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Building an Alternative Communication System for Literacy of Children with Autism (SCALA) with Context-Centered Design of Usage

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1. Introduction

Human language is a system of linguistic symbols acquired through a long ontological process of cultural learning [1]. It serves two functional aspects, communication and cognition [2]. The communicative function of language emerges in the indicative function and allows the establishment of the communication process through choice and combination of symbols [2], whereas, the cognitive function of language allows the representation of beliefs and intentions through linguistic symbols; thus, acts on one's own mental states and that of others [1]. Our view of autism and the way it affect communication is discussed along those lines.

As our conception of language development, it is assumed that communicating is more than speaking. Communicating means skillfully using a powerful tool of mediation[1]human language. In addition, human language is taken here with all its possible modes of expression, including verbal and non-verbal symbols. Communication is neither regarded as a linear process of direct use of a symbolic system (language) nor as a process of language acquisition of grammatical and phonetic items. The complex process behind language acquisition includes social, cultural, historical, and intersubjective dimensions and is interactional in essence. Interaction, the fuel for development, occurs within scenes of joint attention, in which interacting agents intentionally use linguistic symbols to express intentions, beliefs and representations from their own perspective in several ways [3]. These are the premises underlying our research.

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1 From a sociohistorical perspective, mediation is regarded as a scene of joint attention [1] between two or more subjects intentionally using tools and signs (such as language) to promote a process of appropriation with differentiated responsibility and competence among participants.

Human primates' natural trend to understand others as intentional agents with goals and perceptions is the basis for the engagement in collaborative activities and joint attention [1]. Different from other primates, humans have developed a specific capacity to share attention and establish a unique type of social interaction. Hence, scenes of joint attention constitute social interactional processes in which: 1) agents are reciprocally responsible; 2) there is a shared goal, that is, each partner is aware of the goal to be achieved together; and, 3) participants coordinate their plans of action and intentions mutually so that each participant can anticipate the roles in the interaction and potentially help others with their role if necessary[2] [4].

Scenes of joint attention contribute with the *locus* for the negotiation needed for the construction of intersubjective and perspectivated meanings [1]. This is what characterizes the process of communication as a relational and systemic phenomenon. Subjects are actively involved in interaction with a particular dynamics of implicit or explicit rules over which none of the subjects have complete control.

Such intersubjective and perspectivated construction of meanings reveals the uniqueness of human language as, upon the specific use of a particular linguistic symbol, it carries a local, historical and social meaning jointly constructed. This is also to say that in each interaction, participants quickly update possible meanings.

By extension, learning a language is a process situated relationally, historically and culturally. In each interactional process where two individuals engage, there is an intersubjective reconstruction of the perspectives of the others in the representation of their own intentions and beliefs, which requires interacting individuals to select, filter and reconfigure symbols, according to the context, intentions, beliefs and mental representations of co-participants in the communication process.

Communication implies reorganization and coordination of social, cultural and mental representations of subjects in interaction. It is precisely by means of linguistic symbols, namely signs, that it is possible to build and share meanings. That dialectical dimension of the use/understanding/acquisition of a sign is a feature of the linguistic symbol which always involves two dimensions, language and thought. As a consequence, the attainment of a linguistic symbol constitutes a real and complex act of thought, represented by the word. It is not simply acquired by memorization or association [2].

Language acquisition is realized through the use of the symbol in actions of mediation (triadic) by which participants negotiate and construct meaning in an intersubjective way, because "[...] the meaning of a word is given through the process of verbal and social interaction with adults. Children do not build their own concepts freely. They derive them through the process of understanding the speech of others " [5] (p. 121). It is precisely within those triadic scenes, called joint attention scenes [1], that the interlocutors share some Aspect of their context[3] and where intersubjectivity occurs [4]. It is also important to note that interlocutors may reach different levels intersubjectivity depending on the extent of their exchanges [5, 6].

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2 Especially in interactions between subjects with different levels of experience or knowledge about the situation.

3 The context refers to the way objects and events are represented and meant in a situation [6].

Besides intersubjectivity, linguistic symbols require an ability to understand perspectivation. Understanding a symbol is a prerequisite to understanding the intentions, beliefs and background knowledge of others, as well as a particular perspective about an object or event that is incorporated into the symbol [1]. Human ability to adopt different perspectives for the same symbol or to treat different objects as if they were the same for some communicative purpose is only possible because all of those perspectives are incorporated into the symbol. So, this perspectivated nature of linguistic symbols sets forth an endless array of possibilities to manipulate the attention of others with implications for the nature of its cognitive representation [1].

2. Communication in autism: Some considerations

Autism belongs in the group of Pervasive Developmental Disorders (PDDs). Literature highlights a triad of elements [7] for the identification of the disorder: behavior, social interaction, and language and communication [8]. In the presence of autism, such elements portray qualitative features which prove to be peculiar or bear deficits. This session aims at discussing the characteristics related to communication and language in autism in more detail without deepening other inter-related aspects of the syndrome (such as interaction and behavior). Presenting a state of the art of on autism is not intended here, but rather, a brief review of some researches concerning language use and communication.

The field of language and communication in autism presents a great potential for researches. Although there have been many recent studies on autism, there is a gap in what concerns language and communication. So far, emphasis has been on aspects of social interaction, diagnostic and prevalence.

It is widely known that there are certain deficits in communication, such as, the absence of expressive body cues (in non-verbal communication), deficits in understanding colloquial exchanges, and speech that is not adjusted the context (in verbal communication). Several elements in the speech of a subject with autism account for it being regarded as strange, unproductive, monotonous and unusual, such as a) the difficulty in using pronouns properly, particularly, with pronoun inversions; b) the repetition of questions which have already been answered or of fixed sentences in a mediated echolalic process; c) the literal understanding of metaphors or idiomatic slangs; and, d) the difficulty in using predicative abbreviations[4] [9].

In a study involving with neurotypical, mentally impaired and children with autism, the kind of gestures children use to communicate have been analyzed [10] and three main categories of gestures emerged: deictic (pointing); instrumental, to organize others' behavior; and, expressive, to share emotions. The study reveals that while typical and mentally impaired children use the three types of gestures, the group of children with autism only uses deictic

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4 Predicative abbreviations consist of replacind the subject of a sentence so that the predicative remains as a hidden subject. For example: "Laura always buys bread at the grocery at the corner. She takes a bag and some change her mother leaves on the fridge." The second statement has a predicative abbreviation. It contains the action and the subject is implicit (WERTSCH, 1988).

and instrumental gestures. Besides that, other studies have established that children with autism face difficulties when it comes to using time and space pragmatic markers [11, 12], expressing mental states [13, 14], using adequate expressions and gestures [15], organizing more complex and "if-so" statements [16].

As for stories and narratives, the greatest difficulty for children with autism seems to lie in the ability to follow a narrative with multiple characters and organize each character's specific traits and personality. It is also hard for them to follow a character's way of thinking and to put themselves into the character's position [9, 10, 17, 18].

Such deficits in symbolization affect communication because it requires an active use of symbols for representation, especially, when situations involve more abstract elements such as feelings and emotions. Narratives demand the narrator to organize information for a potential listener and to select relevant aspects from the listener's perspective. Researchers have tried to explain such deficits for understanding narratives through the Theory of Mind [11, 13, 14, 16, 19, 20]. In those researches, it is hypothesized that people with autism fail to read other people's state of minds and understand their intentions, beliefs and emotions.

From another perspective, problems in communication could be associated with joint attention [1] or mutual imitation [21]. A recent research, consistent with previous studies, has focused adults diagnosed with high functioning autism or Asperger's syndrome [22]. It has not found deviation in phonology and syntax or deficits in the subjects' ability to understand and extract the plot of narratives. There was significant difference in the use of referents, though. As a consequence, narratives have been less coherent and less organized. Just as in [9], the research has identified pronominal inconsistencies, preference for simple and unbound sentences, disregard for the relationship of a specific event with what happened previously, and limited use of time expressions.

In another research [22], however, subjects are able to apprehend the structure of the story and follow the main plot as they mention all the relevant events of the narrative. Such outcome confirms that adults diagnosed with high functioning autism or Asperger's syndrome do not present difficulties with morphosyntactic aspects but rather a limited perception of a character's intentions and inner states in the story, that is, in pragmatics of communication.

Other study, aiming at the identification of the symbolic understanding of images with three children aged 7 to 9 years old [23], has shown it is possible to use functional communication successfully. In that study, non-verbal children not employing any type of visual/symbolic communication previously have undergone a process of systematic visual literacy consisting of understanding family, people, actions and sequences. Each category has been composed by a set of 10 symbols (or photographs); and, after nine weeks the proposal of intervention has shown positive results as children begin using the images to communicate requests, define tasks and other communicative activities. Such research adds to other of the kind focusing functional communication in autism [24].

Functional communication has started in the 90s with the Picture Exchange Communication System (PECS). PECS is an Alternative Communication (AC) system with a behavioral methodology for children with social communication deficits. Its main goal is to teach

functional communication by means of hierarchical organization, basic principles of behavior such as modeling, differential reinforcement, stimulus control, control transference of stimulus through delayed strategies of questions [23].

PECS is one of several psychoeducational programs for people with autism available nowadays [25]. It seeks to stimulate spontaneous communication through potential reinforcers, images and physical exchanges. The system is organized into six hierarchical phases interwined with a method of behavior analysis and teaching. Although PECS seems functionally efficient, our critique is targeted at the strong behavioral control imposed by the system and its disregard for prerequisite abilities for language use, such as joint attention, imitation or visual contact as previously discussed.

Summing up, it is important to note that even children with autism who do not evidence language impairment might benefit from communication support systems at times, as a way to compensate for their lack of understanding of language semantics or pragmatics [26]. Is such cases, where speech is not present, the use of alternative communication systems can promote and develop processes to facilitate communication (facilitated communication). This way, the use of technology may contribute to the sociocognitive development of those subjects [27]; and, alternative communication systems may assist them in developing meaningful communication [9, 17, 23].

3. Alternative communication: Methodology and resource in an approach to autism

Alternative communication (AC) in one of the most important areas within the field known as Assistive Technology. It encompasses technical aids for communication, be it to complement, supplement or provide alternatives to make the communicative process happen.

There are several systems of AC. These provide a vast repertoire of representative elements, such as photographs, drawings and pictograms. Support for those systems may require either low (concrete material) or high (computational systems) technological devices. The importance of AC lies in the communicative strategies and techniques to promote subjects' autonomy for communicative instances so; it is secondary whether support is mediatic or not.

Given the impact language development on human development, subjects presenting deficits in communication can benefit from the use of AC systems as application of techniques and technology go beyond its instrumental character to enhance the development of abilities to use linguistic symbols intentionally. Considering that in the case of autism, communication deficits may exhibit alterations in language use, form or content in pragmatic level, and to a lesser extent, in syntactic, morphosyntactic, phonological or phonetic level, the importance of employing an AC system is more concerned with adequate reception and production processes, and those play an inter-related role [28].

Although the use of AC dates from the 90s, researches are recent. One of the first works was the adaptation and standardization of the PECS [29, 30]. It is also worthy of note the research

on language development and meaning construction supported by AC with three children with autism [31], which revealed relevant outcomes.

More recent studies [32, 33, 34, 35] have involved the use of AC with Global Development Disorders (autism and Cornelia-Lange's syndrome). Those studies have also come to important results, particularly, when AC processes are supported by digital technologies.

According to the studies cited above, there is significant improvement in communication processes both in enunciation and pragmatics for subjects with autism when an AC system acts as tool of mediation between subjects in interaction. We believe that when AC is adapted to the needs of subjects with autism, it serves as a factor of facilitation and proximity because it contributes with an alternative for communication and establishes a "bridge" between people.

AC systems may function as bridge for human communication. However, it cannot be naively assumed that a technological support can stand on its own. On the contrary, an AC resource must be clearly founded on a methodology epistemologically grounded. The AC system presented in the following session (SCALA) is constituted of technological, human and social elements which are interwined to build an integral relationship, as highlighted by a researcher when stating that "[...] *more important than [...] any resource to intermediate dialogue, it is time, attention to listen and dedication granted to one another*" [36] (p. 139).

Two versions of SCALA have been developed by our team: web and tablet. Development has started in 2009 and the version for tablets is currently undergoing experimentation in a study with three children aged 4 diagnosed with autism.

4. Technology and autism: SCALA project

Researches on the use of technological applications for subjects with autism is frequent in the literature. One of the first studies involving technology and autism used computer-aided instruction (CAI) to stimulate the language development of children with autism [37]. Other studies have been published reporting the positive effects of technological applications in the process of teaching how to read and write [38, 39, 44], problem-solving [40, 41], social interaction [27, 42], and, cognition and learning [27, 39, 43].

Improvement of language use and children's learning how to read and write have been reported by [38] and [44]. In Brazil, the first study dates from 1975 [45]. It has been developed in the Laboratory of Artificial Intelligence of Edinburgh with a seven-year-old child with autism, with the use of Logo[5]. It has pointed out the use of Logo facilitated the process of interaction of the child with other people because "[...] the turtle assumed the role of mediator in the interaction of D. with other people and served as an object to help the development of mental schemes [...]" [45] (p. 73).

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5 LOGO is a computational tool in which a student controls an icon represented by a turtle through simple commands. Designed by Seymour Papert in the 70s, it was the first computational tool especially projected to be constructivist and grounded on Genetic Epistemology.

Other positive outcomes of the studies above include gains in communication and moti‐ vation. Such correlations are often observed in a structured and communicative environ‐ ment supported by technology and organized for interventions with subjects with autism [27]. Even when more guided [38] or more flexible [45] softwares are employed, results are productive. Such outcome could be traced back to the pedagogical strategy adopted by the teacher, who acts as a more experienced partner because the use of computers, particularly in virtual learning environments designed to adapt to the subject's interests and needs, becomes relevant and important tools of mediation as advocated under a so‐ ciohistorical conception [3].

Once strategies are added to the flexibility, adaptation and complexification processes inherent to digital technologies, they help to promote sociocognitive development of participants. Nevertheless, it is necessary to establish strategies for different learning environments, learning situations and subjects in interaction so that the introduction of technology can contribute with its qualitative differential for the enhancement of social interaction of subjects with autism [46]. In doing so, researches corroborate that the use of technologies can help people with autism communicate and interact [47].

Mobile devices also represent a possibility for the use of applications to assist users as well. Their utility extends into day by day activities as they are easy to handle, can be used in different places and allow connectivity to other devices. Connectivity in particular can be quite useful to enable communication and learning in groups and, as a consequence, can help foster the integration of subjects in their social environment [48].

On sociability, a recent study with high functioning autism and Asperger's syndrome adults users of online social networks has found that the structuring features of comput‐ er-mediated communication (CMC) help and promote their participation in social interac‐ tional processes [49]. Similar results have been identified in a study focusing chat room interaction [27]. In addition, a research by [50] highlights that engagement in mediated communication may not only foster participation, but also enhance learning of social rules of turn taking and dialog maintenance when supported by intelligent computation‐ al systems. Despite the likely advantages of CMC, it is important to consider its poten‐ tial limitations and complications when it intensifies problems associated with trust, secrecy, inflexibility and perspectivation [51].

Turn-taking, which underlies unstructured social talk, poses a challenge which can be even greater if some sensorial hypersensibility (to lights, sounds, smell and touch) is associated with the syndrome. In those cases, communication controlled by a computational device may play a role in the maintenance of social relationship and management of feelings of loneliness and depression [52].

Adults with Asperger's may reveal intense isolation and difficulties to initiate social in‐ teraction [53]. They often lack a model of behavior socially acceptable and, as a result, may behave in a way that impacts their communication with other people negatively. Hence, alternative means of communication, like CMC, and other platforms easily availa-

ble such as Orkut, Facebook, and other social networks, can be useful for the promotion of interaction of people with autism [27, 49, 50].

CMC offers users with autism control over their environment as well as over problems with prosody and intonation [49]. A study developed by e-mail with adults with Asperger's Syndrome has found that visual anonymity, time flexibility and the permanence allowed by the internet help diminish the social and emotional pressures of interpersonal communication as well as the cognitive complexity of the processes involved [49]. In particular, the authors state that online communities provide a space for interchanges and talks for people with similar interests or problems, so people with autism do benefit from those possibilities and structuring characteristics of CMC. In their study, 16 adults with high functioning autism or Asperger's syndrome have been interviewed on their daily activities and participation in social networks and attested that CMC tends to be beneficial for the initiation of social interactions – more than half of the interviewees participated in some type of social network. However, limitations and drawbacks in the interactions in social networks have been reported as well, which often refer to initiation of contact, maintenance of interaction for long periods and issues of security and trust. As a result, those users seek to interact with people already known from other spaces[6].

In spite of the benefits reported in studies, few address AC in technological systems with non-verbal subjects with autism. We know that communication with subjects with autism can resemble the "Tower of Babel" and challenges are greater when subjects are non-verbal[7.] In this case, we are in a rather complex situation which requires the adoption of strategies and resources to "climb up the tower". In the researches presented here, we notice that the use of technology is promising for the processes of communication and interaction. That brings us to some important questions: is it possible to identify the same benefits when allying the potential of CMC with AC? And, if so, how to use AC with mobile devices with non-verbal children with autism?

In this specific research node (AC, technology and autism), there are few studies on mobile devices for AC that focus people with the syndrome. In the literature review, in addition to the work of our research group, we found a research with the system Sc@ut [47]. Sc@ut is an AC system adapted to be a communicator for Pocket PC and Nintendo DS. According to the authors, the use of the system in groups of children with autism has shown an improvement in the behavior of subjects in oral language. With some subjects, the models of communication provided by the system were used to train social skills and daily life activities[8] [48]. The studies developed by our research group are reported in the following session.

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6 This is typical within other social groups investigated. In general, confidence is stronger and more consistent among stigmatized group minorities [54].

7 Researches point out that a third of children with autism are non-verbal. Such proportion fells to 14 to 20% when they receive early intervention [55].

8 Another product under development by [47] is a platform for the creation of pedagogic activities for Ipad and Iphone. Activities are diverse including navigation, association, memory games, puzzles, sequencing, visual and aural perception, vocabulary, visuo-spatial coordination, among others. However, this product (Picaa) has not been tested with children with autism yet.

5. Development centered in contexts of use

Since 2009, when we started the development of SCALA, we have aimed at supporting language development of children with autism presenting deficits in communication. The epistemological basis of the sociohistorical theory, which we adopt, implies a conceptual re-organization of the software development process known as User-Centered Design (UCD). In UCD, the objective goes beyond subject-object interaction and focuses on designing strategies to allow interaction and communication between children with autism and other interlocutors [32, 34, 56]. SCALA is composed of three modules: board, narratives and free communication and follows a UCD approach.

From a sociohistorical perspective and the theoretical premises already presented, our approach not only contemplates the subject with disabilities, but that subject in interaction, which broadens our focus of investigation to (a) the **social contexts** in which (b) **cultural practices** of communication and literacy are developed by (c) **different participants** through (d) **mediating actions**.

The general guidelines of the UCD consider the macro context of human development in social interaction as the basis for the analysis of cases. Characteristics and needs of individuals cannot be understood apart from the contexts in which they belong. As a consequence, the development of assistive technology goes beyond a functional view of the human being. In spite of so, we do not ignore functional aspects in our proposal, we consider them within the cultural spectrum in which the AC is to operate. Each individual "inhabits" many contexts in which is more or less active in face of different cultural practices. In some cases, those practices happen within a triadic mediated action (individual-mediator-object) which entails learning and development. So, our focus of analysis is always the individual in relation with his/her different contexts. On its turn, each context impacts our relationships, consequently, the mediations that are possible. In time, we do not regard the cultural context as something that limits the individual, but as an element that shapes the relationship. This is why it is of importance to consider social contexts in the development of technology that will be employed as a qualitative resource and psychological tool in the mediating action.

Context, under such conception, exceeds the notion of physical space. It constitutes a condition that represents the action and is crossed by a space-time dimension. This dimension includes not only physical space but social space, and four types of time: a) present, which is the microgenetic time, i.e., the time now, b) lived, which refers to human history, or the ontogenetic time c) historical, which refers to one's personal story and is related to culture; and, at last, d) future, which is a projection, what one imagines will happen, one's own expectations and that of others, the wishes, the intentions that projects oneself to the future. Those four times frames pervade contexts and are constantly updated, so, they must be taken into consideration when we project assistive technology systems.

The analysis of the different frames of time starts with the present one – microgenetic – and through it, the others are recovered. An ethnographic approach is central in that analysis because "informants" provides information about lived and historical time that allows us to

project into the future [57]. As ethnographic research is strongly based on discourse, therefore, discourse itself is a powerful informant. Because discourse is imbued with subjectivity, a report of memories and expectations, it may be argued that it does not provide a wholly truthful account. However, as subjectivity is an important aspect within the sociohistorical research, triangulation of the data is adopted as a regulating mechanism [58].

The configuration of contexts underlies sociohistorical research. The nature of contexts is a discursive one, in which language emerges and allows us to analyze various elements: persons, situations, cultural practices and mediating actions within those practices (Figure 1) in relation to time. Thus, context cannot be regarded as a static element as it plays a role in the interaction too. Besides the agents (people) – subject A1, subject A2 –, overlapping contexts need to be included in the analysis of contexts of use.

The overview of contexts constitutes the macro level of investigation necessary to deepen the understanding of the phenomenon of communication within educational spaces. In the micro level, triads (subject-mediator, non-verbal subject and mediating actions) represent the starting point for the understanding of the processes of mediation with technologies. Such methodological perspective supports the development of technological resources (for instance, SCALA) in a differentiated way, that is, different from traditional processes of development and different from processes based on UCD, which involve users in the process of development and take their needs, expectations and experiences into consideration.

In SCALA, there is not a single model of user but a diverse range of agents involved with many peculiarities that differ in expectations and experiences, this is why we propose a broader view. We are not only interested in the user, as in the UCD, but in the peculiarities and specificities of the various agents in interaction as well. Our focus encompasses the action implied in the interaction, the cultural practices in which agents and technological resources are embedded.

Besides UCD, another proposal is the Activity-Centered Design (ACD). ACD focuses the activity that is performed and, as in the UCD, tries to create a model of activity. Considering that literacy practices cannot be thought of as an activity but as a set of practices that vary across different situations, we propose a Context-Centered Design (CCD). In this sort of development, differentiated sociohistorical contexts provide the guidelines to orient system development. In other words, what people do in different contexts, with different objectives and scenarios is what guides this project development. Figure 1 shows a scheme of CCD.

Three multi-case researches underlie SCALA developed. The first research allowed us to identify mediation strategies and validate the methodological proposal for intervention with communication with children with ASD [33]. The second case study was concerned with the interaction and intervention with a child aged 5-6 diagnosed with ASD and presenting deficits in communication. This case study was a follow-up to the previous one and derived strategies for the development of communication with the use of a first prototype in this phase [35]. Interventions allowed a broader understanding of the process of use implementation of AC with children with autism, and provided input on how a tool for such purpose should be developed.
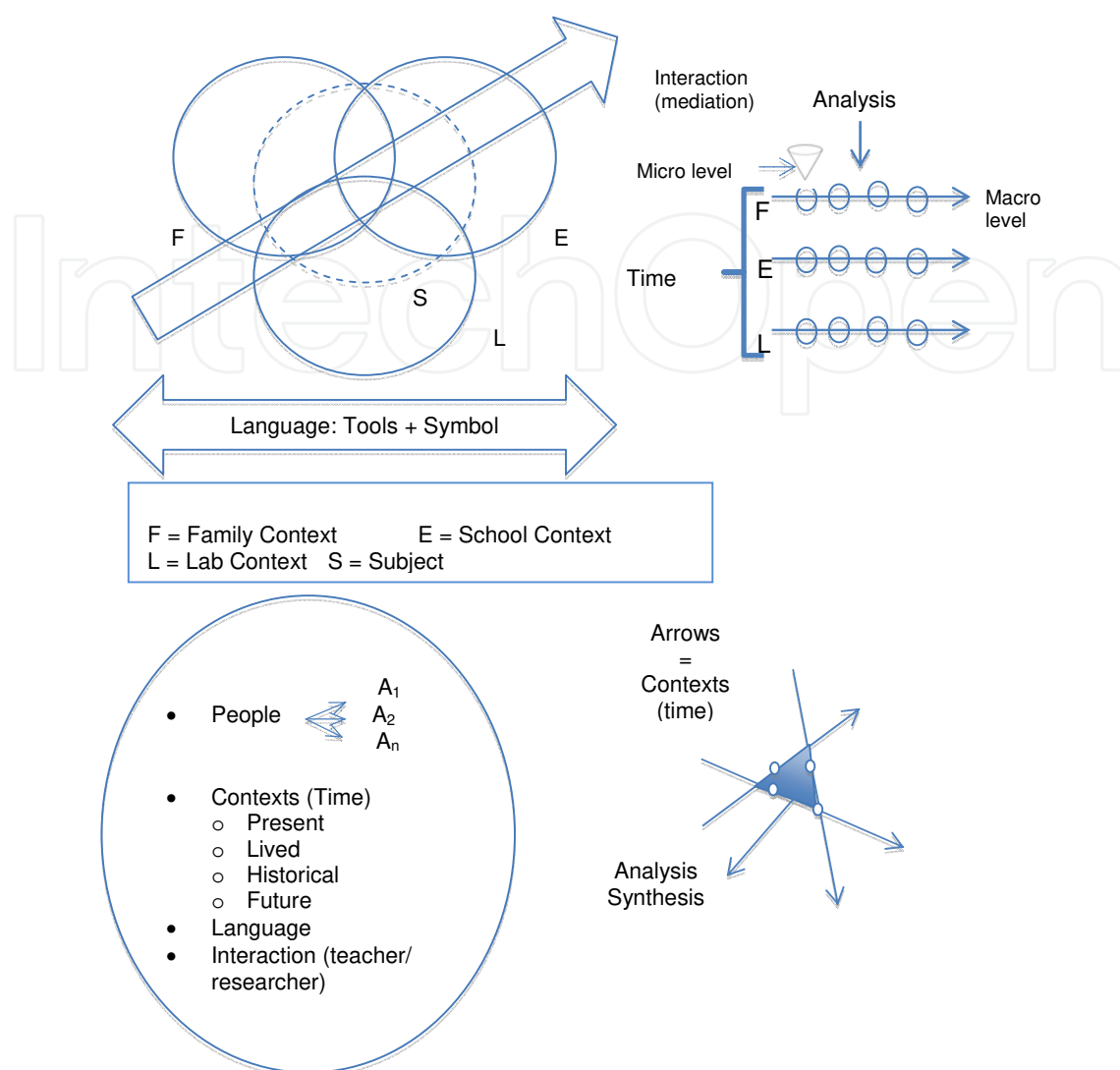
Figure 1. Scheme of Context-Centered Design (CCD)

Requirements, like touch screens and the adaptation of the size of the figures among other aspects, have significantly contributed to the second version of SCALA. A new version, now considering mobile devices and fast connection with the internet is under development (2011-2012) and has been informed by the third study, currently involving three subjects from three different cultural contexts. From the family context, the study took into consideration daily interactions, hygiene, leisure time, among other information. Besides family, other contexts include school and laboratory. The proposal of the controlled context is to investigate interaction with peers by inserting 3 children with autism in the same social space and at present time.

As it is possible to observe, development and investigation imbricate in a spiral process where each process repeats itself reaching greater complexity, and thus, improving the system which proceeds development according to the principles of CCD. To develop SCALA, on the one hand, we address the needs of communication of non-verbal children, the expectations of their

teachers as mediators of educative practices and count on the intense participation of family to use and adapt those strategies and resources [32, 34, 59, 60]. On the other hand, research trajectory involves several investigation projects developed by the research group in different spaces and moments, with points of intersection and team consolidation through regular meetings to keep investigation on track. Spiral development starts from a deep analysis of existing systems[9] adding to the results of the multi-case researches, which gradually informs the construction of requirements for the system and is constantly adjusted.

From a technological standpoint SCALA has as its main features, a module for building communication boards, a module for the construction of stories, and a module for free communication. It also encompasses common application features such as the ability to import files, edit sounds, save, export, and manage the various files generated by the system (Figure 2). The menu on the left to the user presents the categories of images that can be used with all the three modules and the horizontal menu bar displays the features.

From a predefined layout one can fill each card by clicking on the categories of images. Each image has a caption pattern which can be edited. For each card it is possible to record sounds and hear them. If the user does not want to record a sound, a speech synthesizer will read the caption (otherwise, the sound recorded by the user will be supplied).

In addition to the existing images in the system, it is possible to add personal images allowing customization and adaptation to the sociohistorical context of the user. Finally, the last feature designed was the animation of actions. This feature was introduced as empirical studies have shown evidence that animated actions may be more suitable to forge understanding of metaphorical and symbolic elements with autism [46, 61, 62].

SCALA is currently available for two platforms (web e android), which allows its use with mobile devices. In the next session, some preliminary results are presented.
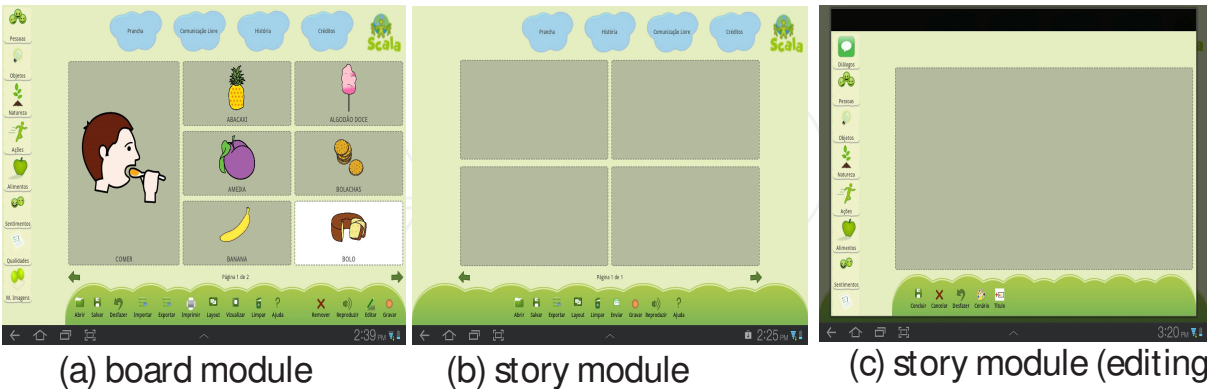

(a) board module   (b) story module   (c) story module (editing)

Figure 2. Board and Story modules in the version for Android for tablets

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9 The main softwares available in the market have been explored, for example, Amplisoft, Boardmaker,and other free systems whose traits concerning interaction and narrative building were relevant to think about the system's requirements. A complete synthesis of such assessment was developed by [35] as part of her masters research.

6. Development and preliminary results

In the session, an extract of some preliminary results of our research is presented. It comprises the period of time raging from August 2011 to May 2012. The subjects are three non-verbal children diagnosed with autism aged 4 years old. Three contexts have been taken into account: family, school and laboratory, but, in this report, we mainly focus on the interactions in the context of the laboratory, so, just a few considerations about other contexts are referred.

Interactions have been planned upon the methodology of mediating actions, with particular focus on the promotion of scenes of joint attention in order to accomplish communication and social interaction of the subjects involved. Those interactions happened simultaneously with the three subjects once a week in the laboratory. Interactions in the laboratory took place weekly and duration was flexible in the beginning[10] to adapt to the needs of individuals. In addition, there were visits to each subject's home and school followed by observation and initial guidance to mothers and school personnel. This way, the subjects' contexts encompassing greater social experiences and participation were accessed. The first contact was with the mothers, school and teachers with the distribution of some instruments for data collection[11] to help set up an initial profile of the subjects.

The interventions of the researcher in the three contexts do not follow a linear fashion. Visits are scheduled according to opportunity and the needs identified in the course of the research. Interventions are filmed for later analysis and to subsidize reconstruction and development of new possibilities of interactional arrangements so as to contribute to subjects' development across contexts.

Besides the scenes of joint attention, which have been promoted as part of the methodology of intervention, subjects had the opportunity to interact with physical AC materials as instruments of mediation of those scenes. Then, during the first weeks, AC material employing both low and high technology was used along with other resources, as Presented in the figure 3.

Mediating actions had a focus on the triadic interactions of the mediator with subjects and objects acting as instruments of mediation to further expand the interactions with the other subjects. With the first interventions in the lab, it was possible to establish bonds with the children and get to know their needs and potential. Furthermore, with the help of their mothers and school teachers, it was possible to outline a descriptive profile of their forms of communication, social interaction and initial potentialities.

In spite of the same diagnosis, the three children have very distinctive characteristics within the symptoms of the syndrome and are accompanied by diverse professionals in therapeutic interventions. They are referred to as Case 1, 2 and 3 in the table 1.

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10 In the beginning, meetings were shorter and gradually increased in time.

11 Open interviews, anamnesis and consent forms

Figure 3. Example of AC material of low and high technology

Case 1	Boy, 3.10 y.o., living with his parents and two older sisters; attends nursery (level 3) school in the afternoon.
	Some abnormality in his development was noticed at the age of 1.3 y. o. as he did not show any vocabulary. ASD was diagnosed at the age of 1.9 by a team of professionals (pediatrician, neuropsychologist and a psychiatrist).
Communication	Makes some sounds, makes meaningful facial expressions (looks) to pay attention, when he is called, to get to know the environment and closes his eyes in protest. He smiles to demonstrate satisfaction and joy and cries, grumbles and mumbles to show contrariety. Body expressions involve pointing and touching what he wants with his finger and waving. Is starting AC with speech therapist. Communicates spontaneously through gestures in order to have his wishes realized. Does not present stereotyped behavior.
Social interaction and understanding	Accepts touch. Understands the meaning of the objects and his own existence. Demonstrates understanding of other people without engaging in turn taking. Interacts when is requested to by sitting at a table. Can interact with objects and other people for short or medium periods of time.
Potencialities – preferences	Can deal with changes in routine. Does not react contradictorily in the presence of people who are strange to him. Is fascinated by lights, fans, drains and objects that spin. Appreciates looking at the mirror. Use communicative gestures through meaningful facial and bodily expressions. Can hold a pencil, paints with some limitation, scribbles. Uses his index finger to point at things he wants. Can eat with independence and can put on shoes without shoelaces.

Case 1	Boy, 3.10 y.o., living with his parents and two older sisters; attends nursery (level 3) school in the afternoon.
	Some abnormality in his development was noticed at the age of 1.3 y. o. as he did not show any vocabulary. ASD was diagnosed at the age of 1.9 by a team of professionals (pediatrician, neuropsychologist and a psychiatrist).
	Is in the process of toilet training and learning to dress and undress with independence.
Case 2	Boy, 4.2 y.o. lives with parents and a brother. Some abnormality in his development was noticed at the age of 2.3 y.o.. ASD was diagnosed at the age of 2.3 by a neuropediatrician and psychologist. Attends nursery school in the afternoon.
Communication	Presents some language delay. It is difficult to understand what he says. Uses a proper language. Understands speech but does not engage in turn taking.
	Facial expressions are observed when he is upset, cries and grumbles to show contrariety.
	Does not sustain visual contact. Knocks his head to call attention or squeezes his arms and legs. Moves his hands and fingers in a strange way.
	To get what he wants, uses other people's arm or hand. Pointing is not part of his routine.
	Has difficulty in sitting still or remaining in an activity.
	Likes to scribbles, but with no apparent meaning.
	Does not use any form of alternative communication.
Social interaction and understanding	Resists to be touched. Contact is accepted only by family members.
	Limited understanding of the meanings of objects or people.
	Does not get attached to his environment or shows a sense of belonging.
	Interaction is restricted to objects when they are interesting to him and gets attached to them.
Potencialities – preferences	Appreciates music, fascination for lights, mirrors and bright eyes.
	Hyposensitive in relation to senses, laughs for no apparent reason, shows good coordination.
	Likes to jump, lie on the floor and run.
	Food compulsiveness needs to be managed.
	Depends on other people to dress, undress and for hygiene.
Case 3	Boy, 3.5 y.o. lives with parents. Some abnormality in his development was noticed at the age of 1.3 y.o.., neurologist attested ASD. Uses anti-psychotic (Resperidal) and anti-convulsive medication. Attends nursery school in the afternoon..
Communication	Oral communication is expressed through few grumbles.
	Communicates through gestures with people who are familiar to him. To get what he wants, uses other people's arm or hand. Does not point at objects.
	Facial expressions are observed when he is displeased, cries and grumbles to show contrariety. Frustration is expressed through aggression (beating himself and others, pulling one's hair, bites).
	Shows great difficulty in demonstrating what he wants to communicate.
	Does not use any form of alternative communication.

Case 1	Boy, 3.10 y.o., living with his parents and two older sisters; attends nursery (level 3) school in the afternoon.
	Some abnormality in his development was noticed at the age of 1.3 y. o. as he did not show any vocabulary. ASD was diagnosed at the age of 1.9 by a team of professionals (pediatrician, neuropsychologist and a psychiatrist).
Social interaction and understanding	Does not accept physical contact and does not make eye contact.
	Elects small spaces to stay.
	In some moments, he seems to "unplug" and becomes apathetic to everything and everyone
	Does not accept the mediation of the researcher and in rare moments, it happens with some object he is interested in.
Potencialities – preferences	Loud noises call his attention, shows fascination for lights, interest in small details of objects.
	Keeps a fixed and strange look at his fingers and hands.
	Often puts objects in his mouth.
	Faces difficulty to run, jump, climb and go down the stairs.
	Exaggerated attachment and attraction to certain objects, likes to spin them and does not use games properly.
	Changes in routine are not well accepted. Sometimes he is too active and other times too passive. Is afraid of wide spaces and symmetric floor.

Table 1. Initial profile of communication, social interaction and potentialities of subjects.

As can be noticed, only one of the subjects used the pointing function. Due to that, initial sessions focused on actions to make that gesture meaningful. SCALA software was used in two versions with symbols and boards with tablets. In the beginning, there was a great need to associate concrete material with the symbols in the boards and, afterwards, the gesture of pointing emerged with the fascination for the tablet technology.

The subject from case 2 accepts to be touched and soon learns to point. He also increases lateral visual contact. Although we accomplished only a few instances of mediation, he started interacting with the technological tool and increased attention span through the observation of details. On its turn, subject 1 improves pointing and eye contact and starts participating in scenes of joint attention in response to the employed mediating actions (mediator-subject-object). He soon shows great autonomy in dealing with the tablet. At last, subject 3 required more time to accept some physical contact and to fix his eyes on the activities proposed. Pointing was initially motivated by the sound produced by this touch on the screen.

Together with SCALA, several free applications have been tried with the children (Figure 4). Applications were picked according to the profile of each of the subjects and that was important to promote the appropriation and understanding of the technology, as seen in Figure 5, along with the use of AC boards (Figure 6).

Figure 4. Using different *tablet* applications

Figure 5. Using *tablets* with subjects with autism

With the use of tablets, we could notice attention spans increased for all the subjects. Speech was also prompted in all mediations. So, subjects' range of vocabulary has increased. Subject 1 showed easiness with the technology and the participation as an intentional agent in mediated actions. He is currently producing more words with two syllables and participating in scenes of joint attention in the mediations with other subjects.

Although subject 2 demonstrates he prefers to interact with the equipment on his own, he also starts participating in scenes of joint attention in the mediated actions. In some few instances, he initiates interactions with the other subjects spontaneously. It is possible to notice the verbalization of some isolated words and that he accepts being touched and demonstrates affection through hugs and kisses.

Subject 3, through mediating actions accepts touch and demonstrates affection through kisses and hugs. Aggression is only expressed when he feels some pain. His interactions with the object increase and he starts participating in some mediating actions with the researcher. Only one word was said after great insistence, but the symbols of alternative communication start being understood, which is likely to contribute to his way of communication soon.

Figure 6. the use of SCALA with subjects with autism in the tablet and a board with symbols

The first image of Figure 3 shows one of the subjects interacting with AC software – SCALA. The second shows a board constructed with the software and meant to be used in the mediated actions. The third image is a board adopting low-technology with printed material.

Apart from the work in the laboratory, mothers were asked to use alternative communication at home. As needs came up, mothers turned to us and together we constructed boards. A tablet was purchased by two families (subjects 1 and 2), so the children started using it in family contexts too. As for schools, the teachers of subjects 1 and 2 have requested some boards to use in that environment too, but we perceived a lack of understanding about how to integrate AC in the school context. Therefore, we are providing two training courses, for teachers and assistants and for the school team.

The results referred here are preliminary as the project stretches until 2013. However, they are consistent with previous research [27, 33, 50, 63] showing relevant outcomes for the social and

cognitive development of subjects with autism through the use of digital learning environment as instruments of mediation. Just as the present study, they have also adopted a sociohistorical view where mediating actions widen the level of development through the use of symbols and tools in a way that the zone of proximal development is adjusted until internalization of concepts is complete.

In fact, we can consider the significant improvement in both social interaction and cognitive development of subjects with autism with the introduction of technology from a sociohistorical perspective as it allows more flexible adaptive and abstraction processes with increasing levels of complexity.

7. Conclusion

To sum up, it is important to highlight that developing assistive technology for alternative communication as proposed in this chapter, that is with Context-Centered Design, implicates a multidimensional process involving technological innovations, pedagogic mediation, cultural practices and contexts, as well as, specific formations pervaded by critical analysis to favor the creation of new technologies with differentiated theoretical and methodological proposals.

The introduction of alternative communication can go far beyond the specialized spaces in the scope of Health and Education, such as the rooms of multifunctional resources[12], for instance. For those who need it, alternative communication is a tool to be used in varied social spaces and systematically in daily life.

Acknowledgements

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12 Rooms of multifunctional resources are equipped with diverse assistive technologies applications that are distributed by the Ministry of Education to regular public schools that serve students with disabilities or special needs through a specialized educational support outside school hours.

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