735711
142.172254	128	1.077735711
284.344508	256	1.077735711
568.6890161	512	1.077735711

As rotate experiment starts from two points only 90degree and 270degrees, and only the size of the block changes, Fitts' Law ID is the same for all tasks. Fitts' Law cannot be modeled for Rotate experiment, because MT varies. However, ID as it shown in table 4.4.1 is constant for all tasks.

4.4.1 Distance variable

Table 4.4.1.1 N of independent variables: initial rotation and size for rotate experiment

		N
	128	32
Size	256	32
	512	32
InitialRotatio	90	48
n	270	48

Table 4.4.1.2 Effect of Size and Distance on AvgDistance results rotate experiment

Dependent Variable: AvgDistance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2065440.260[a]	5	413088.052	19.106	.000
Intercept	6667064.515	1	6667064.515	308.369	.000
Size	2004887.444	2	1002443.722	46.366	.000
InitialRotation	10697.655	1	10697.655	.495	.484
Size * InitialRotation	49855.161	2	24927.581	1.153	.320
Error	1945837.861	90	21620.421		
Total	10678342.636	96			
Corrected Total	4011278.121	95			

a. R Squared = .515 (Adjusted R Squared = .488)

Distance to target variable is the distance between corner of the block and corner of the frame after the first rotation that is first release of the block. Table 4.4.1.1 shows n value for each independent variable as we have three sizes: 64px, 128px, and 256px, and two rotation 90degrees which the participant needs to rotate it counter clockwise, and 270degree the participants needs to rotate it clockwise. The independent variable size has significant effect on variable studied, but initial rotation did not have a significance effect on first release distance variable As table 4.4.1.2 shows that initial rotation degree with 0.484 significance and both size and initial rotation degree with 0.320 significance does not have any effect on the release distance variable.

4.4.2 Time Variable

Table 4.4.2.1 Effect of Size and Distance on AvgTime results rotate experiment

Dependent Variable: AvgTime

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	36662037.552 a	5	7332407.510	.793	.558
Intercept	488699237.510	1	488699237.510	52.839	.000
Size	9408337.521	2	4704168.760	.509	.603
InitialRotation	4681225.010	1	4681225.010	.506	.479
Size * InitialRotation	22572475.021	2	11286237.510	1.220	.300
Error	832394525.938	90	9248828.066		
Total	1357755801.000	96			
Corrected Total	869056563.490	95			

a. R Squared = .042 (Adjusted R Squared = -.011)

The time variable is the average time each participant took to complete the six different tasks for the fourth experiment. The independent variable did not show any significant effect on variable studied, size and initial rotation did not have a significance effect on completion time. As it shown in table 4.4.2.1 block size has a 0.603>0.05 significance and initial rotation degree has a 0.479>0.05 significance which both do not consider to be a factor in time used to complete the task.

4.4.3 Rotation Side Variable

Table 4.4.3.1 Effect of Size and Distance on RotationSide results rotate experiment

Dependent Variable: RotationSide

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	8.634[a]	5	1.727	1.752	.131
Intercept	34.820	1	34.820	35.321	.000
Size	2.545	2	1.273	1.291	.280
InitialRotation	3.793	1	3.793	3.848	.053
Size * InitialRotation	2.295	2	1.147	1.164	.317
Error	88.725	90	.986		
Total	132.179	96			
Corrected Total	97.359	95			

a. R Squared = .089 (Adjusted R Squared = .038)

Rotation side variable is either clockwise or counter clockwise, which we gave 1 for clockwise or 0 for counter clockwise rotation and took the average of each task. The independent variable initial rotation has marginally significant effect on variable studied, size and initial rotation did not have a significance effect on rotation side. Table 4.4.3.1 shows size, and both size and initial rotation does not effect the rotation side with a significance of 0.280 for size and significance of 0.317 for size and initial rotation.

4.4.4 Total rotation variable

Table 4.4.4.1 Effect of Size and Distance on RotationDegree results rotate experiment

Dependent Variable: RotationDegree

Source	Type III Sum of Squares	dfs	Mean Square	F	Sig.
Corrected Model	3294.477[a]	5	658.895	.409	.841
Intercept	490101.740	1	490101.740	304.305	.000
Size	142.511	2	71.255	.044	.957
InitialRotation	420.376	1	420.376	.261	.611
Size * InitialRotation	2731.591	2	1365.795	.848	.432
Error	144950.624	90	1610.562		
Total	638346.841	96			
Corrected Total	148245.101	95			

a. R Squared = .022 (Adjusted R Squared = -.032)

Total rotation variable is the rotation degree from the beginning of rotation till the release. Table 4.4.4.1 shows that there is no significance for size 0.957 > 0.05, and no significance for initial rotation 0.611>0.05. Also, there is no significant result for both size and rotation 0.432.

4.5 Observations on Child Participant with Disabilities

This study hypothesizes that that young children with disabilities will have more difficulties performing the tasks than their typically developing peers. It may be useful to use the results in future research that aims to help children with motor impairment. Also, we expect that there might be differences between touch abilities for each motor impairment condition. However, this research primarily focuses on typically developing 4 to 5-year-old as only 1 child with a motor disability was part of the subject pool. It is hard to encourage

children, especially children with disabilities to show interest in participating in testing the application. Within the same context, there is limited research describing children with motor impairment difficulties with tablets or touch devices in general. Based on the results of this study, future research may be conducted to develop strategies to improve children's performance while interacting with tablet devices. In particular, similar applications may be used to help children with disabilities by identifying their touch gesture difficulties. We describe different types of difficulties we observed in the single child participant that was recruited for this research study.

We have conducted a qualitative description of the disabled child performance in the four experiments. Participant number 5 had an undisclosed disability that effected his motor impairments, and this section describes his performance in the four different experiments and observational difficulties.
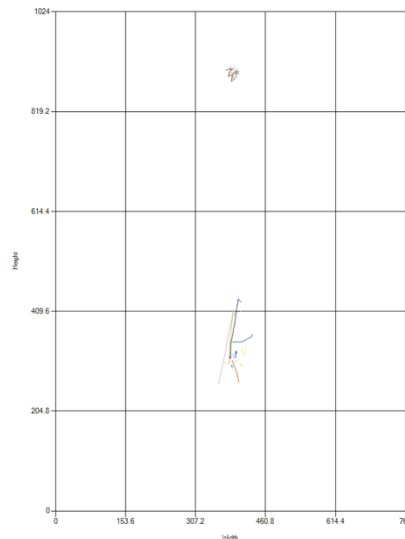

Figure 4.5.1 Point-and-Touch by participant with fine motor impairment
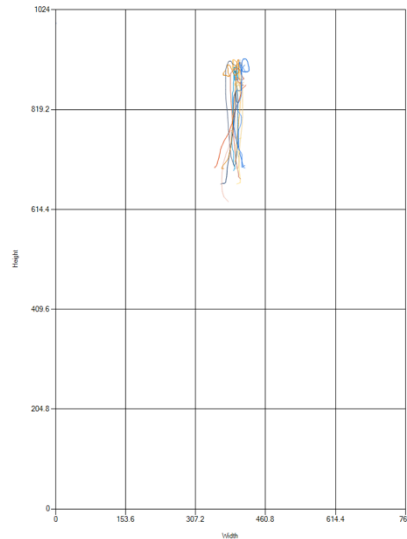
(long, 64px)

Figure 4.5.2 Drag-and-Drop by participant with fine motor impairment

(short, 64px)

In the first experiment, bigger block sizes seemed to be easier for him to complete the tasks. Also, as shows in figure 4.5.1 he performed well and understands the point-and-touch task. In this second game the participant tried to be more accurate than the first game, and as it shows in figure 4.5.2 in general the participant performed well and completed all the tasks in drag-and-drop smoothly.
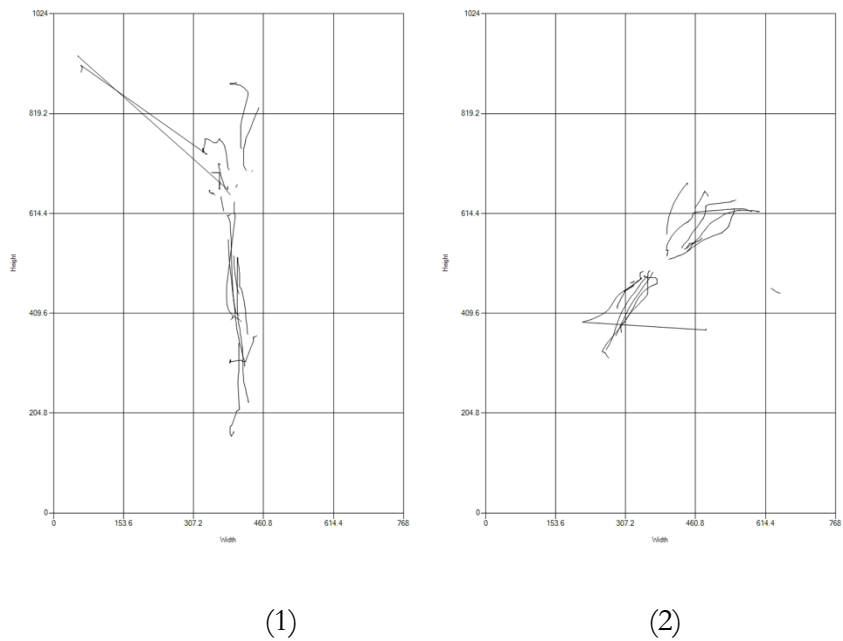
(1)   (2)

Figure 4.5.3 Zoom-in (64px image) (1) by participant with fine motor impairment (2) by

participant without fine motor impairment

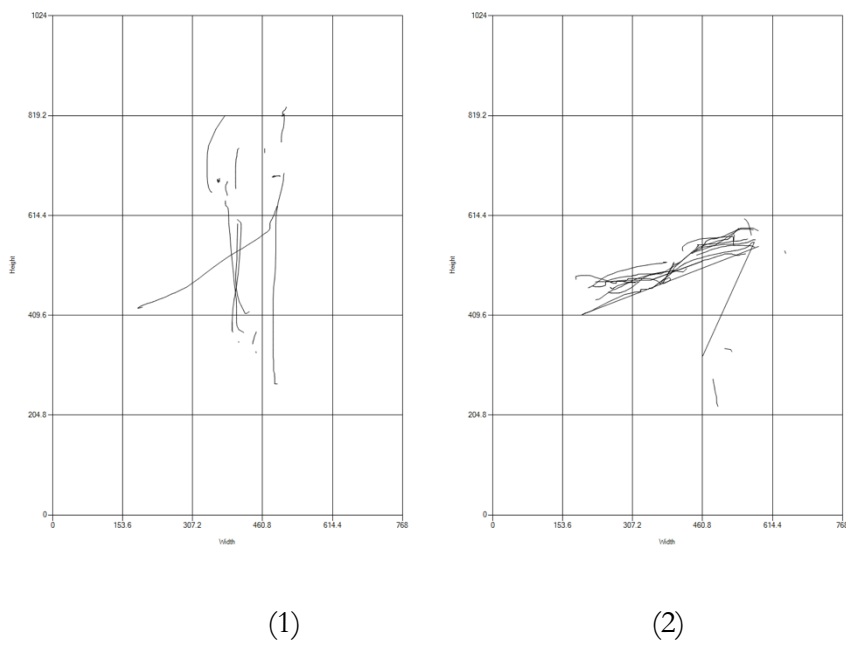(1)   (2)

Figure 4.5.4 Zoom-out (256px image) (1) by participant with fine motor impairment (2) by participant without fine motor impairment

In the third experiment, the participant had some difficulties in understanding the idea of how to zoom-in and zoom-out. Figure 4.5.3 shows zoom-in tasks for 64px image with 256px frame for the fine motor impairment participant, and it shows the same task for an abled body child. We observed that the abled body child had a consistent path for zoom-in. However, participant five had different paths and had some difficulties in performing the task. We have the same observation for zoom-out task that created similar graph to zoom-in as shows in figure 4.5.4, and this zoom-out task was for 256px image with 64px frame.
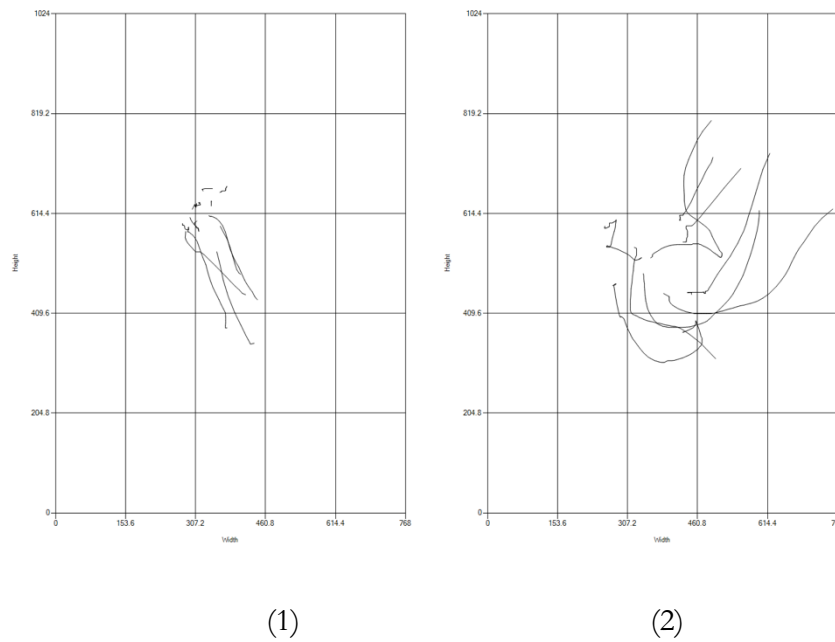

(1)   (2)

Figure 4.5.5 Rotate (counter clockwise, 256px) (1) by participant with fine motor impairment (2) by participant without fine motor impairment

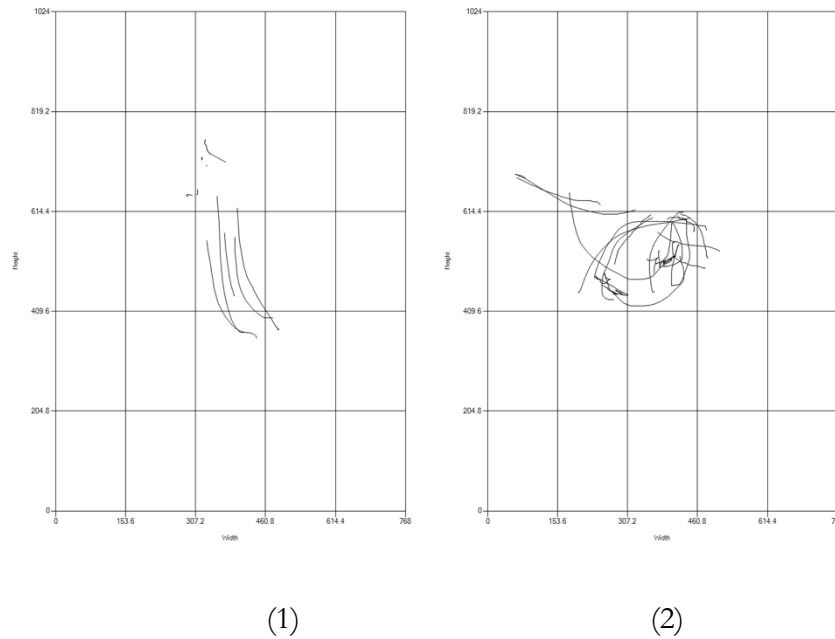(1)   (2)

Figure 4.5.6 Rotate (clockwise, 256px) (1) by participant with fine motor impairment (2) by

participant without fine motor impairment

The fourth experiment shows that participants five had some difficulties in rotate task.

The figure 4.5.5 (1) shows rotation tasks for 256px block size and 90 degree counter

clockwise rotation compared to 4.5.5 (2) that shows rotation for the same task but with

abled body child. The disabled child went through this experiment very fast, because the

application is sensitive and the participant did not actually rotate in most of the tasks, he just

pointed two fingers on the screen and left them up. Also, as shows in figure 4.5.6 same

situation applies on 270degree clockwise rotation, the child did not actually rotated due to

the sensitivity of the application and not being able to control his two fingers to rotate.

In conclusion participant five had some difficulties in performing zoom-in and

zoom-out, and rotate tasks compared to abled body children. Also, the application had to be

restarted several times as the child hit the home button by mistake. We would recommend to

test more motor impairment disability child in order to have a better understanding of their touch gestures difficulties. The previous results were only for one child with disabilities and his behavior compared to abled body children.

4.6 Discussion

Fitts' law proved to be a better model once the outlier point was taken out of the regression analysis. This was probably an effect of the outlier point in point-and-touch and drag-and-drop, and the outlier point was one of the hardest tasks with a high index of difficulty with the smallest size 64px and the closest distance 128px. Fitts' law was a better model for drag-and-drop compared to touch-and-point, which can be due to having touch-and-point experiment based on two steps activating the block and moving the block to a target which was confusing a little bit for children as they are used to drag-and-drop mostly. Also, even after the instructions given to the children they still tried to drag and drop for touch-and-point experiment. Fitts' law could be applied for zoom-in and zoom-out gestures. However, in rotate experiment it could not be applied based on fixed index of difficulty for all tasks. Future research should be done with different indices of difficulty, which have different initial rotation degrees to have several tasks in relation with changing the size.

As per the statistical results section, size and distance has an effect on some of the touch gestures performed by 4 and 5 year-old children. Specifically, in the first experiment that is touch-and-point, distance does effect the distance from initial release point to the target for children. Also, R squared value 11.6% which indicates that most of the variation log_distance is still unexplained. For the same experiment the size and distance or the combination of both of them does not explain the number of frame misses for the children,

R squared value is 0.043 that is low and lots of the variation are still unexplained. In the second experiment size was the main effect on distance from initial release point and frame target. Also, the combinations of size and distance have some significance but not on 5% level. Which means the accuracy can be effected by size and distance in the second experiment that it aligns with Fitts' law model. There were no significant results for zoom-in and zoom-out experiment in any of the variable analyzed for the experiment. In the rotate experiment the results show that the log distance explains variation between image size and target size, which is for release variable. So size contributes a lot in the accuracy of rotation task for 4 and 5 year-old children. Also rotation side did give us significance results to the initial rotation, which indicates the children rotation side is related to initial rotation degree if it is 90degree or 270degrees.

The time variable in all four experiments did not show any significance, which indicates size and distance does not effect the time used to complete each task. This is verified by the poor fit found during Fitts' law analysis. Most of the R square values in the four touch experiment is low, and this can be due to the small number of participants for the experiment. More participants may change the results found in this research, and can be looked more closely for future research, or it could be to the unexplained touches by the children on the screen, such as touching the edge of the screen or touches by their other hands.

(1)   (2)
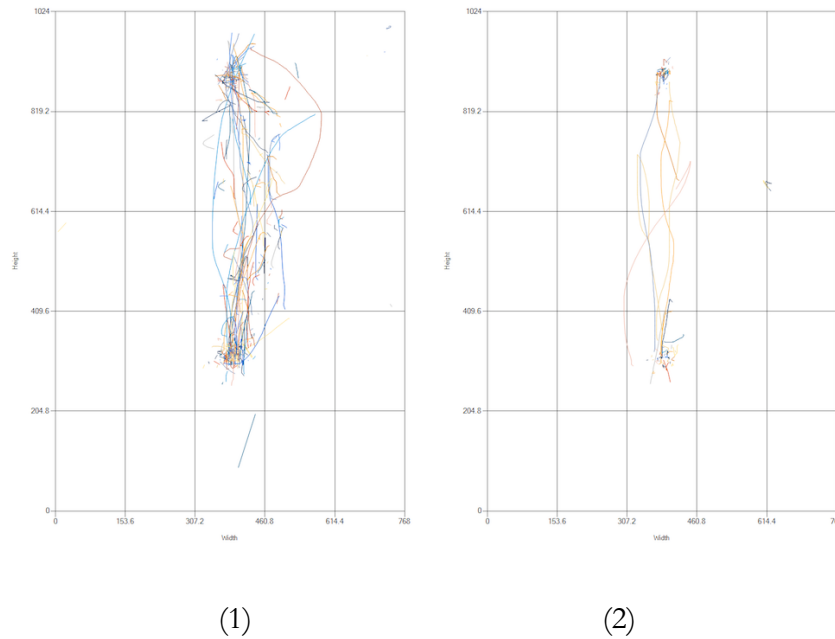
Figure 4.6.1 Point-and-Touch (long. 64px) (1) Four year-old participants (2) Five year-old

participants

Some of the observational notes on the children's performance in the first experiment,

as shows in figure 4.6.1 for 4 and 5 year-old children, and both are for long distance 64px

block, the 4 year-old children tried to drag and drop more than touch-and-point, however, 5

year-old children did performed better in touch-and-point and few of them tried to drag-

and-drop.

(1) (2)

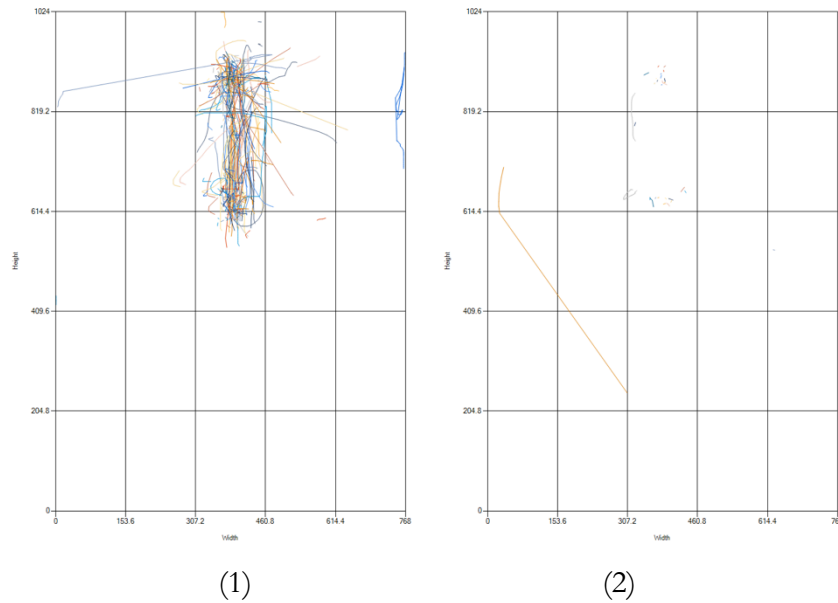Figure 4.6.2 Point-and-Touch (long. 64px) (1) Right-handed participants (2) Left-handed

participants

Another observation is when we compared left-handed with right-handed children, if we look at figure 4.6.2 we found out that most right-handed children tried to drag-and-drop instead of point-and-touch. However, most of the participants were right handed so more testing needs to be done in this regard.

(1)   (2)
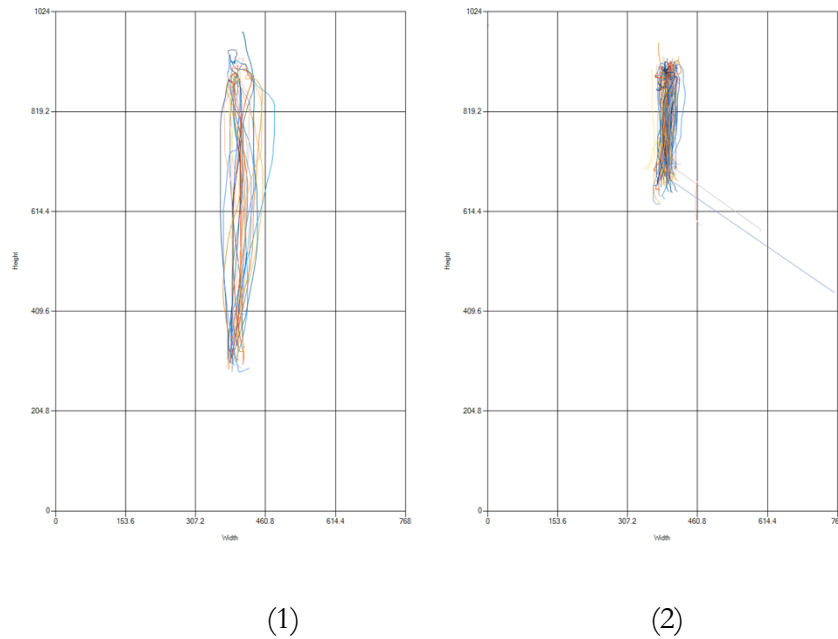
Figure 4.6.3 Drag-and-Drop (1) Long 64px all participants (2) Short 64px all participants

The second experiment which is drag-and-drop considered the easiest experiment as all children picked up the drag-and-drop instructions easily. A similar conclusion for mouse interaction styles has been made by Donker and Reitsma indicating fewer errors were made by children in drag-and-drop experiment versus click-move-click which is similar to point-and-touch experiment (2004). As it is shown in figure 4.6.3 all children for the short and long 64px block task has performed very well, and there was not much outlier lines in drag-and-drop experiment.

(1)   (2)
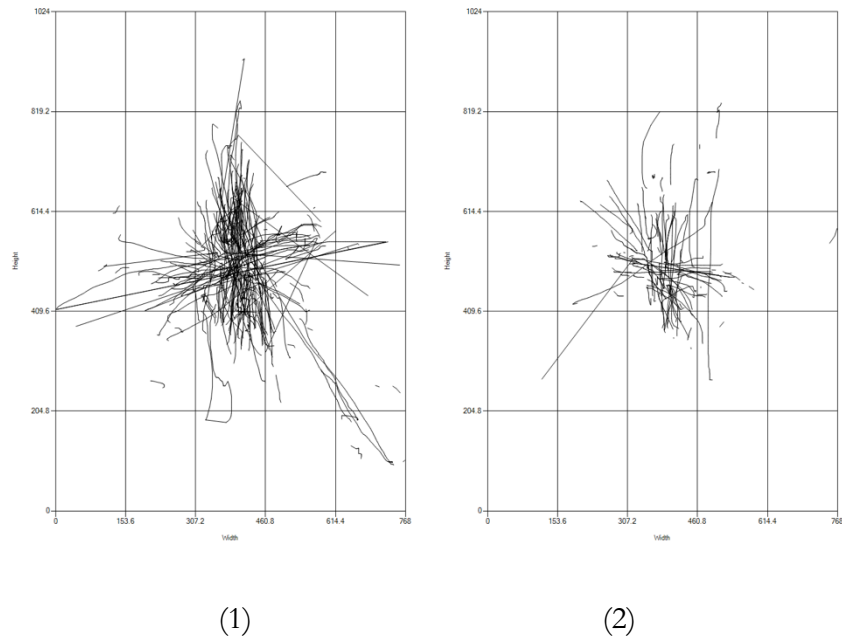
Figure 4.6.4 Zoom-out (256px) (1) Four year-old participants (2) Five year-old participants

The third experiment that is zoom-in and zoom-out was one of the hard gestures for the children to perform. However, there was a difference between 4 and 5 year-old children. As figure 4.6.4 shows that 4 year-old children spread more while zooming out and touch the edges of the screen. However, for the 5 year-old they are more focused on the block itself to zoom-out.

(1)   (2)
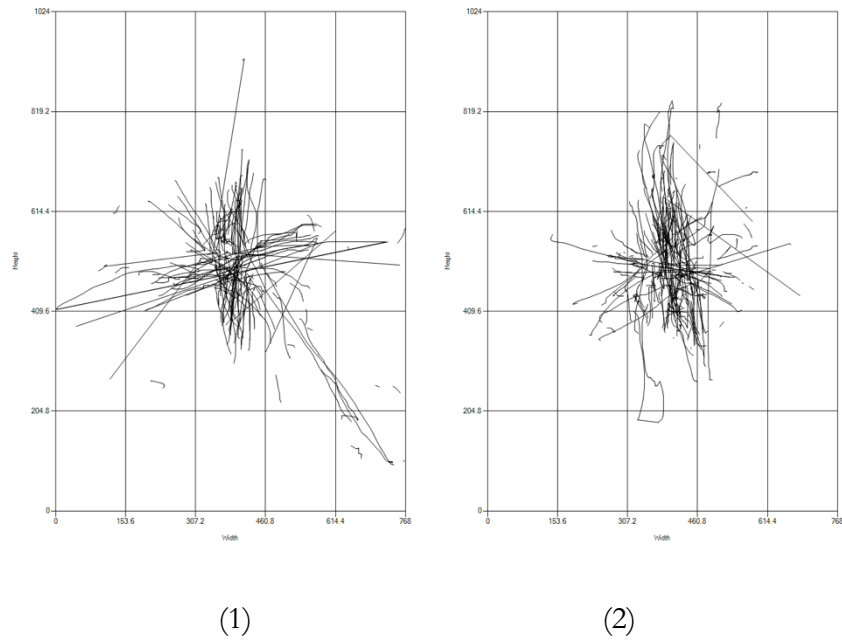
Figure 4.6.5 Zoom-out (256px) (1) Female participants (2) Male participants

Also, in figure 4.6.5 we have tried to observe male and females performances. However, there were not many differences between males and females in most of the tasks. Gender did not effect the child performance.

(1)   (2)

Figure 4.6.6 Rotate (counter clockwise, 256px) (1) Four year-old participants (2) Five year-old participants

(1)   (2)

Figure 4.6.7 Rotate (clockwise, 256px) (1) Four year-old participants (2) Five year-old participants

In last experiment which is rotate, similar to the previous experiment it consider to be one of the difficult gestures for the children. As per figure 4.6.6 and figure 4.6.7 it shows that 5 year-old children performed better and smoother rotation than 4 year-old children, and 5 year-old children were more focused in the middle of the screen. Also, another observation is 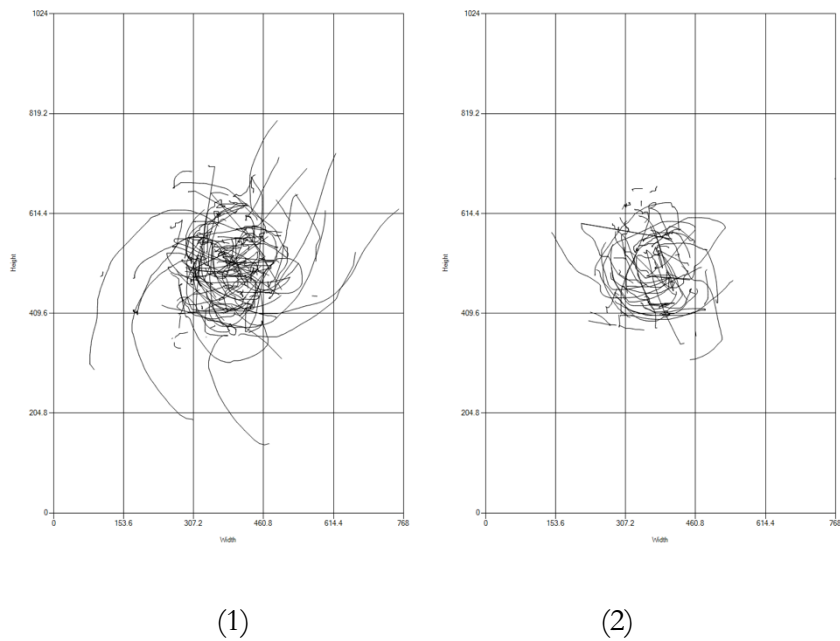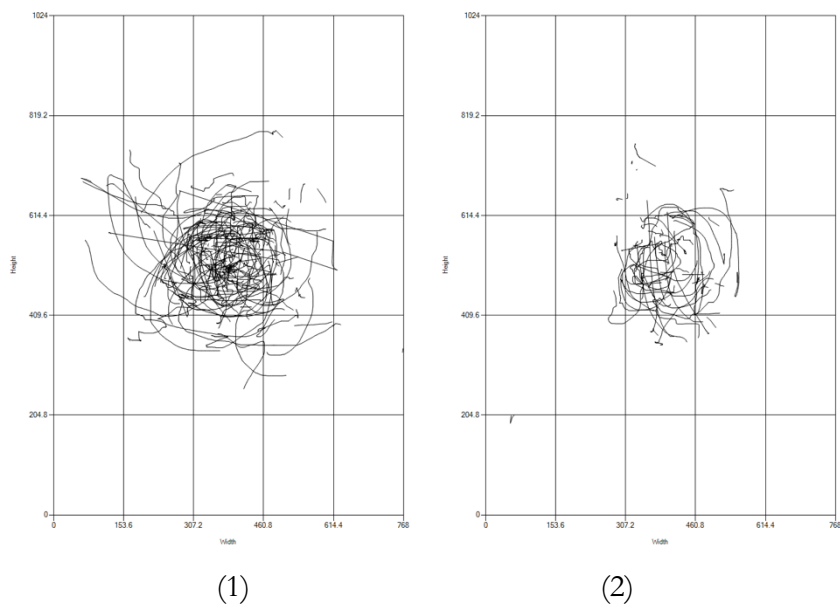children rotation was easier to rotate clockwise and they had some difficulties rotating counter clockwise. A reason to that could be that most of the children were right-handed and less number were left-handed.

4.7 Limitations

Research studies involving young children are sensitive, as is the case of this study were the design of the experiments was carefully tailored to 4 and 5 year-old children. Even though this research design was based on previous research designs which dealt with children's fine motor skills, this research application could be re-designed in a more appealing way for children so the children will not get bored, which some children did while playing the games and repeating the tasks for each test. Another limitation that this research had is having a small sample size. This research was done almost end of school year, and children already started their summer break, so it was hard to find participants. In addition, it was hard to find participants with motor impairment to be part of the research, as this research has one disabled child tested the application. Proposal to conduct research on children in Mankato district was limited with a very tight time frame so it has been rejected.

This research study is a research based on a recent technology, and there is a lack of research studies regarding touch gesture movements and in particular with 4 and 5 year old children. Most previous research are linked with other interaction styles, and even touch

gestures related research discuss only pointing and touch, and drag and drop gestures. There is no research study that discusses zoom-in, zoom-out, and rotate gestures for young children. There are some errors in the research design itself. For instance, in first test and second test there is one task repeated 10 times instead of 5 times. Also, different ways of calculating the point-and-touch and drag-and-drop success tasks does not make it easy to compare those two tests as in other researches. For instance, touching 32px in point-and-touch consider being successful task. However, colliding the image with a 32px in drag-and-drop consider being a successful task. Also, in zoom-in and zoom-out, and rotate tests those tasks were sensitive and ended at the first touch ended for each trial, so it was hard for the children to control the blocks.

Chapter 5: Conclusion

Touch based applications for children should be designed based on the age criteria, and the results indicate there are significant effects in young children's performance depending on design choices for touch interactions. Point-and-touch designs for young children should consider distance, and the drag-and-drop designs should consider the size of the objects on touch devices in order to have the child more engagement and more accurate while performing those tasks. Moreover, designers should consider size as a main element that effects the children's rotation gesture ability. Also, rotation degree effects the children's way of rotation either clockwise or counter clockwise. It is useful for designers to consider rotation side, as it is easier for children to rotate objects clockwise. Designers should consider the children's limitations in performing some of the tasks and have different combinations between easy and more challenging tasks to the children.

5.1 Future work

This research can be used as a start up for other touch based research studies, in order to understand the behavior of 4 and 5 year-old children with touch devices. A different application design can be less sensitive application design with more attractive layout for children. Other touch gestures can be tested, such as rotation with one finger, slide, flick, tap and hold. Moreover, zoom-in, zoom-out, and rotate task could have more challenging ways to complete each task, as the children might perform differently rather than ending tasks on first touch release. Future research us necessary to study the abilities of children with motor impairing disabilities with touch devices, this type of research would support our conclusion

that games and applications should be specifically design for young children, as well as for

children with motor impairments.

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Appendix A: IRB Approval Letters

April 11, 2014

Dear Guarionex Salivia, PhD:

Re: IRB Proposal entitled "[587562-3] Study of Touch Gesture Performance by Children with or without disabilities: Point-and-Touch, Drag-and-Drop, Zoom-in and Zoom-out, and Rotate."
Review Level: Level *[II]*

Your IRB Proposal has been approved as of April 11, 2014. On behalf of the Minnesota State University, Mankato IRB, I wish you success with your study. Remember that you must seek approval for any changes in your study, its design, funding source, consent process, or any part of the study that may affect participants in the study. Should any of the participants in your study suffer a research-related injury or other harmful outcome, you are required to report them to the IRB as soon as possible.

The approval of your study is for one calendar year less a day from the approval date. When you complete your data collection or should you discontinue your study, you must notify the IRB. Please include your log number with any correspondence with the IRB.

This approval is considered final when the full IRB approves the monthly decisions and active log. The IRB reserves the right to review each study as part of its continuing review process. Continuing reviews are usually scheduled. However, under some conditions the IRB may choose not to announce a continuing review. If you have any questions, feel free to contact me at irb@mnsu.edu or 507-389-5102.

The Principal Investigator (PI) is responsible for maintaining signed consentforms in a secure location at MSU for 3 years. If the PI leaves MSU before the end of the 3-year timeline, he/she is responsible for following "Consent Form Maintenance" procedures posted online.

Cordially,

Mary Hadley, Ph.D.
IRB Coordinator

Sarah Sifers, Ph.D.
IRB Co-Chair

Generated on IRBNet

MINNESOTA STATE
UNIVERSITY
M A N K A T O

May 15, 2014

Dear Guarionex Salivia, PhD:

Your proposed changes to your Minnesota State University, Mankato IRB approved research ([587562-5] Study of Touch Gesture Performance by Children with or without disabilities: Point-and-Touch, Drag-and-Drop, Zoom-in and Zoom-out, and Rotate.) have been accepted as of May 15, 2014. Thank you for remembering to seek approval for changes in your study.

If you make additional changes in the research design, funding source, consent process, or any part of the study that may affect participants in the study, you will have to reapply for approval. Should any of the participants in your study suffer a research- related injury or other harmful outcome, you are required to report them to the IRB as soon as possible.

The approval of your changes is attached to your original proposal; therefore, the original approval date has not changed. When you complete your data collection or should you discontinue your study, you must notify the IRB. Please include your log number with any correspondence with the IRB.

This approval is considered final when the full IRB approves the monthly decisions and active log. The IRB reserves the right to review each study as part of its continuing review process. Continuing reviews are usually scheduled. However, under some conditions the IRB may choose not to announce a continuing review or a modification.

I wish you success in your research. If you have any questions, feel free to contact me at irb@mnsu.edu or 507-389-5102.
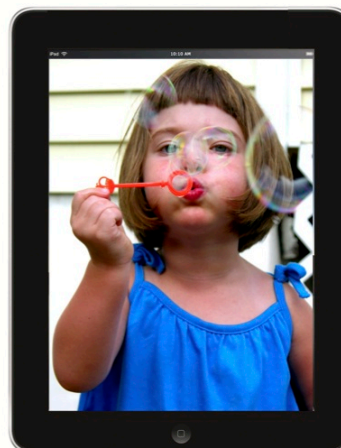
Cordially,

Mary Hadley, Ph.D.
IRB Coordinator

Sarah Sifers, Ph.D.
IRB Co-Chair

Appendix B: Participant Recruitment Flyer

Participants Needed

Researchers at Minnesota State University, Mankato are recruiting children 4 or 5 years old, with or without fine motor skills impairments for a study on iPad usage

IF YOU ARE A PARENT AND YOU AGREE TO HAVE YOUR CHILD PARTICIPATE IN THIS RESEARCH STUDY, ALL INFORMATION RELATED TO YOUR CHILD WILL REMAIN ANONYMOUS AND ALL DATA COLLECTED WILL BE SECURED. FEEL FREE TO CONTACT GUARIONEX SALIVIA AT 5073895311 OR ZAINAB HAMZA AT 5073511766, OR VIA EMAIL AT SALIVIA@MNSU.EDU.

Appendix C: Parent/Guardian Informed Consent Agreement

Project Title: Study of Touch Gesture Performance by Children with or without disabilities: Point-and-Touch, Drag-and-Drop, Zoom-in and Zoom-out, and Rotate.
Parent/Guardian Informed Consent Agreement.
Page 1

Parent/Guardian Informed Consent Agreement
Please read this consent agreement carefully before you decide to let your child participate in the research. You can review the assent form with your child.

Purpose of the research study: The purpose of this research study is to compare touch interaction ability with different gestures (Point-and-Touch, Drag-and-Drop, Zoom-in and Zoom-out, and Rotate) for children with or without disabilities who are between 4 and 5 years old.

What your child will do in the study: Testing will be done through an application that was developed for this research. The application was developed for an iPad. The child will be asked to perform tasks with different gestures such as Point-and-Touch, Drag-and-Drop, Zoom-in and Zoom-out, and Rotating. The number of tasks that your child will be performing are: 30 Point-and-Touch tasks, 30 Drag-and-Drop tasks, 20 Zoom-in and Zoom-out tasks, and 20 Rotate-in-place tasks for a total of 100 tasks.

What you will do in the study: You, the parent or guardian, will not participate in this study; the application is designed for your child. You can be in the same room during the test period. However, you will not help the children with the tasks in the test. Before a test, you will provide anonymous demographic data about your child via a form in the test application, the test application is an iPad application designed for this research, which will contain a form to insert data about you child. The information collected includes, child's age, gender, birth date, hours per week of tablet use, first time of table use and handedness. Answers are completely voluntary and you may skip any question.

Time required: We calculate that testing session will take approximately one hour and only one testing session will be performed.

Risks: The research study involves minimal risk for the participating children since they will be performing the tasks sitting down with an iPad and the tasks only require them to point, drag, rotate, and zoom very simple objects through an iPad application designed for the research.

Initals _____

MSU IRBnet ID#: 587562
Date of MSU IRB approval: 4/11/2014

Project Title: Study of Touch Gesture Performance by Children with or without disabilities: Point-and-Touch, Drag-and-Drop, Zoom-in and Zoom-out, and Rotate.
Parent/Guardian Informed Consent Agreement.
Page 2

There may be other unknown or unanticipated risks associated with being in this study.
- Tiredness or fatigue from repeated tasks
- Frustration, discomfort or embarrassment
- Disappointment from being unable to complete a task

If your child experiences tiredness or fatigue, they may take breaks during the test. If necessary, we suggest that your child performs the tasks in private to reduce or avoid any embarrassment. The testing application provides feedback in the form of sound and a visual whenever your child perform a tests successfully, thus reducing the disappointment effect of not being able to complete a task.

Benefits: There are no direct benefits to you or your child for participating in this research study. The study may help us understand the touch based interaction accuracy for children between the ages of 4 and 5. The potential outcome of this study is to analyze touch ability of children with or without disabilities in order to understand their touch behavior, as well as understanding difficulties in pointing, dragging and dropping, zooming in and out, and rotating an item.

Confidentiality: The information that you and your child will provide in this study will be confidential. The data will be collected through the application; touch coordinates will be saved into a secured offline database. You may skip any questions asked by the application before starting the test. Only the researchers will have access to the information.

Anonymous data: Information related to your child will be stored in I way that will keep your child's identity anonymous. The child will be assigned a random identification number. This prevents anyone form directly identifying your child in any way. Only the researchers will have access to the information.

Voluntary participation: Your child's participation in the study is completely voluntary. Your child participation and your decision whether to participate or not in this study will not affect your relationship with Minnesota State University, Mankato, and no penalty or loss of benefits will affect you.

Initals _____

MSU IRBnet ID#: 587562
Date of MSU IRB approval: 4/11/2014

Project Title: Study of Touch Gesture Performance by Children with or without disabilities: Point-and-Touch, Drag-and-Drop, Zoom-in and Zoom-out, and Rotate.
Parent/Guardian Informed Consent Agreement.
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Right to withdraw from the study: You have the right to withdraw your child and yourself from the study at any time without penalty. All the information regarding your child will be deleted immediately and will not be used in the research once you decide to withdraw from the study.

How to withdraw from the study: If you and/or your child want to withdraw from the study you can tell a researcher and you and your child will be immediately stop the test and data collected thus far will be deleted. There is no penalty for withdrawing. If you would like to withdraw after the test has been completed, please contact Guarionex Salivia at 507-389-5311 or Zainab Hamza by calling 507-351-1766 or by sending the request via email to salivia@mnsu.edu

Compensation: No compensation is provided for participating in the study.

If you have questions about the study, contact:

Researcher's Name: Zainab Hamza
Email: zainab.hamza@mnsu.edu
Telephone: (507) 351-1766

Faculty Advisor's Name: Guarionex J Salivia
Email: salivia@mnsu.edu
Telephone: (507) 389 - 5311

If you experience any research related injuries, contact:

IRB Administrator: Dean Barry Ries.
Email: barry.ries@mnsu.edu
Telephone: (507) 389 - 1242

Initals _____

MSU IRBnet ID#: 587562
Date of MSU IRB approval: 4/11/2014

Project Title: Study of Touch Gesture Performance by Children with or without disabilities: Point-and-Touch, Drag-and-Drop, Zoom-in and Zoom-out, and Rotate.
Parent/Guardian Informed Consent Agreement.
Page 4

Agreement:

Name of parent or guardian: _____

I am the legal guardian of_____ . I consent for her or him to participate in this research study. I understand that Gurionex Salivia, Ph.D. from the Computer Information Science Department at Minnesota State University Mankato (MSU) is the director of the project and that it will serve to fulfill the Masters thesis requirement for Zainab Hamza. I understand that participation in this study includes the following commitment for my child and me:

1) Read and sign this consent form.
2) Answer brief demographic related questions about your child.
3) My child will complete the test hereby described. (takes about 1 hour).

Signature: _____ Date: _____
You will receive a copy of this form for your records

Initals _____

MSU IRBnet ID#: 587562
Date of MSU IRB approval: 4/11/2014
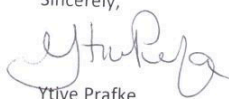
Appendix D: District Permission Letter

Dear Dr. Guarionex Salivia,

I am familiar with your research project titled Study of Touch Gesture Performance by Children with or without disabilities: Point-and-Touch, Drag-and-Drop, Zoom-in and Zoom-out, and Rotate. I am also familiar with your desire to have the Early Childhood Programs in District 508 in Saint Peter, MN involved with it. I understand the role of the Early Childhood Programs in District 508 to allow Minnesota State University, Mankato to conduct an iPad application test on students 4-5 years old with or without disabilities.

We have also discussed the role of the Early Childhood Programs in District 508 students and I am satisfied that their safety and welfare are adequately protected as described in the research protocol. In addition, I understand that this research will be carried out following sound ethical principles and that involvement in this research, for both Minnesota State University, Mankato and the Early Childhood Programs in District 508, is strictly voluntary and guarantees the protection of participant's privacy. In particular, I understand that the investigator cannot provide me with data that might allow anyone other than the research team to identify anyone's answers unless the subject has specifically given permission. I agree that there will be no negative consequences for potential participants based on whether or not they choose to participate in the study, this research is completely voluntary and parents must sign a consent for before conducting the test on their child. The Early Childhood Programs in District 508 understands what, if anything, they expect in return for participation in this research.

Therefore, as the Administrator for the Early Childhood Programs in District 508, I agree to allow you to conduct your research at our facilities at First Lutheran Church, K Ready Program.

Sincerely,

Ytive Prafke
Special Programs Administrator-St. Peter Schools
St Peter, MN 56082

Appendix E: School Permission Letter

SOUTH ELEMENTARY EARLY LEARNING CENTER
1405 South Seventh Street, Saint Peter   MN 56082
Phone: 507-934-2754 * Fax: 507-934-4830

South Elementary

April 28, 2014

Dear Dr. Guarionex Salivia,

I am familiar with your research project titled Study of Touch Gesture Performance by Children with or without disabilities: Point-and-Touch, Drag-and-Drop, Zoom-in and Zoom-out, and Rotate. I am also familiar with your desire to have South Elementary ELC involved with it. I understand the role of South Elementary ELC to allow Minnesota State University, Mankato to conduct an iPad application test on students 4-5 years old with or without disabilities.

We have also discussed the role of South Elementary ELC students and I am satisfied that their safety and welfare are adequately protected as described in the research protocol. In addition, I understand that this research will be carried out following sound ethical principles and that involvement in this research, for both Minnesota State University, Mankato and South Elementary ELC, is strictly voluntary and guarantees the protection of participant's privacy. In particular, I understand that the investigator cannot provide me with data that might allow anyone other than the research team to identify anyone's answers unless the subject has specifically given permission. I agree that there will be no negative consequences for potential participants based on whether or not they choose to participate in the study, this research is completely voluntary and parents must sign a consent for before conducting the test on their child. South Elementary ELC understands what, if anything, they expect in return for participation in this research.

Therefore, as a representative of South Elementary ELC I agree to allow you to conduct your research at our South Elementary ELC.

Sincerely,

Darin Doherty
Principal, South Elementary Early Learning Center
1405 South Seventh St.
St Peter, MN 56082
507.934.2754