DayByDay: Interactive and Customizable Use of Mobile Technology in the Cognitive Development Process of Children with Autistic Spectrum Disorder

Vanessa Tavares de Oliveira Barros, Cristiane Affonso de Almeida Zerbetto, Kátia Tavares Meserlian, Rodolfo Barros, Murilo Crivellari Camargo, and Táthia Cristina Passos de Carvalho

Universidade Estadual de Londrina, Londrina, Brazil
{vanessa,cra,rodolfo}@uel.br, katia.meserlian@hotmail.com, {murilocrivellaric,tathiacarvalho}@gmail.com

Abstract. Autistic Spectrum Disorder (ASD) was firstly described as a disturbance of affective contact, including language deficiency, social interaction limitation, and repetitive/restrictive behaviors. ASD individuals are to be motivated and encouraged to seek for independence and cognitive development, in order to overcome the restrictions imposed by the disturbance. This paper presents the development of an application aimed specifically at helping ASD children aged 8-12 years improve, by establishing a sequential and highly-customizable routine. Developed with the help of professionals that work with autistic children and their caregivers, the application proves to be a support tool for the ASD individuals' reality.

Keywords: Autistic Spectrum Disorder (ASD), Assistive Technology (AT), Accessibility.

1 Introduction

Technology has been used in several health fields to assist illnesses treatment, to improve medical assistance quality and as a tool that comes in aid of people with different kinds of impairment. In this context, this research took into consideration the difficulties faced by children with Autistic Spectrum Disorder (ASD) in order to try to ease or supplement their needs. Although each child faces unique difficulties and potential, some problems are common to the vast majority of them, namely: difficulty or disinterest in socializing, problems in significant language usage, repetitive movements and behaviors, among others. To do so, it was defined to create an application, since smartphones and tablets have becoming increasingly affordable.

An application was opted also because of its high degree of customization, in order to develop a system with functions and interactions designed to reach every user as a unique individual. Furthermore, mobile devices support touchscreen technology, which allows direct contact from the user, providing more precision and motor control during interaction. Therefore, especially for ASD individuals, direct control provides

C. Stephanidis and M. Antona (Eds.): UAHCI/HCII 2014, Part II, LNCS 8514, pp. 443–453, 2014.

the application to be better controllable and more interesting, in addition to increase their learning capacities, instead of a desktop, for example, which would require intermediaries (the mouse and the keyboard, in this case).

Thus, a research was conducted on how to conceive an application designed to reach each subject as a unique individual, with the purpose that this application would draw ASD children's attention.

2 Theoretical Background

Austrian psychiatrist Leo Kanner wrote the pioneer publication on autism in 1943, which he initially called "autistic disturbances of affective contact". After conducting a research, Kanner concluded that the autism comes from an innate incapacity of establishing usual and biological affective contact with people, given, however, the proper importance of environmental aspects in development [Bagarollo & Panhoca, 2010, Mattos & Nuerberg, 2011].

Nevertheless, autism early concept has been altered based on scientific research, which verified different etiologies, degrees of severity and specific or non-usual features, as it appears on the International Classification of Diseases Revision 10 (ICD-10), including autism in Global Developmental Disorder. Well known as ICD F84, this Code on autistic disorder settles diagnosis criteria to identify autism, such as: qualitative loss in social interaction; qualitative loss in oral and non-oral communication, imaginative play; and repetitive/restrictive behaviors and interests.

Since May 2013, there has been a new edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) discoursing on communication and social deficits. An individual is diagnosed with Autistic Spectrum Disorder (ASD) if he holds the three following deficits: alternative emotional or social interaction problems; serious problems in maintaining relationships; and non-oral communication problems. Besides, he must hold at least two repetitive/restrictive behaviors, such as: utter addiction to patterns and routine, and consequent resistance to routine changing; repetitive speech or movements; intense and restrictive interest; and difficulty in integrating sensory information or a strong need to avoid behavioral sensory stimuli.

Furthermore, Schwartzman [2003] adds that this addiction to the routine may cause a catastrophic crisis, resulting even in aggression, simply by changing the itinerary back home, or attempting to change clothes, or placing an object out of its usual field of sight.

2.1 Cognitive Development of ASD Children

This work relates some approaches of ASD study, such as: theory of mind; neuropsychological theory; information processing.

Theory of Mind. The theory of mind, according to Cohen, Leslie and Frith [1985], refers to the ability of inferring what other people think, in relation to their beliefs, wishes and intentions, aiming to explain or predict their behavior.

Neuropsychological Theory: Executive Function. The Executive Function, according to Fuster [2002], is understood as a group of functions responsible for the initiation and development of an activity, with a settled final objective. This is also known as the frontal lobes function, since it appears to be metacognitive rather than merely cognitive. It does not refer to any specific mental ability, but instead embraces all of them. It is important to mention, also, the prefrontal cortex, responsible for the evaluation of success or failure of actions directed to previously set objectives.

Information Processing: Central Coherence. The Central Coherence, according to Hill and Frith [2003], refers to information processing style, specifically the proclivity of processing information inside its context.

However, ASD individuals experience the absence of natural inclination for joining chunks of information to form a total provided with meaning, expressing a poor performance in tasks that demand an unabridged and global acknowledgement of context. In fact, this opposes the idea of a superior performance, which requires attention to sectional information [Bosa & Callias, 2000]. The interesting part of this theory is that ASD individuals' abilities are valued, rather than analyzing only their deficits.

2.2 Digital Universe for Accessibility: Assistive Technology

Assistive Technology (AT) can be defined as every resource and/or service that is able to truly offer functional abilities to impaired people and, consequently, provide higher and better quality of life to these individuals. Accordingly to the Comitê de Ajudas Técnicas (CAT), which is a Brazilian committee to help promote the rights of people with disabilities, the main goal of AT can be described as promoting functionality (activity, interaction) to disabled people, to people with restricted mobility, or elderly people, aiming at their autonomy, independence, quality of life and social inclusion growth, through products, resources, strategies, practices, processes, methods, and services, including the principles of Universal Design and Social Technology [CAT, 2007.a]. CAT approved by unanimity, in December 2007, VII Reunion, the adoption of the following formulation for the concept: Assistive technology is a field of knowledge, of interdisciplinary disposition, that encompasses products, resources, methodologies, strategies, practices, and services aiming at promoting functionality, related to activity and participation of people with disabilities, incapacities or restricted mobility, in order to improve their autonomy, independence, quality of life and social inclusion [CAT, 2007.c].

Regarding the organization or classification of Assistive Technology resources, it occurs according to the functional objectives they are aimed at. The following classification has a didactic purpose, and was proposed by Bersch [2008]. It lists eleven AT areas, based on other classifications, especially on the Assistive Technology Applications Certification Program (ATACP), provided by the College of Extended Learning and Center on Disabilities, from California State University of Northridge: (1) Daily life and practical life aid; (2) Augmentative and Alternative Communication (AAC);

(3) accessibility resources on the computer; (4) environmental control systems; (5) architectural projects for accessibility; (6) orthotics and prosthetics; (7) postural adequacy; (8) mobility aid; (9) support for blind or vision impaired individuals; (10) support for deaf or auditory impaired individuals; (11) vehicles adaptations. Finally, it is noteworthy to mention that this research takes into consideration the accessibility resources on the computer.

3 Methodological Procedures

In order to reach further understanding on the universe of ASD children and technological devices, an analysis was conducted over four similar applications. All of the applications analyzed have the intention to help children with some kind of impairment. The result of this analysis showed that the vast majority of the applications available are not aimed at children with behavioral disturbances and, if they are, they still show graphically or interactively inadequacy.

The first similar analyzed was PROLOQUO2GO, an application developed for people with speech impairment, in other words, it was not developed exclusively for ASD individuals, but for anyone with language disturbances. Its function is to teach the user to build up statements through symbols and pictures. It utilizes text-to-speech technology (text to voice conversion), words prediction and customizable vocabulary. The interface itself keeps unaltered, while the functions can be customized. Illustrations are rather simplified and iconic.

The second similar, FIRST THEN VISUAL SCHEDULE HD (FTVS-HD), aims to assist subjects in need of a clear routine, therefore it comprises disturbances such as dyslexia, autism and attention deficit. This application holds an interface similar to a blackboard that allows the conception of a customized schedule based on pictograms and on the tasks' timetable to help users mark the completed tasks. Pictograms can be replaced with photos, videos and/or sounds.

AUSTISMATE was the third application analyzed. It combines functionality of various applications and was developed specifically for ASD individuals, aiming to embrace the entire spectrum. Parents can set dynamic scenes, like the kitchen of the house, in which the child is able to touch the image of a tap and watch a video of how to wash the hands correctly. The application focuses especially on photographs and videos to help the user fulfill daily tasks, although the highly pictorial interface proves to be complex and, furthermore, there is no evident linearity in the tasks description. These textual descriptions, moreover, are extensive and can be meaningless for ASD individuals. The application also incorporates extra functions to create a visual schedule and a section for statements building.

The fourth and last similar analyzed was MY PAL, also developed specifically for ASD individuals that resorts on Aesop fables jointly with sounds and smooth-colored illustrations to teach children at home or in school. The objective is to teach them basic concepts, such as help identify emotions and teach social interaction behaviors. Through a fable, and a friendly and interactive interface so that the child finds it funny, the application works like a game, in which every completed task is rewarded

with an accessory for the character. Photographs and videos are not included in this application and its image and sound library is preset and limited, becoming impossible to add new files.

Finally, a table was generated to synthesize the main features and functions of the applications analyzed. Table 1 joins information on the applications analyzed and the new application: on the one hand, it shows the features provided by the applications mentioned above, and on the other hand, it summarizes the features to be expected from the new one.

After that, it was carried out talks with two professionals (from the psychology and education fields) that work directly with ASD children. Such interviews helped delimitate the range of target audience the application intended to reach, as well as other important features.

In a talk carried with a psychologist, it was found the ASD children's reality is rather particular and individualized, so the idea of developing an application to support a wide range of common needs to ASD individuals was put away, once it certainly would require a very complex system to be developed and programmed, as well as the possibility of error and inefficiency of the application be much greater. The professional also reported that many institutions make use of technology while working with ASD children, but the majority of tested softwares and applications is not specifically developed for them. Indeed, they are developed, commonly, for a specific problem, such as speech disabilities, which is common not only for ASD individuals, but also to other types of impairment.

Table 1. Similar applications' features/functions

Feature/function	Does the application have the feature/function?				
	Proloquo2go	FTVS-HD	Autismate	My Pal	DayByDay
Graphic interface aimed at ASD	No	No	Yes	Yes	Yes
Parental control	No	No	Yes	Yes	Yes
Customizable interface	Yes	Yes	Yes	No	Yes
Sound support	Yes	Yes	No	Yes	Yes
Stimulus through rewards	No	No	No	Yes	Yes
Sharing network	No	No	No	No	Yes

Another talk, with a pedagogue, shed light on the most common problems in the routine between ASD children and parents/educators and, starting from this point, the approach of the research began in seeking a way to help establish a pleasurable routine for the children and that could be customizable by their parents. The professional also reported it would be extremely important that the application was not restricted to technological reality, but that its activities and outcomes provided real interaction among the participants.

Having those topics in mind, the application was conceived and given the name DAYBYDAY, aimed exclusively at ASD children aged 8 to 12 years as a tool to establish a routine and the tasks they perform. The application main goal is to organize scheduled and sequenced routine, through creation and management of tasks in day shifts.

Regarding the application development, DAYBYDAY was conceived to assist both ASD individuals and parents/educators. Although giving autonomy to ASD individuals is important to help improve their self-reliance, supervision is still required, especially in performing tasks that demand abilities not fully mastered by them. Thus, the application offers two particular kinds of profile, selected while running the application for the first time: the ASD individual profile and the parent/educator profile.

By choosing the ASD individual profile, the user will be given access, basically, to the tasks platform. Such tasks are neither standardized nor preconceived or, to clarify, they can be created and customized accordingly to ASD individuals' particular needs. Assuming that ASD individuals often face difficulties with fixed routines, it is possible to generate tasks such as "have breakfast", "brush the teeth", "take a shower" and "change clothes". But, if the child is unable to have his meals by his own, for example, the task "have breakfast" can be customized and divided in several chunks of a task, such as "fix the sandwich" and "have coffee milk" so that the application proves to be as much relevant as possible for that individual reality.

Tasks are displayed in chronological order and divided in day shifts. Completed tasks display an icon to mark them, while posterior tasks display a padlock icon to indicate they are "locked". Just the current task keeps active and "unlocked". This mechanism prevents the child from, for example, accessing the task "change clothes" before completing the task "have a shower", providing a logical sequence that helps ASD individuals follow the routine. Enriching the idea of day sequence, screen background alters its colors and elements to indicate the day shifts: morning, afternoon and evening. In the morning, there are clouds and the blue color indicates the shift, whilst in the afternoon the blue is replaced with orange; in the evening, stars replace the clouds (Figure 1). Every single color or element was applied to suit the target age selected, and in order to be enticing for ASD children.

By accessing a specific task, the user is taken to a step-by-step screen, pictorially represented, to complete the task. For example, accessing the task "change clothes" will lead to a screen where the child sees pieces of clothes arranged in the righteous order they must be put on (underwear, t-shirt, pants, socks and shoes) to complete the task. By completing the task, the child receives a motivational message from his parent/educator, leading to the understanding of reaching success and therefore being encouraged to complete more tasks. Successfully completed tasks will accumulate points that appear as stars. When the child collects five stars, he can choose a reward.

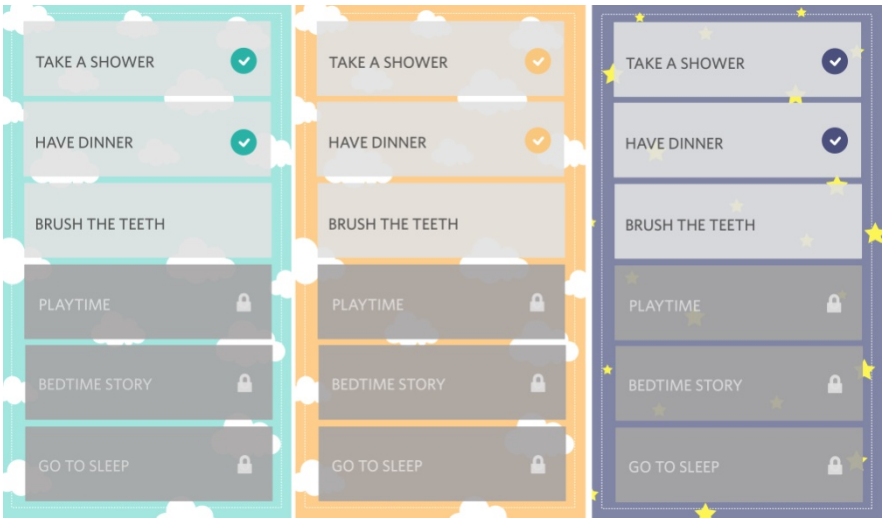

Fig. 1. Tasks' list screen, in three day shifts: morning, afternoon and evening. Note that the original version of DAYBYDAY is in Portuguese.

Such rewards are determined by the caregiver, and must be customized to meet the child's particular interests. After choosing a reward, another message from the parent/educator shows up, setting when it will be handed in. For example, if the child chose a park stroll as reward, parents/educators can set it will take place on the weekend. The rewarding system was developed so that the child could be motivated and encouraged to complete more tasks, and consequently improving his cognitive development. This action is the last of ASD individuals profile cycle so that, from this point, the application returns to the tasks' list screen. The system's linearity simplifies the path to be followed and decreases error possibility.

But by choosing the parent/educator profile, the platform will be completely different. This profile grants access to the control and the creation of tasks and rewards, and also to the system customization settings. In the first screen, there is a calendar giving access to the tasks scheduled for each day, divided in day shifts. Parents/educators can easily verify the programmed tasks for each day, make changes and include new tasks to be completed (Figure 2). It also gives the possibility to observe, in real time, ASD individuals performance, as well as which tasks have been completed.

Accessing the option "add new task" will grant the parent/educator the possibility to create specific tasks according to the ASD individual reality. Settings include adding a name for the new task and a short description, besides pictures and/or sounds. Pictures or photos inclusion leads to the emergence of a familiarity bond to facilitate ASD individuals' performance. For example, by including on the task "change clothes" photos of the child's own clothes, the parent/educator allows the child to recognize the pieces, preventing the ASD child from having to decide which pieces of clothing to wear, since this decision-making might not be simple for him. Similarly, by recording sounds describing the tasks, the speech impaired ASD child will not

have problems with the step-by-step, and recognizing a familiar voice will make him more comfortable and self-confident.

Fig. 2. Parent/educator first screen (to the left) and tasks control screen (to the right). Note that the original version of DAYBYDAY is in Portuguese.

A similar system was applied for the rewards, which can be customized like the tasks. Besides, it is possible to create a picture/sound library, and store the tasks and rewards created to insert them at will, according to the child's needs and schedule. The possibility of customization at high-level provides a safe and useful environment, since the interface enables the user to determinate more relevant aspects for the ASD child.

Furthermore, it is the parent/educator's responsibility to write the motivational messages that will be sent to the child after completing a task or choosing a reward. Thus, the communication between them flows more naturally and veridically, considering that the parent/educator knows exactly what to say to the child. Finally, the parent/educator receives relevant notifications in his own mobile, for example whether the child completed or not a task, which grants him utter control over the ASD individual's development.

In order to integrate and share ideas and experiences, a site for the application was also developed. In the site, information on the application is available, so that any non-registered person could gather more data about it. On the other hand, for DAYBYDAY users there are more possibilities. The site was conceived to work as a large repository of integrated ideas and experiences available for the users. After creating a new task or reward, the parent/educator can upload it to the site, and add tags to it. While exploring the site, other users can find the uploaded task or reward,

through the search system, and download it, whether to have ideas or even to use the ready resource with his own child.

The same applies to pictures, which remain available in the site for the users to download it. Submitted material is subjected to analysis and would pass the sieve of a team of specialists before being incorporated to the site library. This settles an indirect network of communication that keeps in track with ASD individuals' needs, filled with good ideas and experiences to be shared with other parents/educators. Finally, there is a "specialists' recommended activities" section, in which psychologists, doctors, pedagogues, and other professionals provide ideas of games and activities to stimulate ASD child's cognitive development, and to be used as rewards. By doing that, the child can be rewarded with an activity from which he can benefit motor and cognitively.

After the conception and development of DAYBYDAY application, the following step comprised its consistency verification, through a qualitative research using the deductive method. Also, it was carried out the application of a questionnaire with open questions related to the topics mentioned hitherto. The research was conducted with the support from AMA (Associação de Amigos do Autista), an autism-friendly association in the city of Londrina. Seven ASD individuals' caregivers participated in a session of DAYBYDAY presentation at Universidade Estadual de Londrina, and afterwards, responded to the questionnaire.

3.1 Results

The first question asked the caregivers if they think the application would be able to help the ASD child complete daily tasks, and why. The responses obtained were: Yes, to help the routine; Yes, it helps the routine; Yes, it improves the routine; Maybe, my son is hyperactive, so I think it will be a little hard for him to concentrate and benefit from it; Yes, in planning and organizing the routine and to contextualize situations.

In the second question, it was asked if they would include any topic/feature to facilitate the daily tasks with child. The responses were: Yes, something about food. Something that motivates him to eat other kinds of food; Do not know the application completely; I need to know more about the application first; I don't think so, as the child gets accustomed to the program, it gets easier for him; I believe it will improve his autonomy, according to my son's individual potential.

The third question encouraged them to cite more activities they perform which are not on the application. The caregivers answered: Swimming; I don't know; Comb the hair; Specify the game at playtime. In question four, it was asked whether the caregivers would make use of the application or not, as they responded: Yes; Not yet, I need to get to know the application better; Yes; Yes, I believe everything is worth doing to help the child development; Yes.

The fifth question found out if the caregivers enjoyed the graphic interface and why. Obtained responses were: Yes; It is really beautiful; No, it needs more color, although the use of soft colors was explained; I liked it, I think it is simple; Yes, it appears to be relevant for the autistic children. The sixth question asked if DAYBYDAY graphic interface would possibly draw ASD children's attention, and the responses were: I think it can be more colorful and have pleasurable noises; Yes;

Yes; I have to show it for my son to know, because there are some things I think he won't like, but he does; Yes.

Finally, in question seven, it was asked if the caregiver found the application easy to use and why. It was obtained the following responses: Yes, my son even has a tablet; Yes, for the parents; It is easy for the parents, but we have to see if it will work with the kids; Yes; Yes, I caught a glimpse of this application in the daily routine of my son. Since this research was addressed to the caregivers view in relation to DAYBYDAY, it can be concluded that the application satisfactorily met this sampling, in the view of the fact that they were receptive to use it in their children's routine.

4 Conclusion

This work intended to develop an application of interdisciplinary disposition in order to reach a satisfactory result and to ensure its efficiency. The integration of several fields, such as design, psychology, pedagogy and data processing proved to be essential in the preliminary stage of development, which was supported by a theoretical background. The conducted study had the intention to show all of the evolution stages of a product designed to outdo expectations in terms of market and social contribution.

Testing stage, conducted with the caregivers, was also crucial to confirm the application strengths, given the positive feedback in relation to its efficiency. The application of the questionnaire was also important to expose possible flaws as well as improvements to be done both on the interface and on its features, from the viewpoint of those who truly face ASD difficulties. Future stages include improving the final product through usability tests conducted with ASD children to gather further data on whether they adapt to it or not. Finally, it will include the participation of neuropediatricians in order to reach a clinical understanding on the positive effects of the application for the ASD children.

References

1. Abbas, P.: Material de apoio para o curso de coolhunting e pesquisa de tendências. Animatrends, Curitiba (2013)
2. Brasil. Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Ações Programáticas Estratégicas. Diretrizes de Atenção à Reabilitação da Pessoa com Transtornos do Espectro do Autismo. Ministério da Saúde, Brasília (2013)
3. Bagarollo, M.F., Panhoca, I.: A constituição da subjetividade de adolescentes autistas: um olhar para as histórias de vida. Revista Brasileira de Educação Especial 16(2), 231–250 (2010)
4. Bosa, C., Callias, M.: Autismo: breve revisão de diferentes abordagens. Psicologia: Reflexão e Crítica, Porto Alegre vol.13(1) (2000)
5. Baron-cohen, S., Lesliel, A.M., Frith, U.: Does the autistic child have a 'theory of mind'. In: Cognition, pp. 37–46 (1985)

6. Comitê de Ajudas Técnicas, Ata da Reunião III, de abril de 2007, Comitê de Ajudas Técnicas, Secretaria Especial dos Direitos Humanos da Presidência da República, CORDE/SEDH/PR (2007a), http://www.mj.gov.br/corde/arquivos/doc/Ata%20III%2019%20e%2020%20abril2007.doc
7. Comitê de Ajudas Técnicas, Ata da Reunião VII, de dezembro de 2007, Comitê de Ajudas Técnicas, Secretaria Especial dos Direitos Humanos da Presidência da República (CORDE/SEDH/PR) (2007c), http://www.mj.gov.br/corde/arquivos/doc/Ata_VII_Reunião_do_Comite_de_Ajudas_Técnicas.doc
8. Fuster, J.M.: Frontal lobe and cognitive development. J. Neurocytol. 31(3-5), 373–385 (2002)
9. Goldberg, E.O.: cérebro executivo: lobos frontais e a mente civilizada. Imago, Rio de Janeiro (2002)
10. Hill, E.L., Frith, U.: Understanding autism: insights from mind and brain. Philosophical Transactions of the Royal Society Series B: Biological Sciences 358(1430), 281–289 (2003)
11. Kanner, L.: Autistic disturbances of affective contact. Nervous Child 2, 217–250 (1943)
12. Mattos, L.K., Nuenberg, A.H.: Reflexões sobre a inclusão escolar de uma criança com diagnóstico de autismo na educação infantil. Revista de Educação Especial, Santa Maria 24(39), 129–142 (2011)
13. Schwartzman, J.S.: Autismo Infantil. Editora Memon, São Paulo (2003)