

Android app to stimulate and measure children development during their first stage of life

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ABSTRACT

UPDATED—26 April 2019. This paper explains the research and development of a mobile application that helps parents to stimulate their infants and measure the response of such stimulation. The tool considers 4 different sensorimotor substages, with different objects at different speeds. It also performs eye tracking and smile detection as its measurement mechanism. The tool is grounded on cognitive development theories encompassed in the Early Childhood Development framework. The tool was evaluated with interviews and surveys that proved valuable to improve the application itself.

Author Keywords

Early Childhood Development; Computer Vision; Parent's Education; Mobile Computing; Computer-assisted instruction;

ACM Classification Keywords

I.2.10. Vision and Scene Understanding: Motion; I.4.8 Scene Analysis: Tracking; I.5.4 Applications: Computer Vision; I.2.6 Learning: Knowledge acquisition; K.3.2 Computer and Information Science Education: Computer science education.

INTRODUCTION

The field of childhood development has seen many advancements over the past century both theoretical and experimental. From meticulous observations and behavior studies [11,12,13,26] to cognitive theories [23,24,32] with relevant concepts such as Means-ends sequencing and Object Permanence.

The field has developed Early Childhood Development (ECD), a unifying philosophy proposed by Maria Montessori [20] and grounded on cognitive theories.

One subset of ECD deals with physical stimulation and cognitive development. The work from Bushnell [3] highlights experiments and positive results related to haptic and visual depth perception involving retina tracking. Moreover, Hofsten [18] analyses how some physical action engages in a cognitive process with some sort of outcome from newborns to adults.

The lack of well-researched tools presents a challenge to apply ECD at home by parents. Poorly designed and

implemented tools can generate overstimulation [7] or stagnation [8] in children which would affect current and future development stages.

An Android application (app) was developed to stimulate children in the first sensorimotor stage. The app contains 4 main components: the main menu to access all substages, a stimulation component, a measurement component, and a report screen. The stimulation component will have multiple shapes that contain high contrast colors and animations at different speeds. The measurement component has computer vision techniques to track eye movements, face and smile detection.

The app was evaluated with qualitative assessments, that is, interviews, surveys, and prototype testing that helped refine and improve the overall experience.

RELATED WORK

There are tools specifically designed for infant stimulation as well as toddlers education [17,28], that guide the parents and provide stimulation exercises to infants in the form of basic shapes, and black and white colors. Nonetheless, none of them are based on academic or clinical research and they don't have an evaluation component to track the responses to the stimulus.

There are few tools available for parents with an academic background [9], such as a mobile app to track children developmental delays and provide customized feedback to help them reach each children milestone.

In terms of measuring, there are 2 studies [1,19] that showcase tools to measure infant early development at scale, that is, measuring if children can pick up a small object with thumb and a finger.

On the education space, there are apps which describe theories, activities, and exercises that can be applied to children [29,30], albeit, they don't provide resources to stimulate or measure the infant response.

On the physical space, there are robots designed to interact with children [25,27] that encourage interaction and physical stimulation, however, these robots don't measure the interaction they have with children.

THE MOBILE APPLICATION

The app was created following an iterative and incremental development approach, that started with low-fidelity prototypes and evolved into a fully developed mobile app.

Low-Fidelity Prototype

Figure 1 and 2 show the initial application prototypes, they were used to gather early feedback from peer students at Georgia Tech. The response was positive with no changes to the prototypes, which allowed the author to continue to the next development phase.

Baby Stimulation App
Main Menu



Figure 1. Application main menu prototype.

Baby Stimulation App
Stimulation Screen

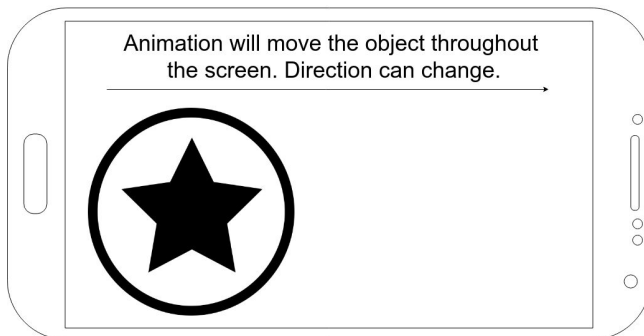


Figure 2. Application stimulation screen prototype.

Final Version

The app aims to develop the brain through visual stimulation with simple experiments a baby can follow based on his/her sensorimotor substage (age). Each substage will present different objects at a different speed with different trajectories.

Figure 3 shows the main menu that contains access to each sensorimotor substage. When the user enters the stage, it will trigger the stimulation screen.

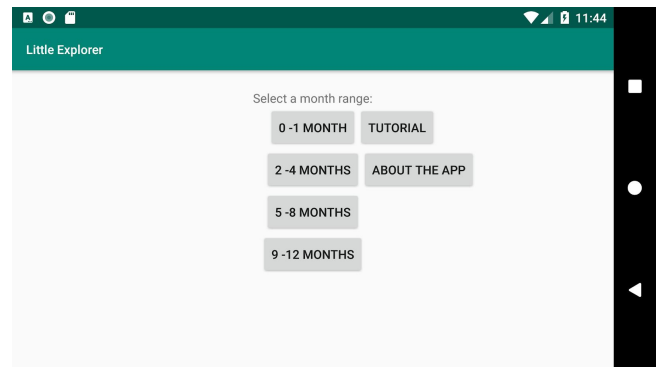


Figure 3. Main menu.

Figure 4 exhibits the stimulation screen which has 1 random high contrast shape moving from right to left. On the top right, there is a live view display of the phone's front camera, where the user can see how the baby is being tracked.

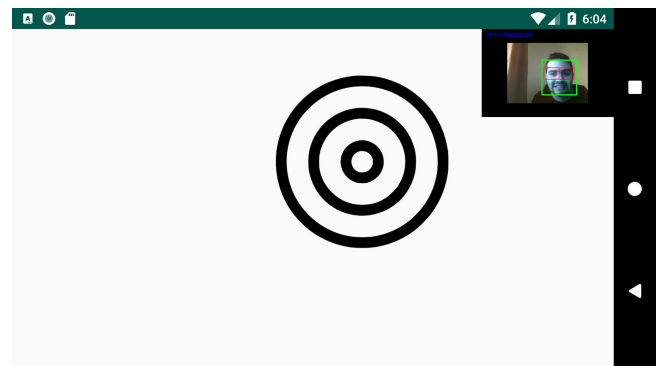


Figure 4. Stimulation screen.

Figure 5 displays the report screen that provides engagement statistics such as the number of smiles and whether the infant tracked the object or not.

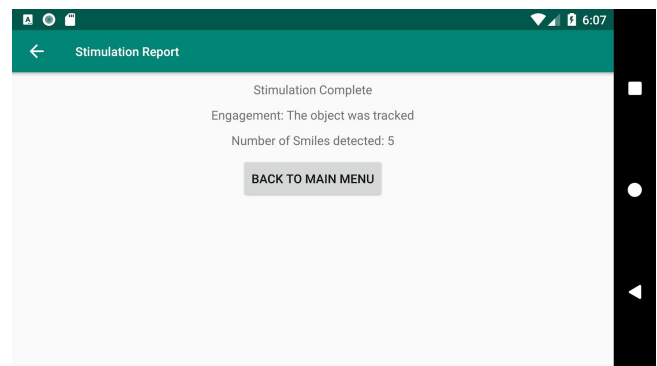


Figure 5. Report screen.

Figure 6 and 7 show the About the App and Tutorial screen, both of them contain information related to the purpose and usage of the app, respectively.

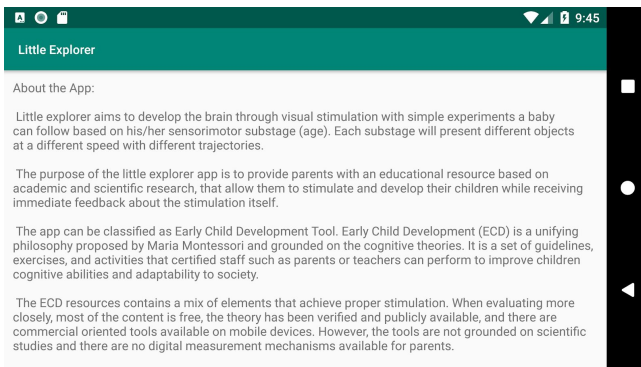


Figure 6. About the App screen.

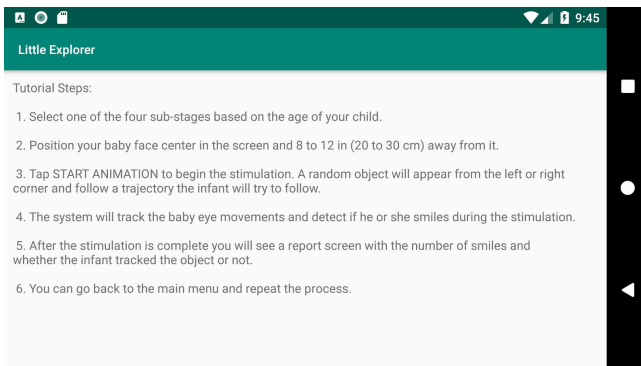


Figure 7. Application tutorial.

Implementation Details

The application was developed in Java, and supports Android API Level 21 (Lollipop) and onwards, which covers 88.9% of Android devices to the present day according to Google [14].

The stimulation screen uses the ObjectAnimator and the PathInterpolator API [15,16] to perform the animations.

Additionally, eye tracking was performed following the work of Choi et al. [6] using the Adaboost Selector and HAAR Features.

The smile detection approach was developed using Box Filters mentioned in the work of Whitehill et al. [33], and the eye tracking and smile detection technology are based on the seminal paper about integral images also known as the Viola-Jones object detection framework [31].

The author evaluated the technique described by Chen et al. [5]. Unfortunately, the TensorFlow Lite Library added complexity that compromised the real-time processing of the phone's camera, consequently, the solution mentioned in the work of Whitehill et al. was used.

Finally, OpenCV Library Version 4 [21] was used to manage camera interactions, that is, open the camera, read the frame stream, and load the cascade classifiers.

Educational Resource for Parents

The purpose of the app is to provide parents with an educational resource based on academic and scientific research, that allow them to stimulate and develop their children while receiving immediate feedback about the stimulation itself.

The app can be classified as an Early Childhood Development Tool. ECD is a set of guidelines, exercises, and activities that certified staff such as parents or teachers can perform to improve children cognitive abilities and adaptability to society.

A recent study [2] has shown that Early Childhood Development has a positive impact in multiple areas like learning and health, and it highlights the importance of stimulation and care in infants.

Moreover, there is a study [4] that proves the importance of parents actively stimulating their children to potentiate their development. This is an important matter because children with proper stimulation can lead to successful adulthood years later [10].

The ECD space contains a mix of elements that provide good resources to achieve proper stimulation. When evaluating more closely, one notices most of the content is free, the theory is sound and publicly available, and there are commercial oriented tools available on mobile devices. Nonetheless, the tools are not grounded on scientific studies and there are no digital measurement mechanisms available for parents.

APPLICATION EVALUATION

The application was evaluated with 4 interviews and 1 survey with 20 participants. The results of such evaluation led to 2 development cycles, in which the About the App and Tutorial screens were added, and technical improvements to the eye tracking and smile detection were performed.

Interviews

With regards to the interviews, 1 was completed in-situ, and 3 were conducted online. The participants were close relatives to the author (family and friends). All of them have children and an Android phone. To avoid social desirability bias the interviews were performed asynchronously and in written to minimize interaction with the author. The participants were given an apk file they downloaded and installed on their devices with installation instructions. They were directed to explore and try to use the app for a few minutes and then answer 4 questions.

All participants felt lost during the first interactions with the app, and ask for some sort of instructions to get started. The application performance was good, with a few crashes that were identified and fixed. The overall experience was positive.

Survey

An online survey with 20 Georgia Tech students were carried out online. The responses were anonymous and the students had no relationship with the author, therefore, the survey didn't have any social desirability bias. To include non-Android users, a demonstration video was posted inside the survey to allow the participants to provide feedback without an Android device.

Figure 8 shows that Android Oreo (version 8) is the most common version in the survey participants, which indicates the app was tested on phones with more than enough capacity to process eye tracking and smile detection.

What Android version do you have?

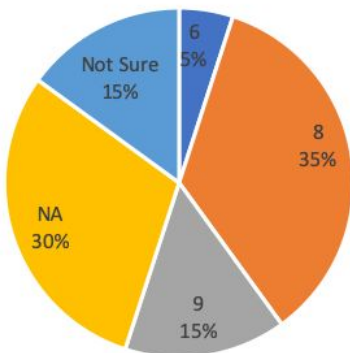


Figure 8. Responses about Android version.

Figure 9 indicates Samsung and Google are popular brands among Android users. Nonetheless, there still exists a challenge to develop an application that works on all Android devices considering the variety of screen sizes and camera resolutions.

What phone do you have?

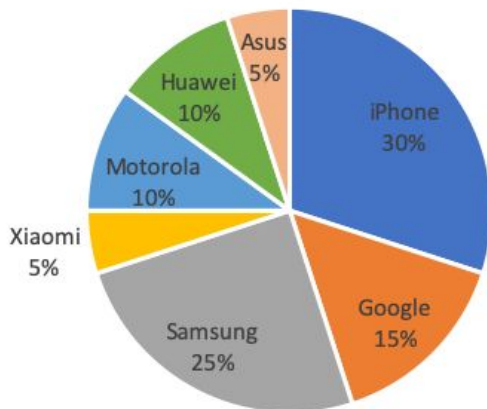


Figure 9. Responses about phone brand.

Figure 10 shows less than 50% of survey participants installed the app, which indicates that a video presentation of the app is a useful strategy to receive more feedback and include users that don't have the hardware to evaluate the application.

Did you install the App?

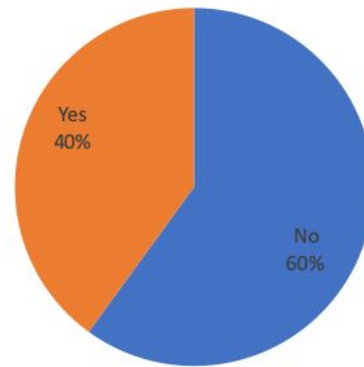


Figure 10. Responses about app installation during the survey.

Additionally, the author wanted to evaluate the application commercial feasibility by querying the participants how much they were willing to pay for the application. Figure 11 reveals that 20% of the users are willing to pay for the app, and 5% would pay 1.99. This early feedback can help refine the application pricing strategy.

Would you buy this app for 1.99?

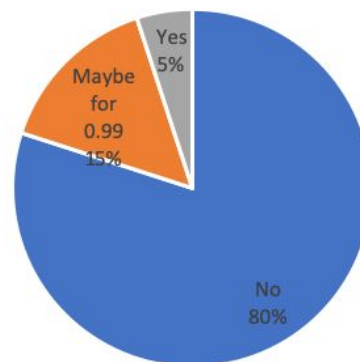


Figure 11. Responses about app purchase intention.

CONCLUSION

An ECD Tool was developed to stimulate children and measure their response to the stimulation. While there are more features to be included, it presents an opportunity for developers and researchers to implement consumer educational tool based on scientific research.

FUTURE WORK

Interestingly, early childhood development can be applied to robots [22], boosting the importance of research and create new tools that can be applied to both humans and robots alike. The tool can be adapted to teach robots how to identify objects, colors, and trajectories. Furthermore, it can be used as a comparison tool between robots and infants on the vision development space.

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