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This is an **author produced version** of a paper published in:

17th ACM Conference on Interaction Design and Children,
Trondheim, 2018

DOI: https://doi.org/10.1145/3202185.3202765

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Leo con Lula, introducing global reading methods to children with ASD

Javier Gomez, Letizia Jaccheri
NTNU
Trondheim, Norway
{javier.escribano, letizia.jaccheri}@ntnu.no

Juan Carlos Torrado, Germán Montoro
UAM
Madrid, Spain
{juan.torrado, german.montoro}@uam.es

ABSTRACT
Children with Autism Spectrum Disorders (ASD) show difficulties in reading skills acquisition with syllabic methods (used in ordinary schools). So that, specific learning methodologies are needed. Thanks to their good visual competences, global reading methods seem to be very useful. This paper presents a technology-driven serious game, based on global reading methodologies and personalized experience to promote children' first contact with literacy skills. This app is called "Leo con Lula" ("reading with Lula", in Spanish) and it is available on mobile platforms.

The paper reports about a pilot study with 9 children, aged 3 to 8 years old. The pilot is based on questionnaires and direct observation to gather teachers' thoughts, discover possible limitations and value game suitability as a tool in class context.

Author Keywords
Reading skills; computers in education; mobile devices; autism spectrum disorders; global reading

ACM Classification Keywords
•Applied computing ~ Computer-assisted instruction •Human-centered computing ~ Mobile devices •Social and professional topics ~ People with disabilities

INTRODUCTION
The term ASD derives from the identification of the formerly called "autism" as a wide group of heterogeneous neurodevelopmental disorders [18]. The most recent diagnostic classification from the DSM-V [2] highlights two main aspects to determine the presence of an autism spectrum disorder in an individual: on the one hand, deficits on communication and social interaction must be found; on the other hand, there would be presence of repetitive patterns of behavior, activities and interests, which manifest through several symptoms. These aspects affect children diagnosed with ASD in different ways: social isolation, lack of communication possibilities or developing limitations. Therefore, their autonomy is limited.

Reading provides independence, it is a communication media and at the same time, a mandatory tool to increase development today. In the specific case of people with ASD, they have to acquire social and communication skills, in order to be able to relate properly [20]. Despite of the popular belief, many people with ASD have significant limitations to learn reading. People with autism may have (or not) reading competences, regardless their communication level, as the study by Nation et al. revealed [21]. The study further reveals different patterns among users and covers a wide spectrum of competences. For example, children with hyperlexia (a syndrome closely related to autism, that manifests an early reading development in the sense of word decoding) were able to read properly, but they did not understand what they read. This is, they were able to decode the words but not to extract the meaning. This issue, reading for meaning, is even difficult to address in ordinary schools.

Opposite to these limitations, people with ASD usually present advanced visual skills [10]. Therefore, they can differentiate images and relate them to their meanings easily. This motivates to introduce new methodologies to teach them read, based on visual information rather than phonetics. This method is known as global reading.

Global reading, as opposed to syllabic methods, begins connecting images with their corresponding written words and how they sound. The second stage includes syllabic decomposition and sounds and, finally, in a third stage of the process, it introduces letters and their phonetics [24]. Figure 1 sketches both reading methodologies as opposite learning flows.

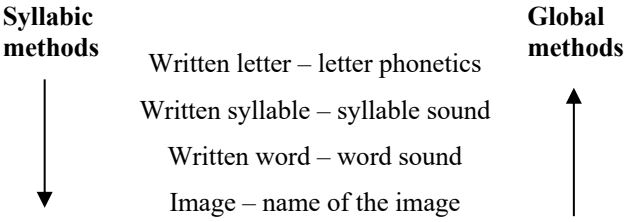


Figure 1: Global vs syllabic reading learning processes. Adapted from [24]

In this paper, we present "Leo con Lula", a novel mobile application to introduce children with ASD to reading and a pilot study involving 9 users, aged 3 to 7 years old. "Leo con Lula" was initially developed for digital interactive blackboards but, due to the ubiquity and multimedia capabilities that mobile platforms provide, we now present the tablet version of the system. This new version is also supported by the increasing interest of using mobile devices in the classroom and their application to special education [14,19]. Tablets are becoming very popular among the ASD

community not only because of their interaction and communication capabilities but also because of the motivational effect and engagement they have on students, as previous studies have reported [3,7,22].

This paper is organized as follows: after this introduction, a review of the related work is presented. Then, the system is explained in detail and the pilot study and findings are described. Finally, we conclude and propose future work lines.

RELATED WORK

In the recent years, the interest of researchers and developers in technologies to assist people with ASD has increased. Some of the difficulties these people have in their daily lives can be addressed by technological aids. For example, Hourcade et al. studied the implications of tablet apps for encouraging social interaction in [12] or Feil-Seifer and Mataric' [8], who introduced a robot in social-interaction therapy. Both projects evidenced the suitability of technology to improve people with ASD social skills.

Another wide-researched area is communication. Particularly, as it is one of the limitations many people with ASD have and, due to its imperative necessity for an autonomous and proper life development, many researchers focused on developing and evaluating tools to provide augmented and alternative ways of communication (AAC) [1,16,25]. Nowadays, these aids are usually provided by means of mobile phone or tablet applications, such as AssistiveWare Proloquo2Go [4] and CPA 2 [28], two different AAC apps that allows people with ASD to communicate by means of visual support. This is, they can build messages by sequencing different pictograms, which are easy for them to understand and meaningful. Once the message is build, the user can show it to a caregiver or it can be read aloud, so the communication can be established.

Literature also provide us with some projects closely related to the research goal of this paper. For example, TaBooGa [17] is a hybrid learning application to motivate children to read. It provides a mixed approach, that combines technology and tangible manipulation to promote reading among children. This hybrid approach arises as many children prefer technological rather than traditional paper support for reading. Consequently, a technology-abuse feeling arises among relatives and educators. In total, 22 children from two different schools evaluated the system. The group was composed of weak and strong readers, so authors were able to get a wide vision of the suitability of hybrid systems. Quantitative and qualitative data showed that hybrid reading systems improves the motivation in reading, particularly for readers with more difficulties.

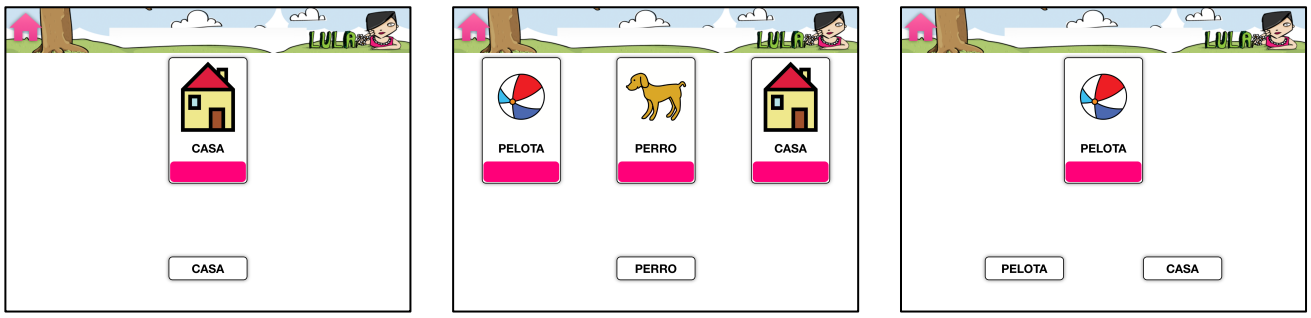
Grindle et al. [11] studied the suitability of an specific software for early reading access (MimioSprout® *Early Reading*, MER) with children with autism. In their study, 4 children (aged 4 to 7 years old) participated in 80 online sessions that took place during the academic year. From the data collected and consequent analysis, authors found that participants presented an improvement in their word recognition skills after completing the sessions.

Spooner et al. proposed the use of the iPad to teach literacy skills to children with autism [27]. Based on the "Building With Stories" framework [5], they modified the materials' content to assure its validity in their experiment. They also employed iPads equipped with an AAC and embedded text-to-speech software to prompt questions and retrieve answers related to the story. Their results indicated the positive effects of the concurrent use of the iPad with shared stories, on users' performance.

In this sense, alternative developers and companies have focus their attention on the use of tablets (i.e. iPads) as educational tools. Particularly, we can find different applications in markets aimed at teaching in special education. For example, "Special Words" [26] promotes language acquisition (vocabulary and word usage) for visual learners. The application can be used both at home and at schools and can be configured to meet users' needs, such as personalized contents, and their progressive adaptation of the help provided. Another interesting application is "Jugamos todos" ("Everyone plays", in Spanish) [13]. Initially developed to introduce technology to people with Down syndrome, it provides games related to reading skills acquisition that can be easily adapted as a global reading methodology, first working with image – word recognition and then advancing to syllabic decomposition. Its interface has been designed to be attractive for their target group, presenting a cartoon style supported with a virtual pet friend.

Finally, ReadingKidz! [15] is a serious game that introduces early reading to children, with or without disabilities. Its videogame features and interface make it very attractive and stimulating for children, as they can earn rewards (such as stars and complements for their virtual pets) and learn reading in a funny and game-like style. It makes use of global reading, starting from image to word recognition and finishing with spelling at the higher levels.

This overview of the literature provides interesting ideas and concerns about the topic: there is an increasing interest on ICT applied to teaching reading. This is demonstrated by



(a) (b) (c)

Figure 2: Screenshot of Leo con Lula sublevels. (a) corresponds to the "learning" sublevel, (b) to "discrimination" and (c) to "reverse discrimination"

the different approaches we found, both as research projects and commercial products. The particular use of mobile devices (such as tablets) is also increasing. They are even more popular in special education than smartphones. Therefore, future developments should consider it and provide adapted interfaces for larger devices. Continuing with design, Frauenberger and Alcorn [9] discussed the importance of including children with ASD and people with extended knowledge about these users' needs in the design process. In other words, they encourage researchers and developers to follow a participatory design approach.

Regarding global reading, although there are some apps available on the market, they are limited in terms of adaptation capabilities and methodologies. Choosing the appropriate vocabulary to work with, adapting interface elements to meet users' needs and capabilities and providing friendly and clear interfaces are mandatory features of this type of systems.

LEO CON LULA MOBILE APP

"Leo con Lula" is a method of global reading's learning. It follows a specific methodology for people with ASD and aims to provide a visual, personalized and error-free learning experience. Particularly, the methodology is based on the global reading process presented in Figure 1.

Game Methodology

The game is divided into three levels. Each level is also divided into three sublevels and, finally, each sublevel consists on a (configurable) set of exercises. Additionally, the vocabulary is divided into groups of three words, so only a reduced number of words is trained at a time.

In the first level, users have to connect a word with the corresponding image. As an additional aid, the word is also written under the image. Besides, the application can be configured to remove this aid after the user reaches a certain number of correct answers. This number can be configured by the educator for each user. This way, the amount of help provided can be reduced as the user advances.

Then, in the second level this aid is removed, so users only have images and the word they have to link. Finally, the third level introduces the syllabic decomposition. This time, users will have to drop each syllable in the appropriate zone (under the image) and the whole word as well.

Each level is divided into sublevels as well. The first one is called "learning" and it introduces the words they have to work with. This is, users are presented one word and one image on each exercise. Then, they can advance to sublevel two, which is called "discrimination". In this case they are presented two or three images (all of them are extracted from the vocabulary) and they have to drag the word into the suitable image. Finally, the third sublevel, "reverse discrimination", is opposite to the second: they are presented only one image and two or three words, and they have to choose the appropriate one. In Figure 2 three screenshots are shown, each one corresponding to one sublevel.

The game relies on a learning without error experience. To do that, the user has to finish all the exercises of one sublevel to move to the next one. Moreover, to unlock level 2, the user has to pass correctly four groups of words of level 1.

In order to provide a personalized learning process, the vocabulary and related images are accurately selected by educators to fit user's interests. This way, we want to promote users' engagement and motivation. In the case of images, "Leo con Lula" uses pictograms retrieved from ARASAAC, the Aragonese Portal of Augmentative and Alternative Communication [23]. This is a pictogram database created by the Government of Aragon (Spain), and distributed under the Creative Commons License. ARASAAC contents are extensively used in special education in Europe. Additionally, educators can also upload any other image they consider relevant for a particular user.

Design and development

In developing Leo con Lula, the main objective is to offer students a tool based on a methodological approach specific in ASD, that they can use as they learn to read. This tool is

based on visual supports, centers of interest, learning without error, gradual decrease of help level and promotion of autonomy.

Therefore, this mobile version of "Leo con Lula" arises as a serious game that provides a personalized and engaging experience. The user is presented with picture(s) and word(s) extracted from the vocabulary the educator chose for her, and she had to connect the word with the corresponding picture. To do that, a drag-and-drop movement is required. This way, not only we work on reading capabilities but also on other motor skills, such as fine eye-hand coordination. As it was reported in [6], this skill is usually inefficient in this population and therefore, providing additional training by means of a game could improve them as well.

The design process was based on a participatory approach, in which educators and experts in special education collaborate with technologists and computer scientists. According to Frauenberger et al. classification [9], it can be considered as a participation via proxy design, as we did not include final users (children with ASD) in the process.

The interface design was based on the digital blackboard version and adapted to match tablet interaction. This is, a more limited screen size, finger-oriented interaction and used by one user individually.

On the other hand, although it was conceived as a game, we wanted to remind the user that it is an educational but joyful tool, so the ornaments are related to some school elements, such as a blackboard. However, during the game we removed almost all the decorations, as we wanted the users to focus on the activity. Therefore, we only keep a top banner with some images and a progress bar.

Regarding the development, it was implemented for mobile platforms (Android and iOS), so the ubiquitous access is granted. Thus, learning and practicing is not limited to school, as students can do it at home on their own devices. Moreover, as the application records all the session events, it is possible for the user to work by her own, as educators can supervise and evaluate her performance afterwards.

Adaptation and personalization

Providing personalized content and interfaces to users' needs is a must in special education. Therefore, "Leo con Lula" provides several mechanisms to adapt the content, the interface and the amount of help to users' needs. This personalization can be done by means of the configuration screen, and it is unique for each player:

- Vocabulary: as it was said before, images and words have to be chosen carefully to meet users' interests.
- Fonts: there are different tendencies in special education that affects directly to fonts and typography. Therefore, educators can choose between 4 font types, including one specifically designed to help children with dyslexia (Helvetica, SaraKanda, chalkboard and scholar). In this same sense, the educator can choose whether words are written capital or lower letters.
- Multichannel: the system can be configured to read aloud the word, so the information is provided by visual and audio channels. In relation to reading, this provides a step forward so users not only decode the written word but also its sound.
- Feedback: right or wrong answer audio feedback can be configured independently. This way positive reinforcement can be promoted, or errors can be highlighted.
- Visual aids: if a user commits an error repeatedly during an exercise, the system can provide her with additional aids. If the user fails once, the only feedback is the word moving back to its original position and the screen flashes in grey. Then, if she commits another error, the other images or words in the screen fade out. Finally, if she keeps on committing errors, the right answer is highlighted in light yellow.
- Number of exercises: each sublevel consists of a set of exercises. This amount can be adjusted for users who need more/less repetition.
- Word support: this value specifies the number of right answers (for each word) the user needs before the extra word (the one appearing under the image) is hidden.
- Statistics: this specific section provides educators a view of the user's performance. It can be delivered as a calendar view with the sessions, or a table view in which each word can be analyze in terms or right/wrong answers on each level/sublevel.

Although the personalization is carried out by the educator, "Leo con Lula" includes a semi-automatic adaptation mechanism. Once the user reaches the number of right answers configured by the educator for a certain word, the text presented under the picture is removed in all levels. Therefore, the amount of help provided is reduced according to her progress.

Tangible interaction

In order to provide a joyful experience, a tangible interaction-enabled level has been included. It is based on QR codes so physical objects can be tagged with them (e.g. a mug or a toy) and recognized by the camera. This special level is also divided in two sublevels, but in this case the first one corresponds to tagged objects or images, this is, a word is shown on the screen (with a preview of the camera) so the user has to point at the QR Code of the corresponding object/image. The second sublevel is the opposite. An image is shown on the screen, so the user has to scan the tagged word. This introduces a new interaction

paradigm and, therefore, new opportunities for educators to create activities and introduce technology in their classes.

PILOT STUDY

In order to improve and refine the application, we carried out a pilot study, in which 9 children with ASD used iPads equipped with "Leo con Lula" during a week. Due to the limited time of the study, we did not focus on reading skill acquisition, as it is a process that takes longer.

Methods and materials

First of all, we asked coordinators of three different special schools to recruit children among their communities. To meet the inclusion criteria, children had to:

- Be diagnosed with ASD
- Be under ten years old
- Had low or no reading capabilities
- No visual nor motor severe disabilities
- Be authorized to participate in the pilot by their parents or legal tutors.

We finally recruited 9 children, 7 males and 2 females, aged 3 to 8 years old.

After recruiting the children, the pilot began with an evaluation of children's reading capabilities. In general, ordinary questionnaires and standardize trials to evaluate reading skills are not suitable for children with ASD. Therefore, teachers were asked a questionnaire to gather their thoughts and qualitative valuation of their participants.

Once we gathered all the information and profiled the participants, we asked teachers to configure one iPad per child with personalized content (vocabulary) and configuration. They were asked to choose 18 words and their correspondent pictures that could be interesting for the user. This way, they had enough words to play the full game, due to the need of having correctly worked with at least 4 groups of 3 to jump to level 2. Some of the most common were relatives names, snacks (cookies, chocolate, candy) and animals.

Although the application can be used by different players on the same device, each user had her own iPad in order to prevent cross-accesses.

Finally, we agreed with the teachers to use the application once a day during a week in their class time. In Figure 3 a photograph of one of the participants using the tablet is provided. As can be seen, the setup motivates the users to use their hands and limit the available space to keep focus on the task and adopt a proper position.

The session time was not limited, as each student has her own needs and the learning process may be different from one child to another. However, participants were asked to play at least one whole level a day. This is, play the "learning", "discrimination" and "reversed discrimination" sublevels with the assigned group of three words. This way, we ensured that they followed all the steps related to global reading learning and checked users' engagement in time.

This way of working, self-paced and aimed at finishing the task rather than time limited is very common in special education. Particularly, it is very common in the early stages of education.

At the end of the week the teachers were asked a short questionnaire to gather their feelings and experiences about the pilot.

Figure 3: one of the participants using "Leo con Lula" in a class setting. The hands on the sides limit the space to put the tablet, so they have to focus on the task and adopt a proper position.

Users profiling

Participants were 3 to 8 years old. Regarding their reading capabilities half of them (5 out of 10) were able to recognize well-known logotypes, 3 of them were able to identify some familiar words (i.e. their names), and only one was reported to be capable to recognize and identify a small group of words (typically, between 10 and 30). Related to reading skills, their teachers reported that 6 of them did not have any oral communication skills and, the other three children, had a very limited capability. Finally, regarding their familiarity with technology, all of them had some previous experience using tablets, either for leisure (games, videos, music) and curricular tasks in the classroom, such as sorting games, puzzles and sounds.

Results

The pilot provided us with some interesting insights about "Leo con Lula" adoption and suitability. First, almost all the participants were motivated during all the sessions. However, there were two cases where teachers reported some frustration. Due to an (already solved) issue, the application crashed and finished suddenly. Although they were two isolated cases and did not affect the rest of the sessions, it is important to remark the high negative impact that software problems provoke in this population. Therefore, intensive and end-user testing have to be included in the development process to avoid frustrating experiences and possible abandonment.

Regarding interaction features, most of them understood quickly the general functioning of the application. Moreover, the drag and drop gesture seemed to be very natural for them. Although they interacted properly with the elements of the interface, teachers reported that three of them dropped the word randomly all the time and needed teacher's support to focus on the task and link the word and the image correctly. Finally, one teacher reported that one participant was more aware of the progress bar rather than the feedback given during the session. This is, instead of focusing her attention on dropping the word and the feedback provided by the application, she looked at the bar to know if it advanced or not. This issue suggests that even the minimal distraction can affect user's performance. Therefore, we are planning to enable a configuration option to hide this bar if necessary.

Despite of the limited information collected, in terms of time and users variability, results suggest that "Leo con Lula" could be included in a special education class context, as a material to introduce reading skills to children with ASD. Its preliminary contribution relays on the motivation that the game provoke on users and the method to teach reading which adapts better to people with ASD needs.

CONCLUSIONS AND FUTURE WORK

In this paper we have presented a mobile application to introduce children with ASD to reading. It was based on a previous development for digital blackboards but, due to the increasing capabilities and popularity of mobile platforms, and the suitability that these devices have demonstrated in other research projects, we have developed and evolution of "Leo con Lula". It is based on global reading methodologies, visual and error-free learning and autonomous work. To do that, several configuration options have been included as well as tools to support later analysis by educators.

The preliminary results obtained in the pilot study motivate us to improve the current version of the application and prepare a wider evaluation of the system to evaluate the impact of the application on users' reading skills.

ACKNOWLEDGEMENTS

The authors want to acknowledge Guadalupe Montero, Laura Muñino and Rubén Velasco for their contributions, ideas and work during the design and development process. This work was carried out during the tenure of an ERCIM 'Alain Bensoussan' Fellowship Programme and was partially funded by project "eMadrid-CM: Investigación y Desarrollo de Tecnologías Educativas en la Comunidad de Madrid" (S2013/ICE-2715).

SELECTION AND PARTICIPATION OF CHILDREN

The research presented in this paper included the participation of children in the pilot study. The recruitment process was based on direct contact with three special education schools and according to the criteria presented in this document. In order to participate, parents and legal tutors were asked for their consent. During the pilot study, children were asked to use the application developed during a week, as part of their class assessments.

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