An Alternative Design Perspective for Technology Supporting Youngsters with Autism

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Abstract. People with autism present several disabilities in communication, social interaction and behavioral fields. There is a wide variation among these individuals and it is essential to develop therapies and materials customized for them. There are many design approaches in Human-Computer Interaction, but most of them present some limitations for designing to this audience. We conducted a study using paper prototyping with children with autism in order to contribute to the design of software for them. In this paper, we report some limitations in using this technique and the need for customizing applications for the individual who will use them. Reflecting on these needs and analyzing approaches to interface design, we present and discuss a proposal for a design methodology that combines Meta-design and Semiotic Engineering.

Keywords: Autism, Prototyping, Semiotic Engineering, Meta-design.

1 Introduction

Autism is a complex syndrome present all over the world and in the most diverse ethnic, racial, and socioeconomic groups. There is a wide variation in the level of deficiency from person to person, and so autism is described as Autistic Spectrum Disorder's (ASD) [18]. According to the diagnosis, it is essential to adopt individualized approaches in order to reduce their difficulties. Among these approaches, the technology use is a possibility of aid in the intervention and different technologies have been used for this purpose (Millen, Edlin-White, Cobb, 2010). Studies using technologies with people with autism show the importance of such artifacts to aid the therapy process. However, many of these artifacts do not consider the individual characteristics of these people and the possibility of customization, and thus it may limit its use [2].

There are different design approaches in Human-Computer Interaction, however, most of them present limitations to the interfaces design for people with autism. This is primarily due to the great variation of behaviors and needs among these individuals.

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We performed – through specialized therapists – a study with children with ASD using the paper prototyping technique [16], which highlighted the need to customize the application, in line to what previous studies have indicated. Furthermore, we identified the need to make changes in real time. From a literature review, we identified Meta-design [6] as a promising approach to the design of applications for this audience, since it is an evolutionary theory that provides the possibility to put the users in charge of the system and to make them co-designers at use time.

In this paper, we discuss an alternative design perspective for this audience that converges the Meta-design concepts with concepts of Semiotics Engineering [4], an HCI theory that emphasizes aspects of computer-mediated human communication.

This paper is structured in six sections. In the next section, we briefly characterize the Autistic Spectrum Disorders and present technologies designed for people with ASD. In the third section, we describe some existing design approaches in HCI. In section four, we report a study using paper prototyping with people with autism. In section five, we present and discuss the proposed design methodology that combines the theories of Meta-Design and Semiotics Engineering. Finally, in the last section we present our conclusions.

2 Autistic Spectrum Disorder (ASD) and the Use of Technology

People with autism have difficulties in social interaction, language development and behavioral repertoire, which consist mainly of repetitive and stereotyped activities. In addition, these individuals may have poor or no imagination, failure to use gestures, no use of language for the purpose of social communication, echolalia, and others [18].

The use of technology in this field has proven to be a potential tool to support the process of therapy for this audience. Technology enables the presentation of activities repeatedly, the simulation of situations that might not be safe or acceptable in the real world, the focus of attention, the use of large amounts of audiovisual resources, and other possibilities and advantages [11,2]. Among the technologies developed and used with this public, we point out robotics, voice communication devices, computer-assisted instruction (CAI), virtual reality, tangible interfaces, among others [2].

Knight and colleagues conducted a literature review of technologies used for teaching academic skills [9]. In this paper, they report a lack of quality work in this area and emphasize the importance of making decisions about the use of technologies based on each individual.

In the context of tangible interfaces, there are many applications to improve collaboration and communication among people with autism, but the huge amount of these applications and the little amount of empirical studies hamper caregivers, therapists and parents to identify useful apps [7]. Some of these applications offer the possibility of customizing certain elements; however, the authors emphasize the need to consider the different characteristics of each individual and having a greater level of customization [15,17].

Through the analysis of studies conducted with this population, we observed the need for customization of these applications, aiming to help each individual according

to his/her characteristics and the context in which he/she is inserted. Moreover, even in the applications that offer some level of customization, evaluators and/or therapists identified the need for changes or interventions according to each user. Such needs are not being deeply considered by most of design approaches, as we present in the following section. We will show, throughout this paper, that these needs are strongly related to the concepts covered in the Meta-Design and Semiotic Engineering theories.

3 Existing Design Approaches

In this section, we describe and discuss some of design approaches in HCI in order to relate them with the design of interfaces for people with autism.

3.1 User-Centered Design

User-centered design describes the design process in which users influence the way that the process is conducted [12]. This approach recognizes the needs and interests of the user and focuses on the usability of the design. The designer plays the role of facilitating the user's task and ensuring that he/she can use the product as intended and with the minimum of effort to learn how to use it.

There are several ways to involve the users in this approach. Some of them analyze users' needs and involves them in specific moments during the design process. In others, users have greater impact on the design when they are involved in the design team throughout the design process, such as Participatory Design, which we describe in the next subsection.

Although this is a fairly common approach, considering the context of people with autism, we have found limitations to using this approach. It is well know that even expending the maximum effort at design time of a computational artifact, changes are always necessary because the understanding of a problem cannot be complete and systems need to evolve to attend new needs [19]. Particularly, people within the autistic spectrum have enormous variation in behavior and needs and, considering that changes are always necessary, the design process needs greater flexibility and an evolutionary aspect.

3.2 Participatory Design

In Participatory Design, system users actively participate in the design team and cooperate with designers in building the artifact at design time. This design approach requires greater organization and management, since it involves a larger number of participants, which should represent a significant amount of users who use the system. [8].

In the context of people with autism, some studies used the Participatory Design approach with this audience [10,1]. In these studies, research participants had high-functioning autism or Asperger Syndrome and they were 10-17 years old at the time

of the study. The authors reported good results with these children, but they stressed that due to the variety of profiles it is not possible to perform the study with any younger person within the autistic spectrum.

We must emphasize that these works involved the participation of people with a lighter level of the autistic spectrum and, even in these cases, there is a great variation in behavior and interaction difficulties. In the case of people with more severe level of the spectrum, the use of this approach becomes much more complex and unsafe, since many of them are nonverbal and have much greater difficulties.

3.3 Meta-Design

Meta-Design enables the creation of open systems that can be changed by system users and evolve in use time. The stakeholders become co-designers not only at design time, but also during the whole existence of the system. Meta-Design has the Seeding, Evolutionary Growth, and Reseeding (SER) Model to support in the understanding of meta-design systems. It is a descriptive and prescriptive model that is based on building seeds that can evolve over time [6].

This approach has been applied in different areas, including the context of people with cognitive disabilities [3,5]. Moreover, it enables the active participation of the user as co-designer and offers a way to design highly adaptable interfaces. Such characteristics make it a promising design approach for people within the autism spectrum and other cases where the technology requires many adaptations.

Based on the approaches described above and on the characteristics of people with autism, we believe that the design process for this audience needs to provide a greater dynamism and the ability to evolve. In order to identify and confirm difficulties already presented in artifact design for these people, we conducted a study with children within the autism spectrum using the paper prototyping technique. This study is reported in the next section.

4 Study Using Paper Protoyping with Children with Autism

We conducted an exploratory study with children with autism in order to verify the need for customizing developed applications and the difficulties in the design process for this audience. For this, we use the Paper Prototyping technique. We chose this technique because it is very common to use paper cards to facilitate communication in interventions with this audience.

The whole phase of the study with the participation of children was performed by two therapists in a clinic specialized in the care for this audience. The research team did not attend the sessions. We asked parental permission to conduct the study and recorded the interaction between the therapist and the child. After each session, the therapists assessed whether we could watch the recording and we talked to them about their perception of the child's interaction. We conducted the study with three four year-old children. Each session lasted 15 to 20 minutes.

Two therapists participated in the study: one was in direct contact with the child and made the necessary interventions during the session, and the other helped to control feedback on the application of paper prototyping. The material represented activities that could compose an application for these children, showing no interface elements.

The activities involved skills such as association, memory, sequences and emotion recognition, identifying objects using different representations, among others. For each activity, therapists could use positive reinforcement feedback, offer help according to the child need, or modify the activity.

We found some limitations in the use of paper prototyping technique. One of them is related to the return time of feedback and exchange of activities. Children demonstrated losing the focus of attention very fast and, in the majority of cases, the time spent to give feedback or make changes detracted their attention. Another issue is related to the abstraction level required with the use of paper. Because these children generally have difficulty to understand abstractions, it did not seem clear that such activity was carried out in a way similar to what would be done on the computer. This could be perceived by the therapist when the end of the tests, she asked that the child perform a similar activity using the tablet. This activity was done more easily.

The application of this technique has brought us some feedback about the elaboration of activities for a tool development, but mainly it confirmed some aspects already related in previous work. One of these aspects is the need for customizing the user interface and the activities according to each individual. Even in some cases where the therapist modified an activity specifically for a child, new adjustments were necessary. Therefore, we identified the need for customization both at design time and at use time.

Based on the literature, the design approaches and the study that we conducted with children with autism spectrum, we started working in an alternative design perspective for this audience, described next.

5 Combining Semiotic Engineering and Meta-Design

After researching the related work, exchanging conversations with therapists who work with children with autism and analyzing the study reported in the previous section, we have identified some needs of this population and the importance of developing more research for the design of technology for them. As reported in previous sections, these people present very different characteristics and behavior variation. Thus, traditional HCI design methods would hardly meet the needs of a broader set of users with this profile.

The works developed in HCI design, including users with special needs, have shown that the Meta-design approach is promising for technologies that require many adaptations. In addition, through the study conducted with children with autism, we have concluded that therapists want to be able to adapt the technology quickly and easily in order to meet the patients in the intervention process. The communication processes involved with the use of technology in therapy (therapist-patient, therapist-technology, and patient-technology) are critical to the success of the intervention.

We therefore propose to adopt meta-design, a highly adaptable design approach, to design technologies for people with autism. Furthermore, we consider that an approach of evolutionary design centered on communication aspects can enhance and maintain in focus aspects related to human communication – computer-mediated or direct – throughout the design process, adaptation and evolution of technology. Therefore, we have outlined an alternative design perspective for this audience that combines Meta-Design and Semiotic Engineering.

Semiotic Engineering is a semiotic theory that views human-computer interaction as a particular case of communication among people mediated by a computer. In this process, the system interface represents the designers view about how, why and what for the users can use the system. Communication breakdowns occur when users cannot interpret, or they interpret in another way, the message sent by the designer [4]. Semiotic Engineering has its own classification of signs based on what they express in a system interface, beyond the categories of signs created by Peirce [13]. They are:

- Static signs: expressing a system state whose meaning can be understood independent of temporal or causal relationships.
- Dynamic signs: These are signs that express the behavior of the system, whose meaning is understood in the course of interaction.
- Metalinguistic signs: they are signs that refer to other signs of the interface, i.e., are signs that inform, explain or illustrate other signs.

In the proposed approach, the meta-designers, who will develop the initial version of the technology, and the therapists, who will act in the role of co-designers, will participate since the beginning of the design process. We will use the seeds and reseeds concepts of Meta-design as well as the categories of signs proposed by the Semiotic Engineering [4]. Fig. 1 shows a schematic of the functioning of this approach.

The concepts adopted by Semiotic Engineering and the proposed categories of signs will gradually guide the building of the first full seed for the therapist's use. The study reported in the previous section served as inspiration for the gradual use of the categories of signs as a way to approach of the interface construction to suit the user needs.

After the initial phase of understanding the problem, the meta-designers create an initial seed for the design process of the technology to be developed using metalinguistic signs. Thus, meta-designers present the proposal of this technology by using signs to communicate what is the technology to be designed, what can be done with it, etc. In this stage, no interface elements are used. After the presentation and the collection of data and opinions of the co-designers (therapists), the meta-designers modify the initial seed in order to meet the requirements listed in the previous step.

In this reseeding process, meta-designers create the new seed by entering static signs at this stage, i.e., they use elements that reference the interface to be developed. As an example, they can design mockups that show the functioning of the design proposal, including what they defined in the previous step.

After discussions and redefinitions in the previous step, the meta-designers design a new seed by adding dynamic signs. At this point, they already develop a prototype of technology for presentation and discussion with co-designers. At each step, they can use the types of signs used in the previous steps as well.

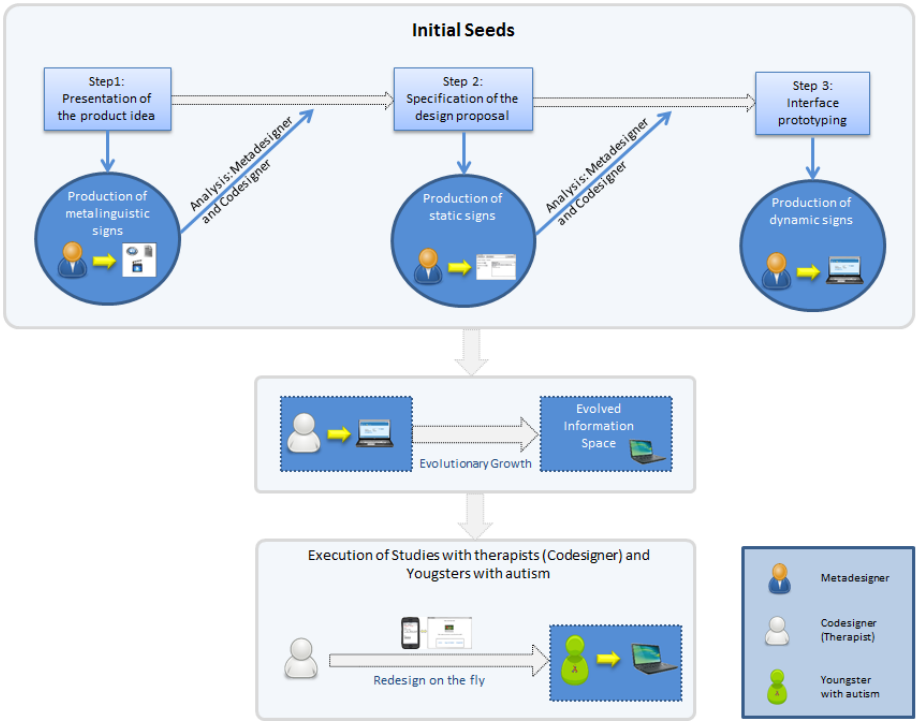

Fig. 1. The Combined method of Semiotic Engineering and Meta-Design

After meta-designers present and discuss about the prototype, they consider the suggestions for changes and, from the previous seed, they create a new seed for co-designers to make use. Based on this last seed, the co-designers may use this version and make their own changes or extensions in order to improve the developed technology, to explore new problems and to create solutions to specific problems, such as occurs in the "Evolutionary Growth" Meta-design phase. This step is a decentralized process in which each therapist who uses the developed application creates his/her own solutions.

Following the exploration phase and creating their own solutions, co-designers will use the solutions created with young people with autism aiming to identify the needs that may arise with the use of this solution and make customizations at use time.

With this proposed approach, we combine the two approaches to enable the semiotic engineering of the interface signs by using as a basis the process of seeds and reseeds the SER model. We are using this combined approach to design a new technology for the use of the therapist with young people with autism. With this technology, therapists can develop their own activities for each young person and make changes on the fly.

We believe the combination of Semiotic Engineering and Meta-Design can contribute to the design of applications for people with ASD. This approach offers the evolutionary design process of Meta-design, which enables to meet the diverse

customization needs of this audience, and provides a new direction to this approach, since Semiotic Engineering keeps everyone involved in the communication processes.

To achieve our goal, after several conversations with therapists and some observations at institutions, we have applied the steps of the first stage with some therapists. We built a video of the interaction using paper materials to explain the technology functionalities that we are developing. Based on the presentation of these materials and the feedback from these professionals, we are building mockups to compose a new seed using static signs. With this, we hope to get closer to the proposed interface and get new feedback on the proposed technology.

6 Final Considerations

In this paper, we report a study of young people with autism that motivated us to propose an alternative perspective for the design of applications for this audience by integrating the concepts of Meta-design and Semiotic Engineering. Through the related works and the study conducted, we identified the need for customization of applications developed for these persons and the importance of using a highly adaptable design approach. Moreover, we see the configuration on the fly as an effective way to meet the needs that arise during the use of these applications due to the high degree behavior variation of these individuals.

Although Meta-Design and Semiotic Engineering are different approaches in the field of HCI, we consider that they can complement each other when integrating the concepts of seeds and reseeds with the focus on the semiotic engineering categories of signs and on the communicability, i.e., the interface capability to communicate the design rationale to the user [4] . We believe this is particularly important in the context of autism, having the therapist as a co-designer of a highly adaptable application with high communicability.

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