ISSN 2409-2665
Journal of Logistics, Informatics and Service Science
Vol. 9 (2022) No.4, pp.27-36
DOI:10.33168/LISS.2022.0403

Association between Screen Size and Touch Accuracy based on a Computerized Fitts' Law Test

Liew Tze Hui[1], Lau Siong Hoe[1], Hishamuddin Ismail[2]

[1] Faculty of Information Science & Technology, Multimedia University, Melaka, Malaysia

[2] Faculty of Business, Multimedia University, Melaka, Malaysia

thliew@mmu.edu.my

Abstract. Screen size does not only imply a certain resolution but fundamentally a different user's experience in human computer interaction. A screen size has major effects on the content consumption and in tasks performance during the learning sessions. The issue of an ill-fitting screen size becomes a big challenge in learning performance with increased cognitive load, split attention span, and increased difficulty in completing exercises and tasks. The purpose of this study is to investigate the effect that a screen size has on child-computer interaction, and to recommend the best practice screen size for pre-school children to interact with computers. A Fitts' Law based application that is named Catch-the-stars has been employed to investigate the screen size that best suits pre-school children, through two types of screen size, specifically a tablet and an all-in-1 multi-touch PC. Each participant is required to touch the stars that appear on the screen until the count of 18. Correspondingly, a total of 103 pre-school children have participated in the testing for a period of 8 months. The results indicate that screen size is an important factor that influences the quality of the child-computer interaction. The study has revealed that the tablet's screen size is the best screen size for pre-school children to interact with computers. This study suggests that screen size is critical to the success of effective learning and that the performance of child-computer interaction is varied based on the different screen sizes.

Keywords: Screen Size, Child-Computer Interaction, Online Learning, Pre-school Children, Fitt's Law Test.

1. Introduction

Interactive technology is reported to have both beneficial (Hanna Rosin, 2013) and negative (Honan et al., 2000; Lovato & Waxman, 2016) effects on pre-school children. The fast-expanding use of interactive technology among pre-school children requires further investigation. Some research supports the use of interactive technology by pre-school children, as well as the educational benefits of such technology for pre-school children (Christakis, 2014; Judge et al., 2015). Other research, on the other hand, are concerned about the harmful aspects of pre-school children's usage of interactive technology, regardless of whether it is for educational or entertainment purposes (Connell et al., 2015; Gallahue, 2006).

For pre-school children, interactive technology is a double-edged sword; the primary concern of child computer interaction researchers is how interactive technology may severely influence pre-school children's motor control, language abilities, eyesight, and attention. These dangers are especially concerning in pre-school children under the age of five (Cara, 2016). According to the Nanny authority, pre-school children are pre-school children are particularly sensitive to the bad impacts of interactive technology (Cara, 2016; David Kates, 2016). Given the large range of interactive device characteristics and the fact that pre-school children know very little about how the characteristics may shape their interaction with interactive devices, such research is critical for the child computer interaction researchers, practitioners and the community.

Despite the fact that there is a significant amount of research focused on discovering the impact of child computer interaction, there is surprisingly little research focused on determining whether pre-school children are affected by specific interaction characteristics such as screen size, position, and object size (Raptis et al., 2013)

The purpose of this study is to determine the elements that influence the overall effectiveness of pre-school children's use of interactive technology in their learning activity. There have been a number of studies conducted to verify the elements that influence the effectiveness of children's interaction performance with interactive technology; however, the results have been mixed, with some studies indicating a positive performance and others indicating no or even a negative impact on the performance of pre-school children (Bryden, 1977; EL & HL, 2016; Huber et al., 2016; Kirkorian et al., 2016; Patchan & Puranik, 2016). As a result, a study to investigate the elements that determine the effectiveness of pre-school children's interaction performance with interactive technology is urgently needed.

Catch-the-Stars, a test developed based on Fitt's Law principle was used in this study to determine the most effective screen size and touch accuracy by pre-school children's engagement with the interactive technology (Fitts, 1954). Fitts' law has become a staple in the field of human-computer interaction (HCI) and child-computer interaction, which has evolved as one of the most accepted design guidelines for such beneficial interaction (Craig & Racheal Siegel, 2019).

Fitts' law, at its fundamental form posits that the bigger an object and the closer the object are to the user, the easier it is for the user to tab on the object. The size of a targeted object and the object's coordinate location on the screen will affect the interaction quality in many ways. Besides, the size of the screen will determine the distance between the user and the targeted objects at different coordinate location as well. Fitts' law has stated that the amount of time that is required for the user to successfully tab a target is determined by the distance to the target divided by the size of the target. Therefore, in theory, the lengthier the object's distance is from the user and the smaller the target's size, the time that is taken by the user to successfully tab on the object will relatively be low (Mads Soegaard, 2018).

2. Methods

The researcher had visited 10 pre-schools in Malacca, Malaysia, for a period of 8 months to complete the testing process. For each pre-school, the researcher had spent about 4 hours per visit. For each visit, the researcher had only been able to collect experimental data from 10 to 12 children, which by average was about 20 minutes for each child. All the pre-school children are aged between 3 to 6 years old during the testing period. A total of 103 pre-school children had participated in this study. The researcher had obtained the verbal consent and permission from the pre-school teacher and parents to conduct the study, and all the pre-school children who had participated in the study had done so on a voluntary basis. The teacher and parents had expressed their preference to be anonymous in this study and not to be identified in any written form.

The interface design of Catch-the-Stars is focused on increasing the interactivity by using the colour, animation and background music. A total of 103 data sets were gathered from the pre-school children. Following the press of the 'Start' button, the pre-school participant begins catching the stars as rapidly and precisely as possible until the game is 'completed,' which is when the number of caught stars equals 18.

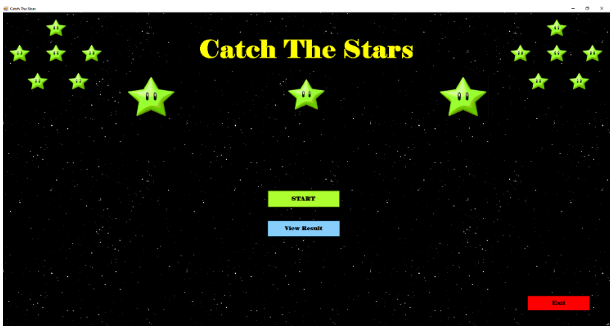

Fig. 1: The catch-the-star application

In total 1,854 entries of data had been collected for each screen size, with an accumulated total of 3,708 entries of data that had been collected for the test. Figure 1 depicts the interface design of catch-the-star application.

Figure 2 and Figure 3 depict the distribution of the coordinate position on the screen size that is tested in this study, namely, the 10.1" tablet screen and the 21.5" multi-touch screen.

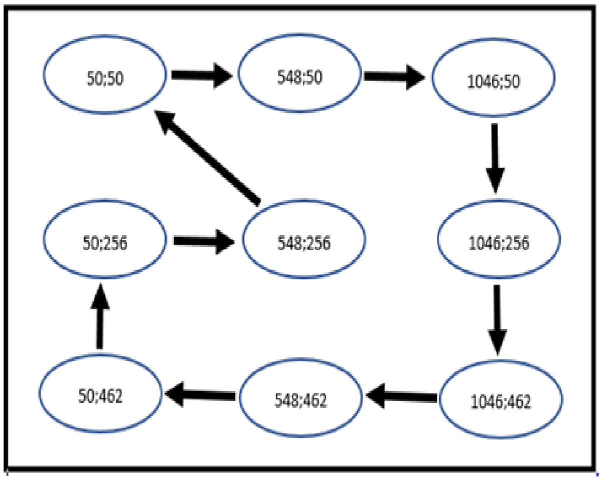

Fig. 3: The distribution of Coordinate position on a 10.1" Tablet Screen

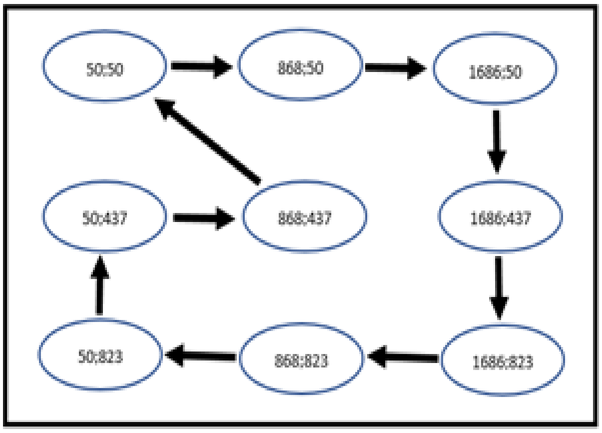

Fig. 2: The distribution of Coordinate position on a 21.5" Multi-touch Screen

3. Results

The best touch accuracy located at coordinate 868;50, which is at the top-center coordinate of the screen. The second-best touch accuracy falls at coordinate 868;437, which is the right-center coordinate of the screen. The results depicted that there are two coordinates with a similar amount of touch accuracy respectively coordinate 1686;437 and 868;823, which are located at the right-center and bottom center coordinates of the screen. Table 3 and Figure 4 below depict the total number of successful touches for each coordinate on a 21.5” multi-touch screen.

Table 1: Total Successful touches for each Coordinate on a 21.5' Multi-touch Screen

X-axis	50	868	1686	1686	1686	868	50	50	868
Y-axis	50	50	50	437	823	823	823	437	437
Small	55	60	63	48	50	63	49	48	56
Medium	43	48	52	57	58	60	46	57	53
Large	61	61	47	59	53	41	44	51	56
21.5"	159	169	162	164	161	164	139	156	165

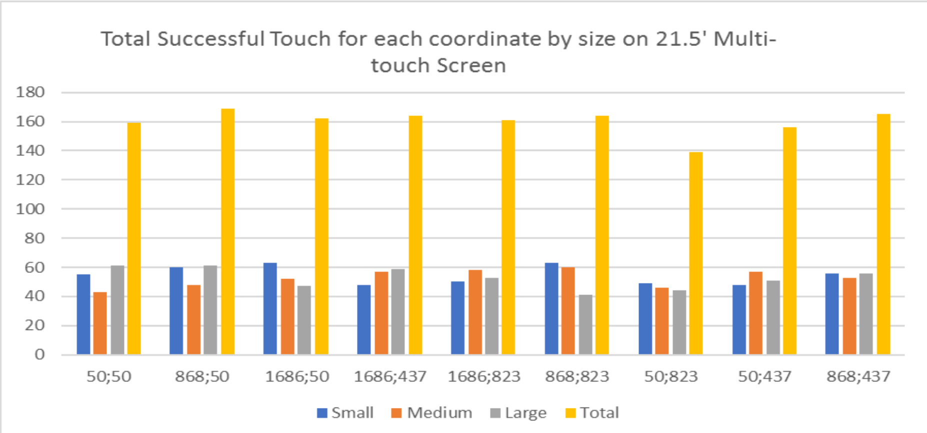

Fig. 4: Total Successful touches for each Coordinate by star size on a 21.5' Multi-touch Screen

On the 21.5" multitouch screen, the best touch accuracy of 169 touches for the test has been achieved at the coordinate 868;50, which is at the top-center coordinate of the screen. The results demonstrate that the center area of the screen, as well as the right-center of the screen, are the most accurate targets for pre-school children. The touch accuracy with the greatest score is 169, while the lowest score is 139. The difference of 20 touch accuracy suggest that the child computer interaction designer should avoid the blind pixel of the 21.5" screen, which located at the bottom-left corner when designing for pre-school children. According to the testing findings, the left-hand column of the screen on the 21.5" earned the lowest three accuracy values, namely 139, 156, and 159.

The middle column, on the other hand, has obtained the three highest touch accuracy scores, 169, 165, and 164, respectively. The right-hand column earned medium touch accuracy, with scores of 162, 164, and 161, a difference of 5 touch accuracy compared to the highest score in the test.

The findings show that the object position coordinate and screen size are major factors influencing touch accuracy on the 21.5" multi-touch screen in children computer interaction.

Table 2: Total Successful touches for each Coordinate on a 10.1” Tablet Screen

X-axis	50	548	1046	1046	1046	548	50	50	548
Y-axis	50	50	50	256	462	462	462	256	256
Small	55	63	67	56	65	62	63	57	58
Medium	55	55	56	59	60	68	55	54	63
Large	53	63	53	65	61	56	48	61	69
10.1"	163	181	176	180	186	186	166	172	**190**

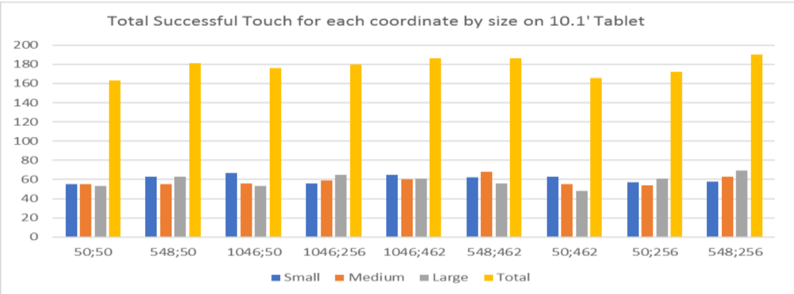

Fig. 5: Total Successful touches for each Coordinate by star size on a 10.1” Tablet Screen

Table 2 and Figure 5 above depict the total successful touches for each coordinate on a 10.1” tablet screen. The best touch accuracy is found at coordinate 548;256, which is the screen's center coordinate. For the second-best touch accuracy, there are two coordinates that have a comparable amount of touch accuracy: 1046;462 and 548;462, which are the screen's bottom center and bottom right-corner coordinates. While the third-best touch accuracy falls at coordinate 548;50, which is the top-center coordinate of the screen.

The total touch accuracy for the test reveals that the coordinate 548;256, which is at the center of the screen on the 10.1" tablet screen, has the best touch accuracy of 190 touches. The results suggest that the center column of the screen and the right-bottom of the screen are the primary target accuracy areas for pre-school children. The results indicate that the touch accuracy score are ranges from 190 to 163, with

190 being the best and 163 being the lowest. The difference of 27 touch accuracy indicates that the top-left corner of the 10.1” screen is the blind pixel that the children computer interaction designer should avoid when designing for pre-school children. The left-hand column of the screen on the 10.1" has gotten the three lowest accuracy values, which are 163, 166, and 172, respectively, based on the test findings. The middle column, on the other hand, has obtained the three highest touch accuracy scores, 190, 186, and 181, respectively. The right-hand column earned medium touch accuracy, with scores of 186, 180, and 176, a difference of 4 touch accuracy compared to the highest score in the test.

The findings show that object position coordinate and screen size are major factors influencing touch accuracy on the 10.1" tablet screen in children-tablet interaction.

4. Discussion

The overall touch accuracy results show that the pre-school children are more comfortable with a small object on the 10.1” tablet screen, as shown in table 3 below. The same pattern is found for the 21.5” multitouch screen as well, which indicates that the highest number of touch accuracy is also for small object. The findings suggest that when designing for pre-school children, the size of an object is one of the most essential considerations for the child computer interaction designer. Furthermore, the findings show that a larger size is not always better for object design, and that, as pre-school children have proven in this study, a small size is the most appropriate object size for them.

Table 3: Total Successful Touch by Object size on 21.5" and 10.1" Screen

	21.5"	10.1"	Total
Small	**492**	**546**	**1038**
Medium	474	525	999
Large	473	529	1002

The small size object had the best touch accuracy, with a score of 1038 touches, based on the data obtained for the test on the total successful touches for small, medium, and large object sizes on the 21.5" multitouch screen and the 10.1" tablet screen. Notably, the lowest touch accuracy score is spotted for the medium size object, with the score of 999 touches.

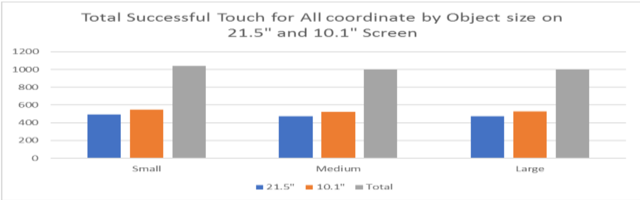

Fig. 6: Total Successful Touch by Object size on 21.5" and

The results that are depicted in Figure 5 are quite different from the researchers' initial perception that a large object will receive the highest touch accuracy. The input from the pre-school children and the teacher suggested that the pre-school children concentrate more to attain the targets that they perceive to be more difficult for them. The sense of challenge and playfulness causes them to be more focused to tap on a specific object size, and in this test, it is the small object target; they therefore miss other objects. Their touch accuracy performance is affected by the speed-accuracy trade-off, where they are only able to touch accurately on the object that they are interested in and concentrated on.

5. Conclusion

Pre-school children were rather direct in their given response towards the test, and the collected data directly reflected their immediate reaction to the test. The results indicated that a small size object received the best touch accuracy score compared to a big object as was commonly understood, and notably age 4 pre-school children had delivered the best touch accuracy score. The results are different from the studies of the previous finding and the common understanding that older pre-school children or age 6 pre-school children will outperform the nursery group of pre-school children due to their better developed motor skills and physical reachability. In terms of object position, the findings are consistent with prior research, which found that the prime pixel fell in the screen's central region. Complex motor coordination, such as two-handed use in multi-touch activities, should not be necessary for pre-school children's designs. From the series of testing, pre-school children only use their index finger while interacting with interactive technology. The scenario is consistent with the findings of a previous study, which found that pre-school children learn through physical interaction by targeting the objects on the screen with their index finger.

The small size object had the best touch accuracy, with a score of 1038 touches, based on the data obtained for the test on the total successful touches for small, medium, and big object sizes on the 21.5" multitouch screen and the 10.1" tablet screen. The medium-sized item has the lowest touch accuracy score, with 999 touches. In conclusion, the findings showed that in child interactive technology interaction, both screen size and object size were important factors influencing touch accuracy at different coordinates on the 10.1" tablet screen and 21.5" multi-touch screen, and that the effectiveness of interaction for both screen sizes and object sizes was moderated by age and usage experience.

The researcher opted to focus on the effect of screen size on child-computer interaction because this research contributes to the first step in the process of understanding interactive device features has on usability metrics (effectiveness and efficiency) while interacting with Fitts' law test application on the two different devices with different screen sizes. The findings are useful in assisting child-computer interaction designers in particular and human-computer interaction designers in general to better understand how screen size influence touch accuracy and the performance of interaction.

For future work, the researcher intends to continue to investigate the impact of screen size on a broader range of interactive devices, tasks, different evaluation tools and with larger sample sizes. The researcher also like to employ the tablet and touch screen desktop with different screen sizes to see if the usability metrics will change within the same continuum of screen size. Finally, as young children getting more and more techno-savvy, research into the screen size effect over time could be pursued.

References

Bryden, M. P. (1977). Measuring handedness with questionnaires. Neuropsychologia, 15, 617–624.

Cara, C. (2016). The Impact of Touchscreen Tech on Kids. Nannyauthority. https://nannyauthority.com/the-impact-of-touchscreen-tech-on-kids-2/

Christakis, D. A. (2014). Interactive Media Use at Younger Than the Age of 2 Years: Time to Rethink the American Academy of Pediatrics Guideline? JAMA Pediatrics, 168(5), 399–400. https://doi.org/10.1001/JAMAPEDIATRICS.2013.5081

Connell, S. L., Lauricella, A. R., & Wartella, E. (2015). Parental Co-Use of Media Technology with their Young Children in the USA. Http://Dx.Doi.Org/10.1080/17482798.2015.997440, 9(1), 5–21. https://doi.org/10.1080/17482798.2015.997440

Craig, T., & Racheal Siegel. (2019). World health officials take a hard line on screen time for kids. Will busy parents comply? - The Washington Post. Washingtonpost. https://www.washingtonpost.com/business/2019/04/24/who-infants-under-year-old-shouldnt-be-exposed-any-electronic-screens/

David Kates. (2016). Kids are getting too much screen time – and it's affecting their development | Toronto Sun. Torontosun. https://torontosun.com/2016/08/23/kids-are-getting-too-much-screen-time--and-its-affecting-their-development

EL, S., & HL, K. (2016). When Seeing Is Better than Doing: Preschoolers' Transfer of STEM Skills Using Touchscreen Games. Frontiers in Psychology, 7(SEP). https://doi.org/10.3389/FPSYG.2016.01377

Fitts, P. M (1954). The information capacity of the human motor system in controlling the amplitude of movement. Journal of Experimental Psychology, 47, 381–391.

Gallahue, D. L. (2006). Understanding motor development: Infant, children, adolescent, adults.

Hanna Rosin. (2013). The touch screen generation. The Atlantic, The Atlantic Monthly Group,. http://www.theatlantic.com/magazine/archive/2013/04/the-touch-screen-generation/309250/

Honan, E., Knobel, M., Baker, C., & Davies, B. (2000). Producing possible Hannahs: Theory and the subject of research. Qualitative Inquiry, 8–32.

Huber, B., Tarasuik, J., Antoniou, M. N., Garrett, C., Bowe, S. J., & Kaufman, J. (2016). Young children's transfer of learning from a touchscreen device. Computers in Human Behavior, 56, 56–64. https://doi.org/10.1016/J.CHB.2015.11.010

Judge, S., Floyd, K., & Jeffs, T. (2015). Using mobile media devices and apps to promote young children's learning. Young Children and Families in the Information Age: Applications of Technology in Early Childhood, 117–131. https://doi.org/10.1007/978-94-017-9184-7_7

Kirkorian, H. L., Choi, K., & Pempek, T. A. (2016). Toddlers' Word Learning From Contingent and Noncontingent Video on Touch Screens. Child Development, 87(2), 405–413. https://doi.org/10.1111/CDEV.12508

Lovato, S. B., & Waxman, S. R. (2016). Young children learning from touch screens: Taking a wider view. Frontiers in Psychology, 7(JUL). https://doi.org/10.3389/FPSYG.2016.01078

Mads Soegaard. (2018). Fitts' Law: Tracking users' clicks | Interaction Design Foundation (IxDF). Interaction Design Foundation. https://www.interaction-design.org/literature/article/fitts-law-tracking-users-clicks

Patchan, M. M., & Puranik, C. S. (2016). Using tablet computers to teach preschool children to write letters: Exploring the impact of extrinsic and intrinsic feedback. Computers and Education, 102, 128–137. https://doi.org/10.1016/J.COMPEDU.2016.07.007

Raptis, D. Tselios, N. Kjeldskov, J., Skov, M. B., Raptis, D., Tselios1, N., Kjeldskov, J., & Skov, M. (2013). Does size matter? Investigating the impact of mobile phone screen size on users' perceived usability, effectiveness and efficiency. MobileHCI 2013 - Proceedings of the 15th International Conference on Human-Computer Interaction with Mobile Devices and Services, 127–136. https://doi.org/10.1145/2493190.2493204