

# Interaction Design Tools for Autism

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**Abstract.** Children with Autism and Asperger Syndrome, though they are very different according to the broad spectrum of the criteria used for diagnosis, can be greatly supported by the use of new digital technologies in their daily lives, at school, at home, with their families. The paper shows the design approach to an interactive application for high-functioning children aged 14 to 18 in order to generate independence in the children, to ensure their safety, to create a network of aware and careful people regarding the Autism themes in order to better support families. The design of the application involves families, patients and educators.

**Keywords:** Interaction design · Autism · Asperger Syndrome · Social inclusion

## 1 Introduction

Digital technologies induced great interest in the families of patients with Autism Spectrum Disorders (ASD) and especially they have high expectations in these tools. One of the main reasons concerns the great accessibility of devices like smartphones, tablets and nowadays wearables. The paper aims to present the first results of the research project called “Interaction Design 4 Autism” in collaboration between the Department of Architecture and Design at the Politecnico di Torino and the C.A.S.A. Clinic (Centro Autismo e Sindrome di Asperger, specialised in Child Neuropsychiatry) based in Mondovì (Cuneo - Italy). The research process firstly describes the scenario of the Autism children and the contribution that technologies can give to the patients. Then a group of application is analysed with a set of heuristics in order to underline potentialities and criticalities. The meta-design part explores the user-needs taking into account the literature and the data obtained from families, patients and educators. The article concludes with the description of the project that contains a new application that aims to generate independence in the autistic children not only at home and at school but also during the movements on the outside.

## 2 The Research Process

The criteria for identifying the Autism Spectrum Disorder are very complex, as various as the patients are, to the point that every person with autism is almost different from the others. That is why the word *spectrum* is used. Some individuals may also be

influenced by the context and show variable behaviours and characteristics depending on the situation [1]. Basically autistic children and adults show, although with varying degrees, the following symptoms: impairment in social interaction, verbal and non-verbal communication; stereotypical or repeated behaviours, interests and activities; an extreme need for consistency and predictability in the routine of daily life [2]; challenges with establishing joint attention [3]. Autism is a neurological disorder that is diagnosed in the first three years of life and causes, even in the less severe cases, difficulties interacting with other people. This happens because social rules, facial expressions and a series of abstract languages commonly used as metaphors and irony, are not understood [4]. These symptoms are effectively summarized in the Wing's Triad [5]. Some patients with Asperger Syndrome (the "high-functioning" end of the spectrum) can often have a certain degree of independence in their life. Their cognitive faculties and their intelligence can enable to establish themselves professionally even if an high propensity to anxiety and limited social skills still persist. In fact, they have to memorize and to reproduce socially correct behaviours considering that they are unable to "naturally" interpret continual signals.

## **2.1 Digital Technologies and Autism: Devices, Tablet, Robots**

Digital technologies have proven to be a great help in the treatment of Autism. Devices such as PCs, tablets, and robots have, in fact, positive intrinsic aspects able to adapt to the characteristics of autism. This is due to: the components and their functionalities, like geolocalization sensors or speech-generation that empower people capabilities and continuously generate useful data; the opportunity of designing an environment and an interaction system that suit the needs of autistic children; the possibility of having a sort of continuous treatment even without the direct observation of medical or professional staff. If the interaction with individuals presenting repetitive behaviours can be difficult and frustrating, that does not happen with specifically designed software. An application can: create a familiar and predictable environment, reward correct actions through visual cues, offer advices and eliminate the complexities due to social interaction, work as one-to-one essential tool to teach even simple tasks. Below a list of uses and main collected results to this day is presented. Desktop systems with dedicated programs and voice output communication devices establish a communication channel between autistic children and, for example, classmates rather than teachers and parents. Some of these devices, including the first PDA, were very resistant and specifically designed to solve the problem of, for example, speech generation. However, they had some issues such as the weight, the size and the high cost, combined with a lack of product availability and assistance services. Tablets and smartphones immediately turned out to be much more flexible tools, cheaper than their predecessors, multi-functional and above all, thanks to their spread, they are more inclusive and socially accepted as a medium of communication [6]. These technologies have been tested mainly in the educational field in which, from the outset, the improvements were evident in terms of attention, motivation and retention of vocabulary during the class [7]. Within the familiar sphere, instead, the majority of applications tried to structure some fragments of communication in a more agile way, the same ones that previously

needed visual-interactive supports made of paper. However the ease and immediacy in the interaction can become a critical issue and a way to be more isolated if applications and use modalities are not specifically designed. In any case, every single action requires extensive training and ongoing assistance especially with low-functioning children. Given the complexity of the theme, a large corpus of scientific evidences that quantify the benefits of using smart devices is not yet available in the literature, but the number of researches is still rising. The first results show that some improvements are possible from the point of view of communication and of behaviours while data are too limited and noisy as regards the social skills [8]. This category is still too difficult to deal with, considering the differences between cases and the extreme difficulty that these subjects show. The study conducted by Hourcade et al. [9], in particular, compares similar activities made with or without an app on a tablet. The results show that the 8 involved children responded very positively to the use of the app by increasing: the number of spoken phrases, the verbal interactions, the physical involvement and somehow the support comments. Beyond the technological tool, which is undoubtedly able to sustain a design action, each subject is able to interact with the application according to three factors: the individual capabilities (that can be motor, sensory and cognitive); the device architecture (the way the display is organised and the interaction modalities); the specific communication requirements [10]. These factors have to be then connected to the specific context of use. This categorization highlights the large number of variables to assess the scalability of each project action. There are also numerous experiences that relate to the interaction between autism and robotics. In the more complex projects, humanoid robots are used to facilitate an interaction comparable to the human-human one. The main difference, compared to a system based on PC or tablet, is the ability to have a direct interaction including all classes, from direct manipulation to multimodal stimuli and feedback. The target of robotics thus relates to design an interaction that is specifically configured on the subject, easily controlling and generating core social interactive behaviour such as: eye gaze, turn taking, joint reference or imitation [11]. Establishing a relationship of direct manipulation with tangible interfaces is important for children with learning disabilities because they can discover a strong correlation between a physical action and a digital feedback, they can obtain the effect of positive reinforcement and their motivation increases in the interaction [12]. Some projects also show that it is also possible to create face-to-face interaction by using, for example, LEGO [13]. The role of digital technology described in this section is a way to emphasize the support that they can provide to children, families and educators. As tools, technologies cannot substitute the human-to-human interaction. On the contrary every device and application is designed to empower autistic children, engage them and to reduce their gap in communication.

## 2.2 Definition of the Heuristics and Critical Analysis of Related Works

There is a large number of applications designed for autistic children in literature and on the on-line stores: applications to create social stories and task analysis; specific

applications for AAC (Augmentative Alternative Communication, a form of communication that substitutes, complements, enhances oral verbal language through pictures, gestures, symbols, and anything that can help users to express their thoughts in an alternative way); apps that use PECS (Picture Exchange Communication System); apps exploiting the ABA method (Applied Behaviour Analysis); apps to reinforce the visual channel (with images, drawings, photographs, symbols, music, sounds, words, objects) or to draw and colour; to produce and listen to music. All these applications offer rehabilitation and educational tools that are very stimulating and can be presented singly or in groups of functions within the same package. The research team chose and analysed 16 applications in order to get a map of the criticalities about usability. The applications have been chosen according to these criteria: a previous analysis or use in the clinic, the creation of independence should be one of the main goals, the availability on the on-line stores. This last criterion has been adopted to get data not only from usability experts but also from common users. Even if those apps may not come from a scientific research, quantitative data, like comments that come from personal use, can be considered useful to have the big picture of the actual scenario. The creation of independence, instead, is one of the most important needs that the team has found and will be discussed in the next section. In this way the team created a system, including quantitative and qualitative data, to evaluate the apps using the heuristics of Nielsen [14]. For each heuristic, the research team assigned a rating on a scale from 1 to 5 (5 = perfectly coherent with the heuristic) in order to identify criticalities and strong points to be taken into account during the project. The evaluation considers both the qualitative rates given by three usability experts of the team (with a review by the staff of the clinic) and the quantitative data harvested from reviews of the users. The reviews have been collected through the app-stores and also in the web sites that are worldwide considered as a reference for families for autistic children. Quantitative data have been considered as a feedback from the real world and have been used to average the ratings given by the experts or to highlight malfunctionings. Some differences have been applied to the original heuristics because autistic children have different perception and degree of attention during the interaction. For example “User control and freedom” cannot be applied because autistic subjects need to follow well-defined paths. The heuristic should be changed by referring to the persuasive technique called tunneling by Fogg [15]. For the same reason “Flexibility and efficiency of use” cannot be considered. Design for flexibility means in this case the need to customize the paths and, where possible, take advantage of this to improve the level reached in communication and interaction. The analysed apps are: Tools For Autism, FTVS HD - First Then Visual Schedule Hd, Autism Emotion, Immaginario, TOUCHforAUTISM, Able AAC Free, Upper Case - Autism Series, Autism & PDD Associations, AutisMate, Zac, Autism iHelp - Toys, Io Parlo, Emotions, Proloquo2go, Autism Speaks, Teens With Autism. Figure 1 shows that very important heuristics like for example visibility, aesthetic and minimalism are not well considered in the majority of the evaluated app. The research team used these criticalities to better implement the graphic visualization and the interaction design of the app.

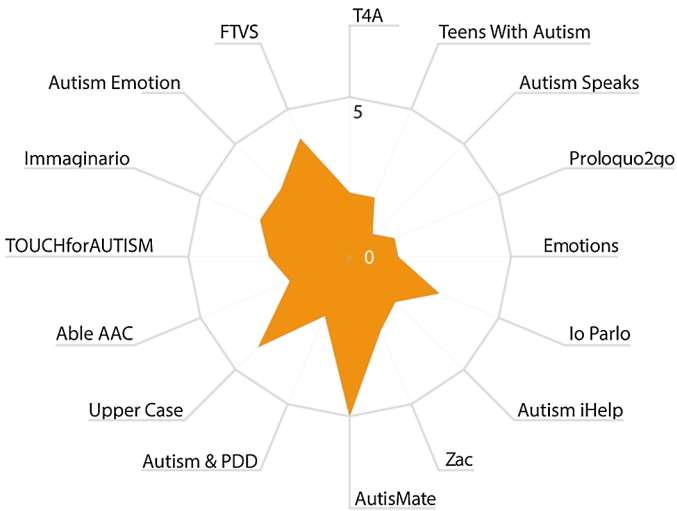
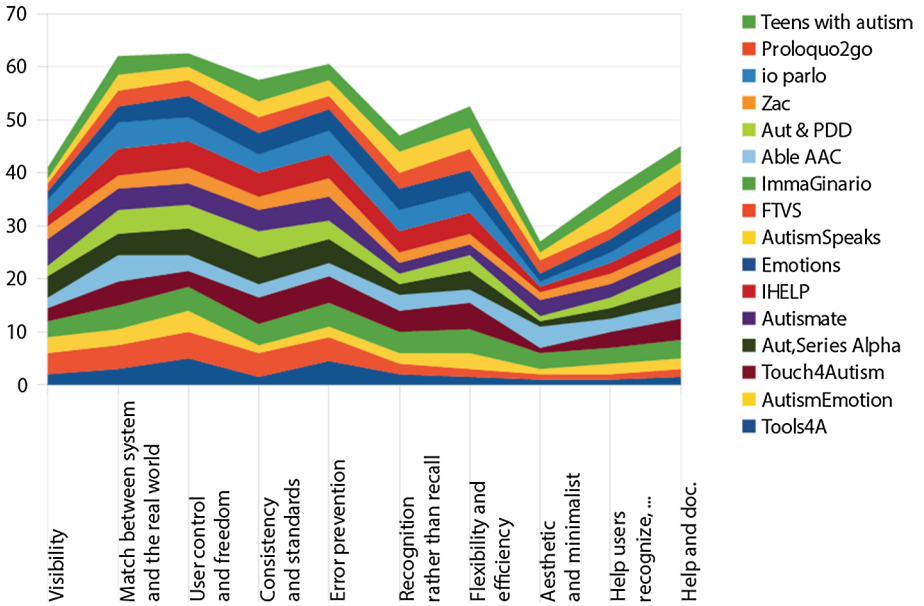


Fig. 1. Comparison between apps (above) and focus on the visibility heuristics (below).

### 3 The Meta-Design Phase

In this project the design research team, supported by the expertise of the clinic staff, tried as much as possible to think with a systemic design approach [16], to connect participating stakeholders, to build engaging interactive modes. In this way the team firstly conducted a period of observation of the activities in the clinic, then proposed semi-structured interview to the medical staff. After that the team participated to discussion groups inside events in which the autism's problems were discussed by parents of autistic children, their familiars and educators, to explore user's needs. Before the concept design phase the team checked user's needs coherence in literature, then designed the app and the interactions following an iterative design process both with the medical staff of the clinic and a group of educators. Approximately one year after the start of the project, the team presented the mock-up to other discussion groups to obtain useful feedback.

The described path is peculiar to the design methodology but, considering that children with Autism Disorder show greater difficulties in some characteristic aspects of the interaction, the interaction design team acted also as an aid tool in the project to collect heterogeneous approaches to the problem that come from very different fields of research and practices. Assistant teachers anecdotes, for example, often describe the effectiveness of self-made tools and teaching strategies that have been developed day by day trying to adapt general knowledge to custom-tailored intervention. It is not simple at all to create a system starting from these several needs, as well as the full replicability of any test on an autistic child can be quite difficult because of the many differences within the spectrum.

#### 3.1 User's Needs

One of the main postulates of Interaction Design is the importance of involving stakeholders in the process and iteratively verifying the output with the users, but applying this concept to the case of autism becomes critical. It is rather rarely possible to reconstruct at least the needs or the feelings of the subject itself, precisely because of its communication difficulties. The concept itself of Human Centred Design in this case relies more on the observation and the comments of therapists and parents obtaining ex-post data. Recently, some research has attempted to collect the needs of the three more important involved actors like family members, teachers and subjects through series of questionnaires. The first results show that the needs are an improvement of: social and communication skills, academic skills, the development of a greater capacity for flexible organization [17]. In particular, most of the obtained answers regards the possibility of creating independence. These answers are quite the same that the team obtained during the discussion groups. Even in front of these responses it should be emphasized that expectations for achievable results should be proportionate to the real possibilities of the children that differ according to the spectrum. Although the percentage of people with autism that can live independently in adulthood remains low [18, 19], it can be assumed that, through a structured and early intervention, good results can be achieved in terms of independence. At the present time as the enthusiasm

derived from the first application has encouraged the spread of smart devices, such as tablets, they are mostly used with educational or communication purposes but not for the creation of independence.

The generation of anxiety is one of the biggest problem that parents and educators usually underline. This phenomenon occurs in more than half of people with autism, especially in those who have higher cognitive skills. Anxiety is usually due to the inadequacy in dealing with unexpected social situations and changes and can be approached in several ways. The ones that are most closely related to the Interaction Design include aspects such as the hands-on tasks, visual supports and modulated integration of personal strengths and interests of the subject [20, 21]. Some anxiety-perceived tasks, if they are gradually addressed, can be achieved in the course of time in a more relaxed way increasing the level of independence in daily life [22].

## 4 The Design Project

The project is developed in cooperation with the C.A.S.A. clinic that has worked closely with the design team during all the phases. Among the many initiatives of the centre there is a project that includes activities inside the clinical, in the form of rehabilitation laboratory, using touch technologies. Consequently the medical staff has already experienced treatments using smart digital devices. According to the needs that emerged in the research phase, the team focused on the concepts of: creating independence in the autistic children aged 14 to 18 during the movements on the outside; ensuring the safety of children; creating a network of aware and careful people regarding the Autism themes in order to better support families; using inclusive common smart devices as smartphones. The main goal regarding the autistic child is to help him reaching a series of pre-defined places in autonomy and assisting him in case of emergency or anxiety. At the same time both parents and members of the community must be informed of a possible emergency in order to intervene immediately and reassure the child. The designed application has three access mode: one for the autistic child, one for the parent, and one for the users belonging to the community. Every user can operate different functions. The first step of the project concerns the design of a further aid that has to meet the demands for independence, security and daily life, especially in children. Some high-functioning children may in fact also begin to move outside on their own. This percentage may reach the 20 % of cases. This decision aims to fill the current shortage of applications that support individuals and families not only in protected and well-known environments, as a house, but that can become also portable. As it happens with able-bodied children, the fears of parents considerably increase when they cannot assist their sons doing tasks that until that moment were faced in protected environments, but interactive digital tools allow them to create an opportunity. The same application is accessible from two users, the parents and the child. The two users are connected to the same service to get different information. Four options are presented to the autistic child: “communicate my position”, “call parent”, “talk for me” and “where I’m going”. The first in order of importance, therefore regarding shape and colours, allows the child to communicate its position in the event of emergency (using the built-in GPS module) to 4 pre-set contacts.

This message will appear on the smartphone of the parent who can easily get to the child. Considering the importance of this function it can be activated at any time through the tangible help button that corresponds to the volume command on the smartphone side. This aspect is still undergoing study, especially from the point of view of the code and the constraints that some operating systems impose in application projects. “Call parent” allows the child to directly communicate with the parent, or with other reliable person, via a shortcut button. This does not necessarily imply an emergency but it is useful if the child needs to be reassured by a friendly voice or a face, if video call is set by default. The third button is the “talk for me”. This feature is designed for non-verbal children that need to ask for help. A voice message can be earlier recorded and it can be played to anyone around the child. The last key is the “where I’m going”. This is a simplified navigator that helps the child to autonomy follow a path and to reach the destination. After the choice of the point of departure and of arrival, simple screens made of brief texts instructions and photographs come in succession. This feature has been designed starting from the configuration used for social stories; autistic children are used, in fact, to perform tasks step by step, reading simple instructions. It is assumed, therefore, that the path and the images have been previously configured with the help of a parent. The parent can instead contact the child, identify its location, have access to settings that will have an impacting also on the settings of the child’s app (like destinations or preset phone numbers) but mainly adds the functionality of the “Find close friend”. This function integrates in the app the key part of the community of people interested in and attentive to the issue of autism. In case of difficulty, in fact, the application is able to send a message to all the holders of the app that are located close to the child. This feature allows the parents to ask for help to the community in case of danger; the goal is to create a network of informed people about autism in contact with each other. An autistic child caught by anxiety can indeed make gestures and behaviours that are socially misinterpreted. People who are part of the community can help him or at least explain the situation and ask for help by themselves. Regarding the interface and the wireframe of the app, two main working environments have been created, one for the autistic subject and one for the parents. The requirements are in fact very different. The child with autism should stay focused on the task until its conclusion. The number of interactive elements in the user interface has been reduced both to become minimal and because, especially on pages where he needs to make choices, it is more likely to make mistakes. A uniform and consistent grid has been created in order to gather non-interactive elements as much as possible in defined areas. The interactive areas of buttons and their perceptibility were increased to correctly support also the children with motor disabilities. The chosen colours are suitable for a children to be attractive and friendly; they differ in sections while maintaining a narrow range of colours. Great care has been taken to ensure a high level of contrast in order to maintain high legibility and to highlight the differences between interactive and non-interactive areas. Once the activity starts, the screen modulates avoiding deviations from the path and hiding, for example, system bars or panels. The fonts has been examined to address the possible reading difficulties which some autistic patients may present. Often children with autism have difficulty learning to read and write; it is a issue that has been also observed in subjects suffering from the dyslexia. Appropriate fonts were then analysed [23] to ensure high readability, with highly



irregular features (that is without symmetry between letters that could be confused) with evident ascents and descents. The chosen font, TestMe, has then be adapted by increasing line-spacing and kerning, using words and phrases as short as possible and avoiding interruption between lines. The illustrations were not the subject of a redesign because the clinic uses them for many years and they have proven their effectiveness in communication. This application is also part of a larger project that integrates an awareness and communication campaign made through a video and a payoffs printable on, for example, t-shirts and other objects typical of a teenager (Fig. 2).



Fig. 2. Examples of the new designed screen's app for the child and the parent [24].

## 5 Conclusion and Future Work

The paper tried to demonstrate how interaction designers can design tools to improve social inclusion of autistic children and of their parents, through technologies that today are accessible and sustainable from the economical and social point of view. After the first year of research, the team presented the app to discussion groups and dedicated events for obtaining feedback about the goal and the interaction of the app. The application has been positively evaluated, the main criticality underlined by the groups was the trustability both of the app and of the community. They imagined their children lost in a anxiety state and they remarked that children may not operate the right sequence of actions. In this case the touch interface, even if it has been designed respecting all the usability criteria, seems to be not so appropriate in case of some mobility impairments summed to an increasing anxiety. One solution discussed with the parents could be the use of a wearable device connected to the app, in order to track physiological parameters and automatically communicate the need for help to parents or community. This new concept, and the first results, needs a test phase in real conditions and an implementation that should solve some of the coding problems related to the OS constraints. The team planned to test the app connected to a wearable device with at least 5 children in the next months in a defined area in order to obtain more data observing the children behaviours and the perception of their parents. The trustability of the community is instead related to the creation of a community of informed people, while today there is not a proper communication about autism. In this case the project includes a communication part that will be implemented and can be used in the dissemination part of the research.

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