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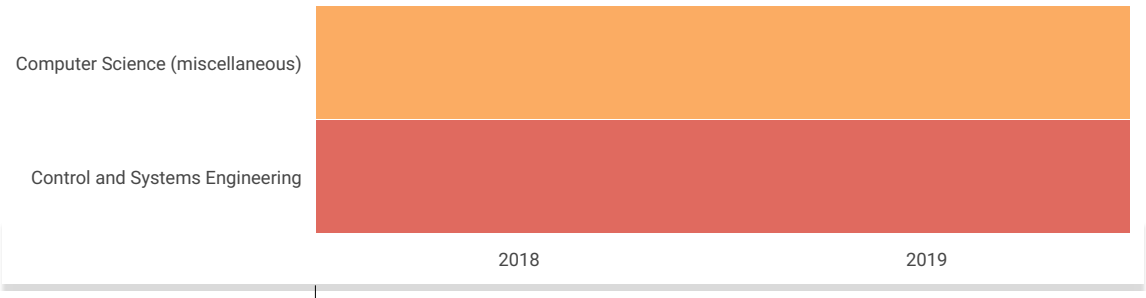

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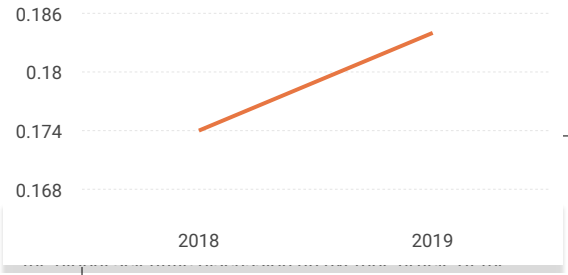

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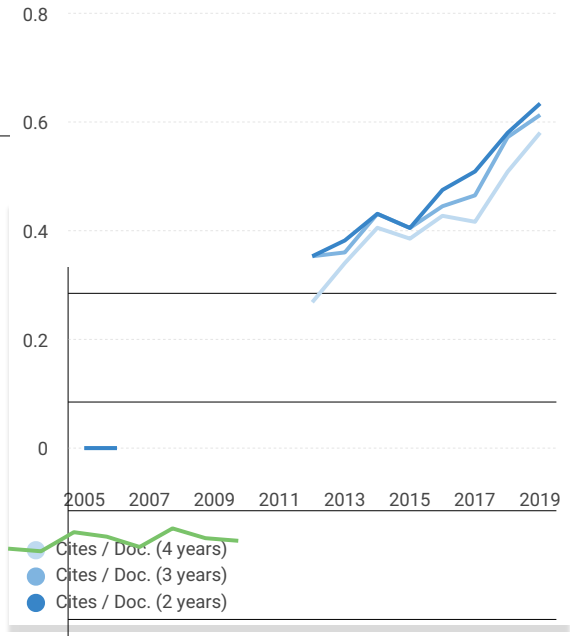

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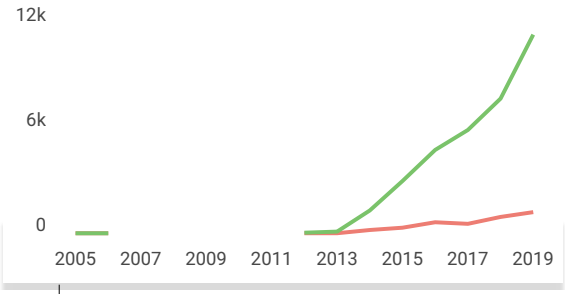

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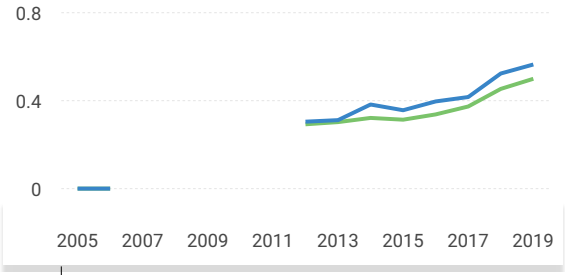

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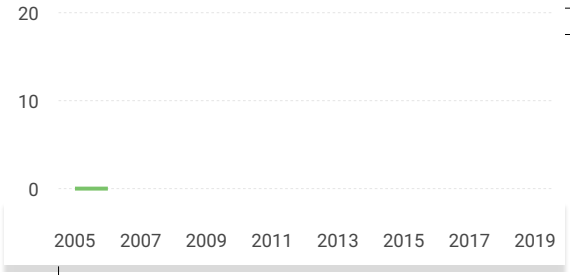

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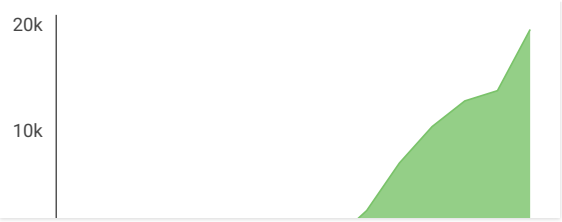

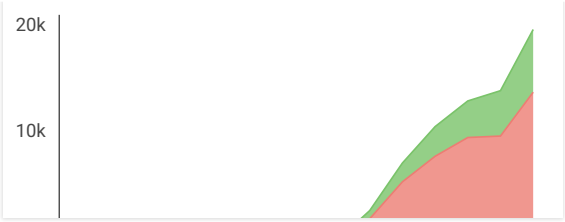

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Contents

Measurement of Drag Distance of Objects Using Mobile Devices: Case Study Children with Autism

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Abstract. Today, children with autism show a great interest in using modern technology such as tablets and smartphones. Also they show a kind of skills to operate such devices; however, the set of operators used to interact with these devices were not designed for people with impairments. There is a lot of research that has been done and is focused on helping users with this type of disorder, but a challenge still remains to create applications that adapt to their physical, cognitive and motor skills. This article focuses on identifying the distance of drag that users with autism can perform with less complexity, as well as identifying the time that the user with autism needs to complete the task. The results show that the greater the drag distance, the more complicated this type of user will be. With these results we can recommend to consider smaller drag size and an image size greater than 63 pixels to design and develop mobile applications to support the teaching of autistic users.

Keywords: Autism Spectrum Disorder · Usability, drag, autism

1 Introduction

Autism Spectrum Disorder (ASD) is a pervasive neurodevelopmental disorder characterized by impairments in social communication and restricted, repetitive patterns of behavior, interests or activities (American Psychiatric Association [APA], 2013). On the other hand, recent studies indicate that people with ASD may present deficiencies in motor skills [1].

The accelerated increase in mobile games in the market is being driven by a powerful development of tablets and mobile phones. This tendency, have made the development of mobile applications have increased. Although the number of developments aimed at people with autism has grown in recent years, as are studies that seek to produce knowledge on how to find solutions for possible motor difficulties that people with autism can present.

Due to this, it is necessary to develop technology that adapts to the motor disabilities that people with autism can present.

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the diversity in the design of the applications implies the use of different drag distances (D) and image sizes; therefore, it is necessary to perform an analysis of the size of the drag distance with different image sizes using mobile devices.

The drag and drop operation on a touch screen was proposed for users with motor problems [10]. In this study, the authors proposed a new technique for the selection of the objective called barrier signaling; this was done with the aim of helping users with motor problems. In this article, the drag time (D) with two different drag distances is evaluated using two applications that comply with what is specified in [11], this is to define the drag distance that users with autism can make with less difficulty and the time that are needed to carry out the task.

3 Experimental Design

3.1 Method

The objective of this study is to identify the drag time (D) that users with autism can run with less difficulty when using mobile applications. It is for this reason that two applications with different sizes of drag were evaluated to define the time that a user needs to carry out the task, as shown in Fig. 1.

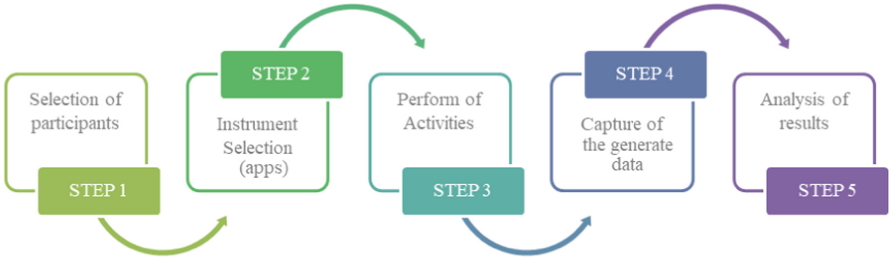

Fig. 1. Methodology of experimentation

3.1.1 Participants

The experiment was conducted in a special education school with 11 users diagnosed with autism. In this sample, 6 users were diagnosed with level 1 of autism and 5 with level 2 of autism. The users were diagnosed by specialist psychologists and each user was associated with a level of autism according to the DSM-V [12]. Users with autism are between 5 and 11 years old.

3.1.2 Instruments

a) Kids Animals Jigsaw Puzzles
It is an application to assemble puzzles developed for children offered by App Family Kids - Games for boys and girls. Each relaxing puzzle presents a beautiful different scene drawn by a professional cartoon artist, and a unique reward when the

puzzle is completed. The scenes include things like cute animals, unicorns and rewards may depend on the level of the game.

For this experiment, a Samsung Galaxy Tab 4 tablet was used with specifications that included a 7-in. resolution screen and 1280 × 800 pixels in the Android operating system. Figure 2 shows the characteristics of this application Kids Animals Jigsaw Puzzles, such as image size and drag size.

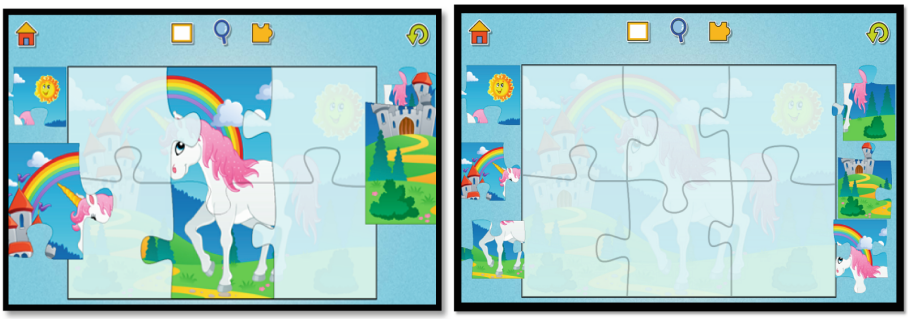

Fig. 2. Interface characteristics of app Kids Animals Jigsaw Puzzles

b) Drag and Learn the Colors
For the application Drag and Learn the Colors was developed considering the drag sizes. In this application a screen with three different colored boxes is presented, which the user has to drag depending on the color that appears in the bottom part, this is to support the user in the identification of colors. This is repeated several times until the user decides to leave this activity. The objective of this application is to support users in learning colors (Fig. 3).

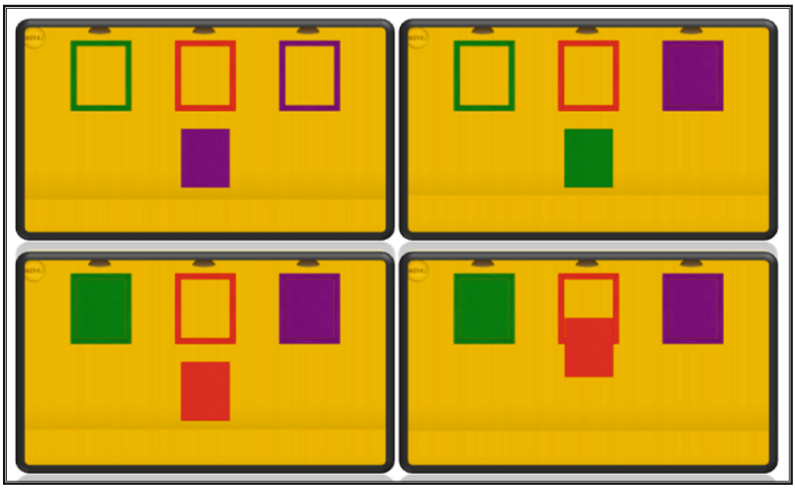

Fig. 3. Interface characteristics of app Drag and Learn

To measure the interaction time of the users, a video camera was used to record the interaction in the video, and then we used the ELAN is a professional tool for the creation of complex annotations on video and audio resources to measure the time of the video.

3.1.3 Procedure

The experiment was carried out in the place where users attend teaching classes. A room was chosen where children attend their therapy so that they could interact with the tablet in a quiet environment. Before carrying out the experiment, the parents of the subjects signed a letter of consent for the video recording, only their hands were recorded and only while using the tablet. During the experiment the support staff (psychologists) were explained what the procedure consisted of and the use of the application. The support staff was responsible for supporting the children to perform each of the tasks.

Participants used the index finger of their dominant hand to perform each of the tasks set. While the experiment was running, the participants were asked to execute the task of the first drag as quickly and accurately as possible. When the users started to interact with the applications, these interactions were recorded to measure the time later. All the tasks were repeated at least 5 times, and for the measurement they were only used from the second interaction, since the first one was considered as training.

4 Results

In this section we present the results of the tests for executing the tasks. We present data about the times that users need to perform each task for each different drag distances. Figure 4 and 5 show the times for each group of users using the application Kids Animals Jigsaw Puzzles and the application Drag and Learn the Colors.

Group of Autism Level 1. The results show that the maximum time of use of a user of level 1 was 2.0 s and the minimum of 1.7 s for the distance of drag, with a standard deviation of 0.1 and a median of 1.8 as shown in Fig. 4.

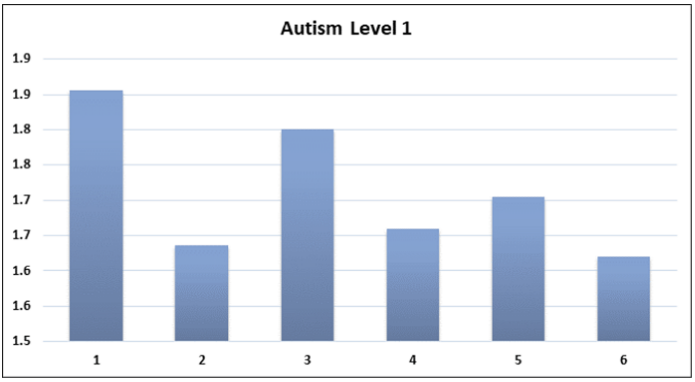

Fig. 4. Drag task for level 1 user for app Kids Animals Jigsaw Puzzles.

Group of Autism Level 2: In the case of users with level 2 of autism, the results show that the maximum time of use of a user of level 2 was 3.3 s and the minimum of 2.1 s for the distance of drag, with a standard deviation of 0.4 and a median of 2.9, as shown in Fig. 5.

It can be seen that the results show that users with level 2 of autism needed more time than users with level 1 of autism, this is understood by the nature of their spectrum, but it does not mean that they could not perform the task.

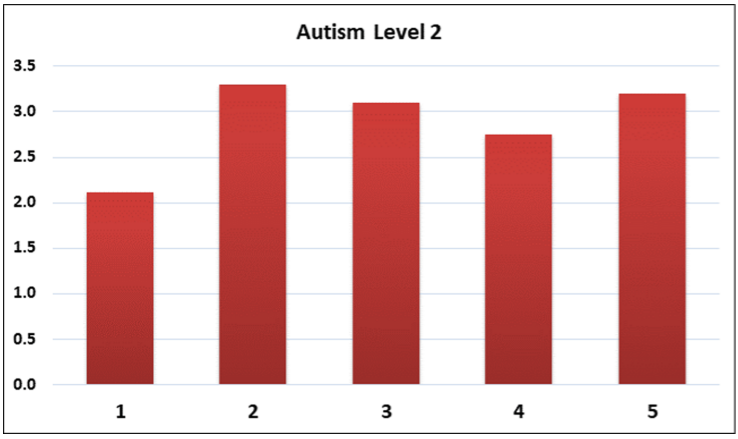

Fig. 5. Drag task for level 2 user for Kids Animals Jigsaw Puzzles.

Table 1. Comparative analysis between the times used by each child

User	App				
	Drag and learn	Puzzle		Drag and learn	Puzzle
	Autism level 1		User	Autism level 2	
1	1.4	1.9	1	1.7	2.1
2	1.7	1.6	2	1.4	3.3
3	1.8	1.8	3	2.0	3.1
4	2.0	1.7	4	2.5	2.8
5	1.9	1.7	5	2.9	3.2
6	1.2	1.6			
Max	**2.0**	**1.9**		**2.9**	**3.3**
Min	**1.2**	**1.6**		**1.4**	**2.1**
Median	**1.7**	**1.7**		**2.1**	**2.9**
S.D.	**0.3**	**0.1**		**0.5**	**0.4**

Table 1 shows a comparison of the times used in the use of each application for each child depending on the level of autism. As you can see that the application with which it was easier to carry out the task was that of Drag and Learn, due to its ease of use and its design. Users with level 1 autism performed the task in less time, due to the implications of level 2 users.

In the case of the interaction with the application Drag and Learn the Color, users with level 1 of autism executed the task in a maximum of 2.0 s and in a minimum time of 1.2 s. For users with level 2 of autism the maximum time to execute the same task was 2.9 s and a minimum of 1.4 s, as can be seen there is a slight variation between both groups, as shows in that Fig. 6.

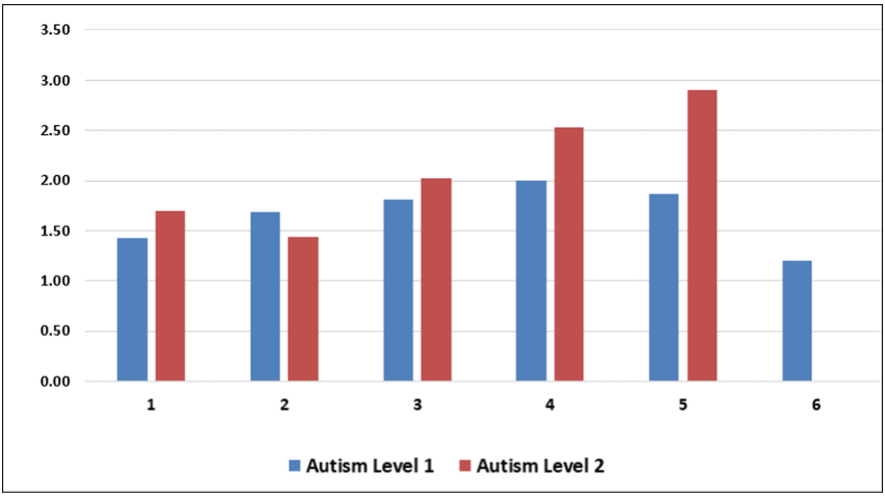

Fig. 6. Drag task for level 1 and level 2 user for drag and learn the colors.

5 Discussion

The results in Fig. 4 and Fig. 5 show that there is a variation between each group of users, users of level 1 required less time to perform the first task that consisted of dragging an image as shown in Fig. 7, in which the time to perform the same task as users with level 2 autism required more time to carry out. This indicates that due to its nature of the spectrum this type of users require more time to be able to execute tasks using mobile applications. In addition, there is mention that most users successfully completed the assigned task, which consisted in dragging the image of the puzzle to each part of it. In the case of some users, it was necessary to instruct the use but the

majority had much or little knowledge in the use of puzzles. The same case occurs in the execution of the second task with the second application Drag and Learn the Color. In this case the task was to choose the color of the image and drag it to the box this was with audio support which indicated the task to be executed. As can be seen in Fig. 6 there is a variation between the group with level 1 of autism and level 2. For this task, the users with level 1 of autism required less time to carry it out; otherwise it happens with the level 2 which required a longer time. This may be due to the size of the icon that is within size recommended by Android: the tactile lenses must be at least 48 × 48 dp (density-independent pixels) (Fig. 8).

Based on these resulted, it may be appropriate to use larger tactile lenses to accommodate a wider spectrum of users, such as children with lower motor skills. We can see that the bigger the image, the better the user interacts with the interface. It was also observed that the applications should be as simple as possible to achieve the child's attention. This indicates that developers should take into account the motor skills of users as are users with autism.

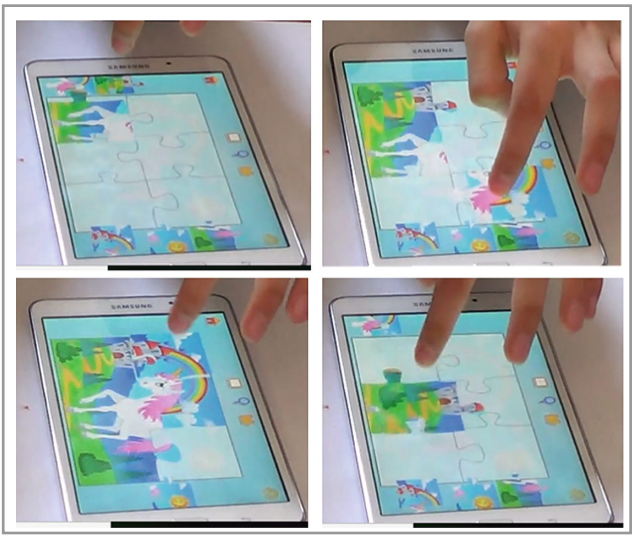

Fig. 7. Interaction for Kids Animals Jigsaw Puzzles

Years ago different models have been developed that determine the usability of various types of applications, but these models cannot be applied to users with autism, such as (KLM-GOMS [2] and FLM [3]). The original GOMS model has been modified due to the increasing progress of technology. Despite this, research has been insufficient on how to improve user behavior techniques in users with autism; in particular, those where it is sought to evaluate the time used to achieve frequent interactions when using touchscreen devices. The objective of this study is to identify the drag time (D) that users with autism can run with less difficulty when using mobile applications.

The rest of the paper is organized as follows. In Sect. 2, we analyze related work. Section 3 describes the experimental design. In Sect. 4, we present the obtained results and then Sect. 5 presents the discussion, and finally, Sect. 6 presents conclusions and future work.

2 Related Work

With the progressive popularity of mobile devices, the KLM-GOMS model has recently been revised to evaluate interactions based on touch-screen devices [4, 5]. The model KLM-GOMS determined 5 operators: Drawing (D), Keystroke (K), Mental Act (M), Pointing (P) and Homing (H).

Similarly, in [3] the authors proposed a modified version of the KLM-GOMS model called FLM (finger stroke level model). The purpose of this study was to define the time it takes to perform the operators of mobile devices with direct movements of the fingers (Drag (D), Point (P), Move (F) and (Touch (T)). In the experimentation using KLM-GOMS and FLM models, the authors analyzed the interactions only in typical adults with experience in the use of technology.

In [6] a study is shown that evaluated the operators of drag, zoom and movement for mobile devices. The research consisted of comparing efficiency and user satisfaction during navigation with 2D documents on mobile screens. Although the results obtained were positive, the experiment was only applied to users with a typical psychological development.

Also, in [7] a study was presented about the accuracy of drag-and-drop interactions for older adults when analyzing the number of additional attempts to position a target during the execution of tactile puzzle games in two different screen sizes, a smartphone and a tablet, with finger and ballpoint interaction. This study shows that drag and drop is an effective technique to move objectives; even on small touch screen devices, interaction with the pen can support older users to execute more accurate drag-and-drop interactions on touch-screen devices.

In the other hand [8] examines the size of the objective and the distance between each one with smartphones. This study was applied to older adults who had little experience in the use of touch technology. The results of this study show that the larger the size of the lens (image), the easier it will be to use touch technology for this type of user.

In the same way, in [9] analyzed the interaction of autistic users with mobile devices. This study took into account 6 operators: M, K, G, I (Initial Act), T (Tapping), and S (Swipe). The results suggested that users with level 1 of autism are more likely to perform operations such as K, G, I, and T than users with level 2 of autism. However,

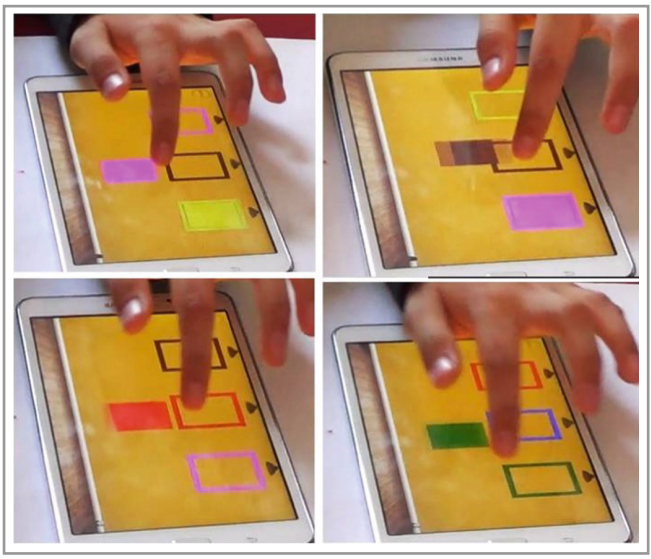

Fig. 8. Interaction for app drag and learn the colors.

6 Conclusions

This article presents an experimental design to evaluate the time required for two groups of users (level 1 of autism and level 2 of autism) to perform trawl operations with different distances using a puzzle of animals for children. In this experiment, the time required by each group to perform the operations proposed by KLM and FLM, which are variants of the original model proposed by GOMS, was evaluated. In the case of the application called Drag and Learn Colors, which was considered to be larger than 60 pixels, the results showed that the interaction was easy for both users, for both applications. This indicates that the larger is the size of the image and the smaller the drag, then it will be easier for users with autism to use.

The results obtained in this study allow us to conclude that users with level 1 of autism performed tasks in less time compared to users with level 2 autism, due to the cognitive and motor deficits that each user level has, despite the fact that have the same task. The difference is identified for each of the trawls with the distances used in each of the applications.

As future work, more experiments will be carried out with typical users and with users who have some motor disability; two new levels will be developed in the drag and learn the colors application, where the objective will be to change the size of the images, this is to be able to counteract the results obtained with this experimentation and be able to compare the results between each group of users, this is with the purpose of being able to develop applications that they adapt to the different motor and cognitive abilities of each user.

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