Towards the Design of an Assistive Technology Reducing Sensory Stimuli to Enhance Social Interaction for Students with Autism Spectrum Disorder

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Abstract
This work presents ideas for the design of an Assistive Technology to Enhance Social Interactions for Students with Autism Spectrum Disorder with a smart wristband. We discuss previous work guiding our investigation, as well as the design, that reduces sensory stimuli, and evaluation to be done in an autism institute in Mexico City.

Author Keywords
Autism; Support Technologies; Design.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
This work focuses on designing interactive assistive technologies within the context of Autism Spectrum Disorder (ASD). ASD is a neurobiological disorder that is defined clinically by two deficits: (1) impaired social interaction and communication, and (2) restricted behavior [1].

The impairment to have successful social interactions persists through the person's lifespan. This has motivated multiple efforts to increase and improve social interactions in children with autism since they help to establish a self-concept and learn what others expect from the child; they are also shown appropriate social behaviors and improve their communication, cognitive and motor skills.

Within this context, we are currently working with DOMUS, an institute of Autism in Mexico City, to develop an application to aid kids with ASD, who are in inclusive schools, to establish successful social interactions. The solution is implemented in a Microsoft Band 2, a smart wristband, using notifications to provide cues for appropriate social behaviors, and sensors to detect stress and proximity.

Our investigation and design builds from the findings of the researchers who created MOSOCO, a mobile assistive tool to support children with autism practicing social skills in real-life situations based in the classroom lessons of the Social Compass Curriculum [2].

Based on MOSOCO and building upon the idea of assistive technology, we followed an user-centered design strategy and conceived modifications in the form factor and interface, aiming to increase the system's effectiveness and the adoption process with an interface that does not generate sensory stimuli, and an interaction method in accordance to the therapy used with these students. In this paper we present the design elements that we considered to create a prototype and our criteria to choose the selected smartwatch technology.

Background & Related Work

There have been multiple efforts to create technologies that aid students with autism to create or improve social interactions with their peers.

Tentori and Hayes [3] defined principles for Ubicomp technologies to support interaction immediacy and enable the use of the Social Compass Curriculum lessons outside the classroom; following that research, Escobedo et al. [2] created MOSOCO to help children remember those lessons in real-life situations.

Hourcade et al. [4] conducted research of the impact of multi-touch tablet applications to enhance social skills by enabling collaboration, creativity and a better understanding of emotions. Similarly, McEwen [5] demonstrated that the use of iPod Touch devices in classrooms can motivate the initiation of social interactions between classmates.

The use of social stories has been proposed as well, with technologies that establish a structured scenario or storyboard to develop social skills as shown in [6] and [7].

Changing the way we understand autism

The DSM-5 (Diagnostic and Statistical Manual of Mental Disorders), published in 2013, modified the way we see autism when two of the basic triad problems were joined into one: social interaction and social communication impairments are now described as one conjoined problem [1]. Almost 20 years of separate therapy for language and social interaction have now been deemed unsuitable and new strategies and design for assistive technologies are required.

A few years earlier, a new theory trying to explain the cause of autism was proposed: there is neural functional under-connectivity in people with ASD, and the hypothesis is that brain regions are not properly linked to each other, as demonstrated in [8] and [9], which leads to a rigid and static view of the world as well as the difficulty to perform cognitive tasks that require inter-coordination in the brain [10].

A new theory and a revised manual are changing the way we understand autism and thus, we should change the way it is treated and the technology interventions we make. We are aiming to create a technology with this new concept of autism and evaluating the experience of the students with ASD accordingly.

User Experience and Senses

Our senses are the window through which we perceive and capture the world, but many people with autism have an impairment modulating all the sensory inputs they receive, which derives in stereotyped behavior and the individual's withdrawal [11], [12]. The DSM-5 includes the sensory behaviors again —they were not considered in the previous version, the DSM-IV— as criteria under the "restrictive, repetitive patterns of behaviors" descriptors.

Our design acknowledges this sensory sensitivity and develops an assistive technology with a design that decreases the stimuli in two senses: touch and sight, with appropriate color choices for the interface, as well as adjustable haptic sensors in a comfortable smartwatch; exploring the theory that this kind of technology will increase the tool's adoption and influence. To accomplish that, we analyzed the visual elements of the interface that might create a sensory stimulus and created guidelines to mitigate them.

DOMUS institute uses visual elements for the children, supporting the idea that most of the children with ASD are visual learners. Based on that, we considered color and iconography essential elements for the interface. Color is crucial: 85% of children with autism see colors with more intensity [13]; it has been demonstrated that there are certain colors that are more amicable than others. Another relevant element on the interface is the iconography. The National Autistic Society in England and PECS therapy (Picture Exchange Communication System) sustain the importance of visual supports when presenting information. Even if we are working with verbal young students who can read, we cannot undermine the importance of clear and meaningful visual prompts as support.

Finally, we also studied the different hardware options considering elements like weight, form, and fragility to ensure we choose hardware that can accompany the child in their everyday activities without breaking or being intrusive.

Interaction with the Application

The communication strategies for children with ASD are the most important element, as they define the behavior of the application and its interaction methods.

DOMUS institute uses the Relationship Development Intervention (RDI) [14] as their principal behavioral treatment. The guidelines for language, instructions, and feedback methods are derived from this methodology.

Our design is based on implementing software running on a smart wristband, the Microsoft Band 2. To draw attention to the messages in the band we use a haptic vibration motor with three different vibration levels. The messages give cues about appropriate social behaviors and they remind all the steps required –such as greeting before initiating the interaction or maintaining an appropriate distance with their interlocutor- to complete a successful social interaction.

We wanted to reduce the instructions to a minimum, using declarative language as a cue instead of giving an imperative order. We also give the feedback immediately during the interaction. While it might be disruptive, giving immediate praise encourages the student and helps them reduce their stress. Also, RDI explains that if the feedback is given at the end of the interaction, the student's attention might already be focused on the next activity.

Expected Challenges on the Implementation

Since this is a work in progress we are expecting some challenges with the creation of the prototypes and the implementation. The first challenge is to create and validate the prototype. We will use two methods of validation in the prototype:

1. Validation of the iconography with neurotypical children to ensure it is clear and easy to understand.
2. Via proxy, with the aid of the student's therapist to validate the language and iconography used.

The next challenge will be to validate the design with the boys with ASD that are going to work with us. We have talked with the DOMUS institute and although a full participation of the students on the design process with a design critique method would be very beneficial as it has been shown in ECHOS [15] and ReackTickles [16], we will use another approach to be able to involve the boys with the design without taking time from their therapies.

We want the students who will be using the band to feel a sense of belonging with the tool and to express themselves. We will create a semi-flexible code and leverage the options the Microsoft Band 2 has to allow them to modify things like their name, the color in the interface, the level of vibration in the haptic sensor and some of the messages the application sends to create a unique tool for every one of them. This final design process raises two important questions: how to make the code flexible enough and how to conduct the final design process to receive feedback from the students.

The last challenge will be the use of the sensors to give social cues; we are currently researching if their precision will suffice to detect proximity and the student's stress levels during an interaction.

Future Work

The next steps are going to be the creation and validation of the prototype and the code; subsequently we will conduct a field study with four students with autism. Since this study will be conducted with few participants, we are aiming for a qualitative analysis. We will measure stress levels and the success of the social interactions for two weeks without using the Microsoft Band 2 and we will do a comparison of the results of another two weeks of observation with the Band.

Conclusion

This work allowed us to have a better understanding of what autism is and how can we help to enhance social interactions recognizing that visual elements, sensory-free interfaces and participation in the design are key elements for the adoption of a tool.

Although a comparative analysis between an interface that does not generate a sensory stimuli and one that does not consider those elements would be desirable, it is unethical to conduct an experiment that might generate stress or even a behavioral regression which is why we decided to only compare the success of social interactions before and after the use of the Microsoft Band 2 with our application.

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Fernanda Bonnin is a student of Computer Engineering at Instituto Tecnologico Autonomo de Mexico (ITAM) in Mexico City; her current areas of interest are: HCI and the impact of technologies in people with disabilities. She has work for one year with children with autism learning about ASD and researching the impact of technologies in their therapies. She is currently working on her thesis and she will be joining Microsoft as a Program Manager this summer.

The opportunity to attend to the Autism and Technology, Beyond Assistance & Interventions Workshop will allow me to look closely at the current state of research in the field and broaden my view; I look forward to discuss the impact of technology on autism interventions and their implications as well as the opportunities to innovate in terms of design, development and validation of new technologies. On the other hand, I hope to receive feedback about the research that I am currently doing to enrich it and improve it.

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