Contribution of tablets to the support of children and adolescents with autistic disorders

Case studies

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ABSTRACT. Despite their recent arrival on the high-tech market, touch-screen devices are becoming increasingly present in our everyday lives. In this study, we have focused on the potential advantages of these devices, in particular to children and adolescents presenting an autistic disorder. Two exploratory studies were carried out to collect and to analyze information regarding the behavior of children/adolescents with autism when a tactile device is used. One presents the results obtained during a self-confrontation task carried out with adolescents presenting Asperger's syndrome, and the second as part of a categorization task for young children with autism using two different situations (so-called classic teaching materials, consisting of paper illustrations, and an iPad tablet). Although the tablet generates

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a lot of interest in all subjects, study one demonstrates that it tends to be the best exercise device for the children whereas study two serves to identify the advantages of self-confrontation. Even though these studies remain exploratory due to the low number of participants and the range of their autistic disorders, they reinforce the results obtained during previous work (also carried out with a low number of subjects) and encourage further research in the field of technological innovation and cognitive disability.

RÉSUMÉ. *Apparu depuis peu, le tactile est maintenant de plus en plus présent dans notre vie quotidienne. Nous nous intéressons dans cette étude aux éventuels apports de ce support, en particulier pour des populations d'enfants ou d'adolescents présentant un trouble autistique. Deux études exploratoires ont été menées afin de recueillir et d'analyser les comportements d'enfants/adolescents avec autisme. L'une a été menée, à l'aide d'une tablette tactile, auprès d'adolescents atteints du syndrome d'Asperger et présente les résultats obtenus lors d'une tâche d'autoconfrontation. L'autre, menée sur de jeunes enfants avec autisme, a été réalisée à partir de deux supports différents (support dit classique comportant des vignettes papier et tablette tactile) lors d'une tâche de catégorisation. Si pour l'ensemble des sujets, la tablette suscite beaucoup d'intérêt, l'étude 1 permet d'identifier les bénéfices de l'autoconfrontation et indique que la tablette tactile tend à être un meilleur support d'exercices. De même, les résultats de l'étude 2 montrent que les enfants avec autisme semblent plus réceptifs à l'apprentissage avec un support de type tactile. Même si ces études restent exploratoires compte tenu du faible nombre de participants et de la diversité de leurs troubles autistiques, elles viennent corroborer les résultats obtenus (sur peu de sujets également) lors de différents travaux antérieurs et encouragent la poursuite de recherches dans le domaine de l'innovation technologique et du handicap cognitif.*

KEYWORDS: *tablet, autism, self-confrontation, categorization.*

MOTS-CLÉS: *tablette tactile, autisme, autoconfrontation, catégorisation.*

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1. Introduction

Nowadays, New Information and Communication Technologies (NICT) are becoming increasingly incorporated into educational practices. Indeed, the benefit of NICT for teaching is exploited through Digital Work Environments (DWE), which provide online access to resources through specialized software or, more simply, through the Internet.

NICT also stimulate exchange between individuals. For example, they allow for the creation of a collaborative area, i.e. a computerized environment aimed at encouraging peer collaboration, through the sharing of each individual's capabilities to successfully achieve a common target.

Thus, certain studies (Hernandez-Serrano, Gonzalez-Sanchez, & Munoz-Rodriguez, 2009) have been carried out aimed at determining the basic principles of the creation of a Digital Work Environment (DWE), promoting social interaction. The main results observed show that individuals become more involved in environments that promote social interaction. The authors conclude that by facilitating social interaction, NICT may promote the development of the exchange of knowledge and know-how. The same is true of seniors that may benefit from the use of tablets adapted to their needs (Vandi, Rico-Duarte, & Tijus, 2001).

They may therefore also help with the care and support of children and young adults with mental or cognitive disabilities with a view to achieving school, social and workplace integration by contributing to current programs in place to assess and support them (Adrien & Gattegno, 2011).

The aim of the two exploratory studies presented in this article is to understand the contribution of tablets as support and learning aids for individuals with autism. For the first case study, the idea is not to show that touch-screen devices can be the best method for supporting adolescent subjects with autism, but to suggest other types of games that may also be efficient in their treatment and therapeutic monitoring. The second case study aims to assess applications specially designed to be used on a tablet, to help young children that also have an autistic syndrome learn categorization.

1.1. Autism, support and assistance in the development of children with Autistic Spectrum Disorder (ASD)

Autism is a Pervasive Developmental Disorder (PDD), now more commonly known as Autistic Spectrum Disorder (ASD). This disorder appears during childhood (before the age of three) and is characterized by three main aspects which are qualitative impairment in social skills, qualitative impairments in verbal and non-verbal communication, and restricted interests and/or repetitive behavior (Adrien & Gattegno, 2011). Individuals with autism demonstrate a pattern of behavior characterized by autistic withdrawal that manifests itself through a lack of interest in others and indifference towards them, as well as emotional indifference and a lack of emotional expressiveness. Children may appear completely detached from all that is happening around them. They do not seek contact and may even refuse it or avoid it. Considerable heterogeneity is observed in subjects with autism in terms of cognitive abilities. In the same child, all cognitive activities are not developed in the same way. However, the average IQ is in general, for the majority of them, below 55, which indicates a deficiency (Rogé, 2011).

Various support programs exist to help children with ASD which use specially-adapted methods, new tools and new technologies. For example the ABA method ("Applied Behavior Analysis") which is the result of behavioral studies, where all of the concepts and principles that it applies are aimed at encouraging functional behavior that is adapted to society (Foxx, 2011).

The TEACCH program (Treatment and Education of Autistic and Communication Handicapped Children) was created in 1971 by Eric Schopler. This program does not aim to teach a specific form of behavior to a child, but rather to assess the prerequisite skills needed to behave in this way and to teach children these skills when they do not have them by placing them in an environment which encourages the learning of these missing skills. The focus is on the development of forms of communication. This method suggests that professionals and parents work closely together and that parents are trained as soon as a diagnosis is made. The TEACCH program anticipates the needs of future adults with ASD.

The recently implemented IDHSFC (Intervention, Development, Home, School, Firm, Coaching) program (Gattegno, 2003; Gattegno & Rogé, 2001; Gattegno, Fernier, Granier-Deferre, & Adrien, 2005; Adrien *et al.*, 2001) is aimed at developing individual integration projects for children and adults with autism into mainstream environments (school or workplace). The program's purpose it to create and build conditions that allow for a better regulation of cognitive and social learning for these individuals, as well as improving their cognitive and emotional structure with a view to appropriate social integration. The aims "of such a project" were to allow people with autism to flourish and achieve their potential by supporting their achievements, reducing their failures and encouraging the creation, development and maintaining of social ties. The IDHSFC program is currently used in France (Gattegno, 2003; Gattegno, Abenhaim, Kremer, Castro, & Adrien, 2006) by psychologists specializing in the assessment and care of individuals with development disorders. Their knowledge of these disorders is therefore crucial for the child's care, integration and assessment (Wolff, Gattegno, & Adrien, 2005; 2009). It is in this context that the project to integrate tablets as a support tool came about.

1.2. Benefits of Information and Communication Technologies (ICT) to people with a cognitive disability

ICTs, which are primarily based in the digital world and that of Internet, have recently been enhanced by the emergence of *serious games* (mental exercise, played on a computer in accordance to specific rules, which uses entertainment to achieve objectives). The idea of learning while playing games is extremely attractive to the majority of users (Hussaan, Sehaba, & Mille, 2011), and especially for children with an Autistic Spectrum Disorder (ASD) which are highly motivated by computer-based activities, and that they make significant progress in terms of vocabulary, emotional expression and the resolution of social issues (Battocchi *et al*., 2008; Mazurek, Shattuck, Wagner, & Cooper, 2012). Some software even offer interactive games specifically designed for children with autism (Tanaka *et al.*, 2010). These games aimed at face discrimination, such as recognition through changes in expression, orientation, etc. The results demonstrated that this software helps develop a skill which is very weak in people with autism: face recognition. Interactive systems based on Distributed User Interfaces (DUI) equipped with Radio-Frequency Identification technology (RFID) such as tabletop or collaborative wall display projector give multiple possibilities to help children (Kubicki, Lepreux, & Kolski, 2012) or people with cognitive disabilities because these new environments are more natural to use than a computer connected to a keyboard and a mouse (de la Guia, Lozano, & Penichet, 2012). These systems provide the use of familiar objects or toys which can be easily moved on connecting surfaces, therefore interactions human-machine are facilitated and learning is easier.

It’s the same case with people affected by Alzheimer’s disease: to stimulate their cognitive abilities, collaborative and interactive game (*Co-Brain Training* system) was developed using tangible and DUI with Near Field Communication (NFC) and mobile technologies (de la Guia, Lozano, & Penichet, 2013). Because these games presented on new media are attractive, provide training in a fun, and don’t need an experience with computers, they can help seniors to develop attention, language, executive functions or memory.

In terms of touch-screen interfaces, the interaction between human and machine where users use their fingers to move certain objects or navigate menus, is also more natural than classic interaction with a mouse and less cognitive and motor efforts are required to choose using this type of device than with indirect pointing devices (such as a mouse for example). Moreover, the use of a touch-screen device is very intuitive and therefore does not require learning, contrary to using a keyboard or a mouse (Decle, 2009). Finally, a touch-screen device has the advantage that it can be used by several users simultaneously. In contrast, a mouse often remains in the hand of one unique user (Villata, 2009). In the case of cognitive disorders, the sensory and intuitive aspects of "touch-reaction" may help with the understanding and use of new technologies as it is recognized that people with autism prefer proximal (touch) to distal perception (vision and hearing). Vibratory feelings are also often sought after.

Language impairment is one of the most common problems among children with autistic syndromes. The aim of Rahman *et al*.’s paper (2011) is to study the introduction of interactive games in traditional therapy in order to help improve the speech of children with autism. The results are in line with their assumptions. The authors however stress the importance of designing various software according to the development of each child. They also underline one specific aspect of ICTs in that children experience a sense of security as the answers are predictable and consistent.

The Morgan Autism Center (based in San Jose, California, United States) is a school that accommodates children and adults with autism. In this school the iPad is used as a learning tool. The team is adamant: the use of tablets has helped children improve their communication and collaboration abilities (Staley, 2012). Moreover, the fact that the touch-screen device can be accessed by more than one user at the same time may help encourage collaboration and interaction between individuals while a game is played together on a tablet. The Battochi *et al.* study (2008), on the use of touch-screen devices to improve collaboration among children with pervasive developmental disorders, highlights one possible use of these devices for children with disabilities. The aim of this study is to assess the level of collaboration between subjects using verbal and non-verbal indicators of social behavior. To do so, the authors chose to use a touch-screen device: the DiamondTouch table (DT). Results show that the use of the DT encourages social interaction in general.

Similarly, an experiment was carried out to analyze interaction behaviors of pairs of subjects with autistic disorder or with a mental deficiency during an execution of *tangram* puzzles performed on a tablet computer, or in the conventional way using wooden pieces (Amar, Goléa, Wolff, Gattegno, & Adrien, 2012). Results suggest that the touch pad generates an increased motivation in comparison with the wooden tangram, and promotes positive interaction between subjects. They also show that communication and collaboration behaviors increased when an unsolved puzzle was presented on the tablet, unlike the wooden game which generated rather negative behaviors and verbalizations, signs of fatigue and avoidance behaviors.

Using these various works as a basis, two exploratory studies using a tablet such as the iPad were carried out, to understand the possible advantages of their use for children and adolescents with autism. The first experiment using *tangram*-type puzzles focused on collaboration behavior in situations of self-confrontation among five subjects with Asperger's syndrome[1], and the second studied the effects of using applications specifically suggested by the *LearnEnjoy*[2] team to carry out categorization tasks among five children with autism with developmental ages of 2-5 years.

The self-confrontation tasks, carried out as part of *Social Ability Training (SAT)*, may encourage collaboration and interaction and the categorization tasks simplify the environment in order to understand and organize it better (Shulman *et al.*, 1995). Categorization is therefore a core function in an individual's interactions with his or her physical and social environment.

1.3. Social Ability Training (SAT) and categorization

1.3.1. SAT

Social Ability Training (SAT) is a structured method used to teach the social skills required for interpersonal relationships and to promote the maintenance and generalization of these skills in the patient's everyday life (Gattegno & de Fenoyl, 2004; Chambon *et al.*, 1993, 1995; Chambon & Marie-Cardine, 1993). Its aims were: cohesion within the group, the expression of thoughts and feelings, knowing how to respond to others in an appropriated manner, and the generalization of acquired skills for daily life (Gattegno & de Fenoyl, 2004).

Using videos of role play exercises that the subjects took part in, they are asked to comment in a self-confrontation situation. In order to evaluate both verbal and non-verbal behaviors, Gattegno and de Fenoyl (*op. cit.*) have drawn up an assessment chart: ASAIR (the Assessment of Social Abilities required for Interpersonal Relationships).

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1. ASD: characterised by significant difficulties with social interaction, associated with restricted interests and repetitive patterns of behavior. Language and cognitive development are nonetheless relatively intact compared to other autistic spectrum disorders. Although not included in a diagnosis, clumsiness and atypical language use are often reported (McPartland & Klin, 2006).
2. http://learnenjoy.com/

Results from the monitoring of a subject over a period of several months show that behavior tends to improve gradually over time, which favors the assumption that self-confrontation may be efficient for subjects with autism. This experiment, along with the ASAIR, thus forms a basis for reflection on the possible advantages of new devices for self-confrontation, such as an interactive game developed for a iPad tablet in this case (but it could be also developed for other devices). This will be presented in the first case study hereafter.

1.3.2. Categorization

The autistic syndrome has an impact on an individual’s cognitive functions and categorization is also affected, as shown by Shulman *et al*. (1995). Their study compares the performance in various categorization tasks of 16 subjects with autism (aged 13 to 34) and 16 "random" subjects (aged 5 to 11) chosen based on their developmental age. Both groups presented similar results in the perceptive categorization task (by shape, color, etc.), but the subjects with autistic disorders scored much lower than the other subjects in the conceptual categorization tasks (associating animals or vehicles). The authors argue the assumption that a shortfall in language functions affects the classification abilities of individuals with autism.

People with ASD appear regularly to learn how to recognize the categories, but have difficulty implementing a strategy to recuperate these categories in order to process the information. This is shown in the study by Minshew, Siegel, Goldstein, and Weldy (1994), in which the authors subjected people with autism to the *Twenty Questions Procedure* and compared not only the results, but also the asked questions by the subjects, with the results of a control group of random participants. The *Twenty Questions Procedure* is adapted from the 20 questions game: the subject must guess what the researcher is thinking of from a list of items visible to the subject. An analysis of the questions asked shows that the individuals with autism eliminate items one at a time whereas the individuals in the random group ask questions covering categories of objects in order to eliminate more than one item at once. Subjects with autistic spectrum disorders therefore struggle to implement strategies that aim to regroup information on the various categories presented to them in order to solve a problem.

Other research (Gastgeb, Dundas, Minshew, & Strauss, 2012) presents the assumption that the impairment in the categorization abilities of individuals with autism is due to their difficulties in establishing prototypes (with a category based on its prototype, which demonstrates the most typical characteristics of the category in question (Rosch, 1973)). Individuals with autistic syndrome therefore cannot establish a prototype for a category stored in their memories. This cognitive ability is key for learning, as it allows information to be processed more quickly and more efficiently. This assumption may be associated with the preference shown by people with autism to focus on details (Frith & Happé, 1994), as described by Piaget’s studies about relations between “parts and the whole”: the child perceives the parts of an object before perceiving the whole of the object.

Categorization has been the subject of many studies, in particular among persons with ASD, because we know since Piaget and Inhelder (1959) that it is a key cognitive function that allows us to deal with concepts and organize the environment.

Recently, the *LearnEnjoy* team has developed categorization applications for children with autistic disorders. The second study presented in this article therefore aims to compare the results from two media (classic/touch-screen) during categorization tasks.

The two underlying studies aim to show that the tablet may be a useful support and learning aid as part of both Social Ability Training (SAT) and categorization tasks.

2. Case study 1: Social Ability Training (SAT)

2.1. Method

2.1.1. Participants

After achieving the compulsory authorization and guaranteeing anonymity to those involved, five subjects with Asperger's syndrome agreed to take part in this experiment. They were divided into to "play" groups according to their age: two subjects aged 11 and 13, and three subjects aged between 14 and 15. They are part of the ESPAS-IDDEES Psychology Practice[3] SAT groups where they are monitored regularly.

2.1.2. Procedure

For each of the two groups, the experiment took place as part of a one-hour SAT session, during which the subjects took part in two periods of play of around 10 minutes each. Each session was supervised and led by a therapist and psychologists from the ESPAS team and proceeded as follows: the subjects (who were briefed in advance on the content of the session) were filmed playing together for five to ten minutes with the "*Tangram Puzzle Pro- secret garden*" application on the iPad. This application was chosen as the handling of the pieces of the tangram is extremely intuitive and does not present any problems. The user has the choice of a number of possible shapes to create. The shapes mainly represent animals and the pieces are in a neutral tone (wood colored).

At the end of the first period of play, the subjects watch the video made of their actions (self-confrontation situation). The group leaders then ask them a list of pre-defined questions in the aim of making them react to their behavior and their collaboration. They also offer advice on how to improve their collaboration during the second period of play.

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3. ESPAS-IDDEES Psychology Practice, 97 avenue Charles de Gaulle, F-92200 Neuilly-sur-Seine

This second period (game 2) proceeds like the first period: it also lasts between five and ten minutes and is also filmed, but the subjects must take into account the comments made and advice given during the first self-confrontation phase. After using the tablet for the second time, the group leaders again ask the subjects to react to their level of collaboration, their communication and any differences noted compared with the first period of play.

2.2. Data collection procedure

The video recordings of both sessions were analyzed using an observation chart drawn up based on work by Amar, Golea, Wolff, Gattegno and Adrien (2012) and by Gattegno and de Fenoyl (2006). This chart has three main categories, the most important of which in this case being positive/negative interaction behaviors, the category called "neutral behavior" which includes the "random" and "classic" actions towards a given task:

– "Neutral behavior": "Taking initiative", "Expressing an idea to complete the task", "Requesting an opinion on an action", and "Expressing a problem".

– "Positive behavior": "Expressing agreement with an idea put forward or an action carried out", "Making a positive criticism regarding a participant", "Doing what the other says".

– "Negative behavior": "Expressing disagreement with an idea put forward or an action carried out", "Making a negative criticism regarding a participant", "Ignoring what the other says", "Rejecting a participant".

Mean intercoder reliability (number of agreements + number of disagreements) based on a random sample of 20% of observations was 92%.

The time spent using the tablet and the various types of behavior were noted and then analyzed in terms of relative frequencies.

2.3. Data analysis

Analysis was carried out on both an individual and overall basis (for all of the subjects by game). Figure 1 below compares the relative frequencies of behaviors in an aim to measure the effect of self-confrontation on the subjects (game 1: before self-confrontation; game 2: after self-confrontation).

The results support those obtained by Gattegno and de Fenoyl (2004) on a subject monitored longitudinally: although the "neutral" behavior with no particular connotations are almost identical, we see that the positive behavior tends to increase (difference of 5%) and the negative behavior decreases (difference of 6%).

In terms of time spent using the tablet and verbalization, we also noted that self-confrontation had a beneficial impact on all subjects: those who did not use the tablet or who spoke very little during the first period of play doubled the time they used the tablet and expressed themselves better during the second period of play.

The same is true for those who appeared to monopolize the device and discussions: after the self-confrontation session, they withdrew slightly to let their partner express themselves.

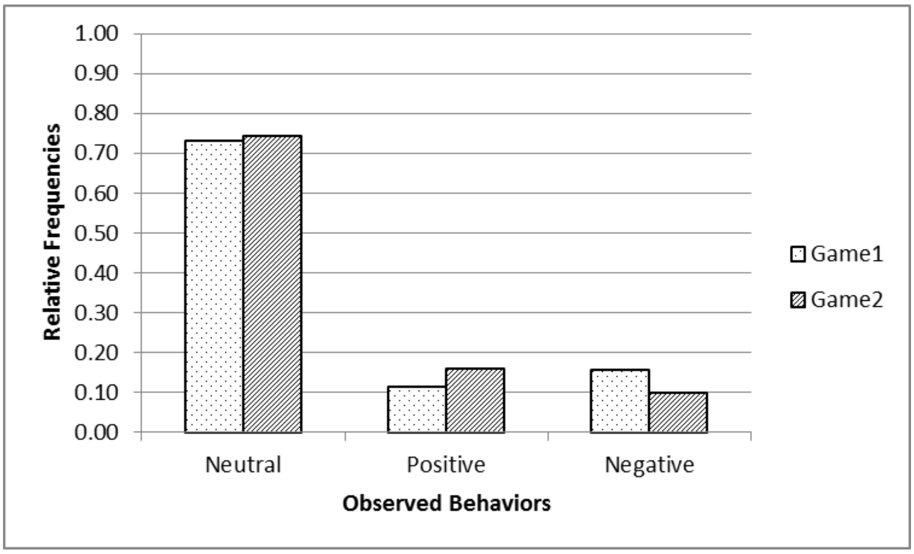

Figure 1. Behavior analysis and effects of self-confrontation

The therapists noticed that from the very first period of play, and in both groups, the group game on a tablet quickly accentuated the profile of each subject. Some subjects imposed themselves directly both verbally and physically whereas others withdrew. During self-confrontation, the subjects quickly became aware of their behavior and of what they could do to improve their interaction with their partner. In both groups, self-confrontation was beneficial as every subject made the effort to correct their behavior and a real difference in behavior was observed between the first and second period of play. Self-confrontation therefore had a positive impact on inter individual relationships and the young users particularly enjoyed the fun side of the tablet which some of them also used at home.

Moreover, for some types of person with Asperger's syndrome, the tablet brings another advantage: for example, one of the subjects who was fairly withdrawn had difficulty replying orally to an instruction or a request, which may often give the impression that he is not listening. Using the tablet was particularly beneficial for him as it allowed him to give a motor response as opposed to a verbal response. According to the therapists, the use of the tablet is interesting for the SAT session as it allows for an alternative method of response to the verbal response.

3. Case study 2: Tablet and categorization task for children aged two to five

3.1. Method

Also through the collection of observations, we decided here to study the behavior of children with autism, of a developmental age of between two and five, who were confronted with categorization tasks. These tasks were presented using two different tools for the same exercise: paper illustrations (label format) and tablet (iPad format). The aim is to see the tablet as a new fun learning tool that may encourage the cognitive development of the children and make interaction with the real world easier.

3.1.1. Participants

Seven children with Autistic Spectrum Disorder (ASD) took part in this study, all of which are patients at the Policlinique Ney (Bichat Hospital, Paris). The center currently treats 13 children and about half of the parents accepted to let their child take part. The children are aged between five years and six months and seven years and three months. In terms of developmental ages, six of the children have been assessed using PEP 3 (Psycho Educational Profile, 3rd edition). Developmental ages range from 1.25 years to 1.75 years in terms of communication (mean: 1.53 years), and from 1.2 years to 2.75 years in terms of motor ability (mean: 2.05 years). The seventh child had a higher developmental age and was assessed using WPPSI III (the Wechsler Preschool and Primary Scale of Intelligence).

3.1.2. Material

Two tools were used: an iPad tablet with the specific *LearnEnjoy* applications, and printed labels (paper labels condition). All seven subjects were observed using both formats (touch-screen/labels conditions) which were presented randomly.

For the “touch-screen device”, the *LearnEnjoy* categorization tasks are divided into three applications (“Basics”, “Progress” and “Preschool”) designed for people with ASD, but which can also be used by individuals with a mental disability or presenting intellectual, cognitive and social skills deficiencies. These applications respect a logical and complementary improvement in a child’s motor and cognitive abilities.

The Basics application aims to teach the basics of communication, understanding and independence. This application also allows users to familiarize themselves with pre-school skills.

The Progress application aims to encourage communication and develop the skills needed for conversation. This application helps work on abstraction and introduces reading, writing and mathematics.

The Preschool application helps develop richer and more complex conversation. It includes reasoning exercises and helps strengthen basic school skills.

Each of these applications has five activity categories: Understanding and organizing, Communicating, Daily living, Playing and interacting, Contemplating school.

Between 20 and 30 activities are available in each of the five categories. The same activities are available in each application, Basics, Progress and Preschool, but with varying levels of difficulty.

As we highlighted in the first section, categorization is a key cognitive function which allows us to deal with concepts and organize the environment. However, individuals with autistic disorders have trouble establishing prototypes and therefore categorizing. Children with ASD at the Policlinique Ney are used to carrying out this type of task using printed labels. For this reason, the categorization activities from the *LearnEnjoy* application in the “Understanding and organizing” category were used for all three applications (Basics, Progress and Preschool). Each category of these three applications has different sets which correspond to exercises of increasing difficulty. See Figure 2 hereafter.

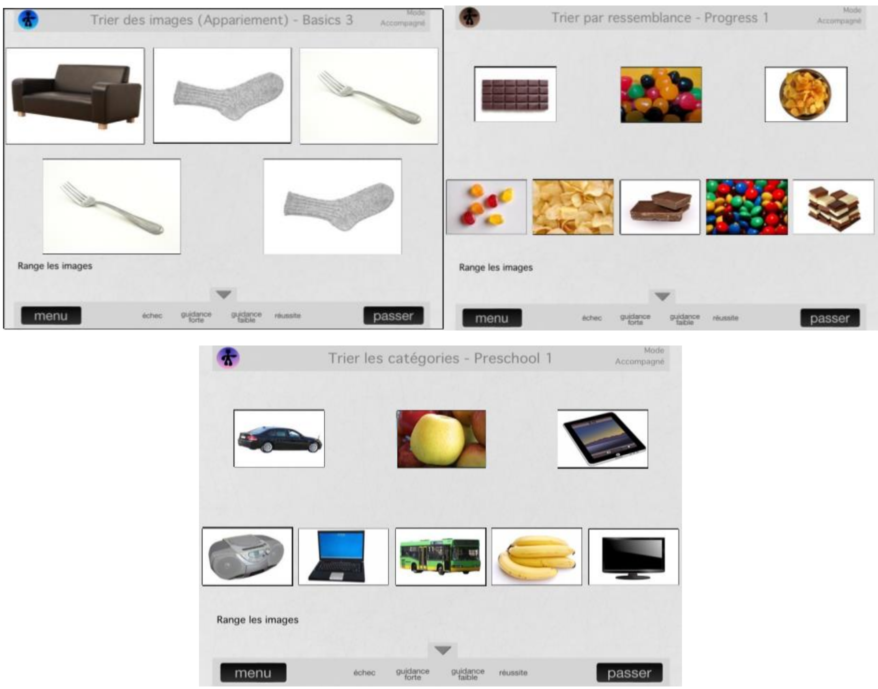

Figure 2. Illustration of the tasks in the “Understanding and Organizing” category for the Basics (top left hand image: matching), Progress (top right hand image: sort by resemblance) and Preschool (bottom image: sort by category) applications

In terms of the format of the paper labels, the images presented are the same as those presented on the tablet and their size are the same as those of the touch-screen device so that the nature of the images presented to the children is not a bias. The images from the applications were printed and then glued to laminated card.

Pre-tests carried out on four children using only the iPad (two of which did not then take part in the experiment) allowed us to define the time limit as well as which application to choose (Basic, Progress or Preschool). The pre-tests were carried out a month before the tests, and so a learning effect on the two children who took part in the pre-test can be ruled out.

3.1.3. Procedure

The experiment was carried out over a one-day period at the Policlinique Ney, during which the subjects were confronted with both formats at an interval of about two hours.

During the experiment, the child sat in the psychologist’s office, with his or her back to the wall, and did not have a view of the window in the office. This was done with the aim of avoiding all distraction from the outside world as children with ASD have limited attentional resources. One of the researchers sat opposite the child, while the other filmed.

The order of presentation of the two conditions was counterbalanced: four subjects saw the task on the iPad first and three saw the task using labels first. For both formats, the next level up of exercise was shown to each child after six successful attempts, to ensure that they did not get bored.

The time limit for each condition and each subject was four to five minutes, depending on the child’s attention span.

The time set on the iPad was as follows: the iPad was set on the table in front of the subject; the application adapted to the child’s level was launched. Once it was clear that each child had mastered the “drag” movement necessary to use the tablet correctly, the following instruction were given for the Basic and Progress applications: *Place the same with the same* and for the Preschool application: *You must sort the pictures*. If the child remained stuck on a set of images (for more than 30 seconds) the researcher named the categories to be sorted. Once the set of images were correctly categorized, the researcher pressed on “Next” to call up another set from the same level. Each time the child successfully placed the image in the correct category, he or she was congratulated by the researcher (*Well done!*, *That’s great!*). After six successful sets, the researcher took the tablet and accessed a set from the next level up so that the subject did not get bored and in order to maintain his or her attention.

The time set with the labels condition followed the same pattern as with the iPad (with the same instructions), but when the labels were correctly categorized they were removed from the table. Moving on to the next set required a little more preparation time as the labels had to be laid out manually.

All of the sessions were filmed with the authorization of the parents who received a guarantee of anonymity for their child, then the videos were analyzed using an observation chart based, as was the case for study 1, on the work of Amar *et al.* (2012) and Gattegno and de Fenoyl (2004).

3.2. Data collection procedure

All exercise sequences were filmed and the children's behaviors were videoed using an observation grid that has been communally developed in ergonomics. The behaviors were identified through a seven-step analysis (Sommer & Sommer, 1980): 1) preliminary viewing, 2) choice and definition of classification units, 3) development of an initial category list, 4) reduction of the category list, 5) classification of the behaviors by two external coders who were blind to the aim of the study and subject group assignment, 6) consensual agreement in case of doubt, 7) analysis and interpretation. Mean intercoder reliability (number of agreements + number of disagreements) based on a random sample of 20% of observations was 90%. The first viewing of the children's behaviors generated a wide variety of categories. After successive viewings, the researchers and two coders agreed to combine the categories into three major behaviors types: signs of positive contributions, signs of negative contributions and atypical behavior. The first two categories were each divided into three sub-categories: verbal communication, motor ability and non-verbal communication.

We also decided to time how long the subjects spent examining (the device or the labels, the tutor, or a third party element), correctly manipulating the tool (corresponds to moments when the subject uses the chosen tool with the aim of carrying out the assigned task), and parasite periods (when the subject manipulates the tool without the aim of completing the task, for example for self-stimulation). As the filmed extracts were all of slightly varying length, these times are presented as a percentage.

3.3. Data analysis

The varying behaviors were counted and then studied using a double-entry table called a "contingency table". This kind of table is generally used in exploratory studies to highlight any possible relations. In order to identify different behaviors in the children, we adopted an approach classically used to analyze categorical data (Darses & Wolff, 2006; Wendland, Maggi, & Wolff, 2010; Gandillot, Wendland, Wolff & Moisselin, 2012; Amar, Golea, Wolff, Gattegno & Adrien, 2012).

The children's behaviors recorded during the observations were classified into distinct categories to obtain a contingency table. Hereafter, a contingency table (see Table 1) presents the distribution of the relative frequencies – percentages – (and observed counts) of the children's 427 behaviors in the different categories for each condition. For this cross-classified data table, the global association test is carried out using the Chi-square test (χ^2 test). In addition to this global association, we also studied local dependencies (local associations) within the contingency table to highlight the specific group of cells that was over-represented or under-represented. The analysis of these over or under representations was carried out with a specific index called the Association Rate – AR - (Bernard, 2003; Corroyer & Wolff, 2003; Wolff, 2003), as presented in the next section.

Table 1. Observed relative frequencies - % - (observed counts) and observed Association Rates (AR) for children's behaviors by condition (Paper Labels or iPad)

Children's behaviors \ *Condition*	Paper Labels		iPad		
	% (counts)	AR	% (counts)	AR	Total
Signs of Positive Contribution	12.88 (55)	-0.30	16.16 (69)	+0.51	100% (124)
Signs of Negative Contribution	40.75 (174)	+0.11	17.56 (75)	-0.18	100% (249)
Atypical Behavior	9.60 (41)	+0.20	3.05 (13)	-0.35	100% (54)
Weighted mean (WM)	63.23 (270)		36.77 (157)		100% (427)

As we attempted, for all children, manipulations of paper illustrations were observed more often (Weighted Mean WM: 63%) than iPad manipulation (WM: 37%) because it is more restrictive handling paper than a tablet device.

Children's behaviors differ according to the task and global association is significant (χ^2 [2] = 27.48; $p < .0001$) but we are more interested in emphasizing the similarities (or differences) between the children's behavior (as they appear through the observations) than in knowing if the behaviors globally differ from each other. To this end, we studied the local independencies (local associations) within a contingency table to highlight which specific group of cells is over-represented or under-represented. As indicated above, the analysis of these over-representations or under-representations is carried out with a specific index called an "Association Rate" (AR).

Association Rates are used in exploratory studies since they enable local associations within a set of data to be measured. For each cell of a contingency table, the AR index between modalities is defined as the comparison between the observed frequency and the expected frequency[4]. The sign of the Association Rate

4. Expected frequency is obtained by calculating, for each cell of a contingency table, the product of corresponding marginal frequencies of the value *a* (*Variable A*) and *b (Variable B).* The expected frequency is defined as the product-frequency. In independent cases, the observed frequency is equal to the expected frequency. For each cell, the association rate is obtained by calculating the difference between the observed frequency and the expected frequency. This difference is then divided by the expected frequency. To obtain more

indicates whether there is an attraction (+) or a repulsion (-) between the modalities. The AR index can also be interpreted as an over-representation of a cell. For example (Table 1), the cell AR [Signs of Positive contribution/iPad = +0.51] indicates that the cell contains 51% more observations than it would have contained in the case of independence.

The AR indexes with a positive sign indicate similarities between the variables of the cells while negative AR indexes would indicate a disparity. Association Rates analysis can be supplemented by a geometric analysis aimed at processing a correspondence analysis (Le Roux & Rouanet, 2004). In this study, there were not enough available values to allow the use of this method. The more relevant Association Rates obtained in Table 1 reveal that signs of positive contributions are more observed for the iPad condition and there are more signs of negative contribution or atypical behavior with the label condition. These results are similar to those presented by Battocchi *et al.* (2008) and Amar *et al.* (2012).

Other results relate to the analysis of time spent by the child correctly manipulating objects, making parasite manipulations (the child manipulates without the aim of completing the task), examining the tutor or the tool, or looking elsewhere (these times are presented as a percentage).

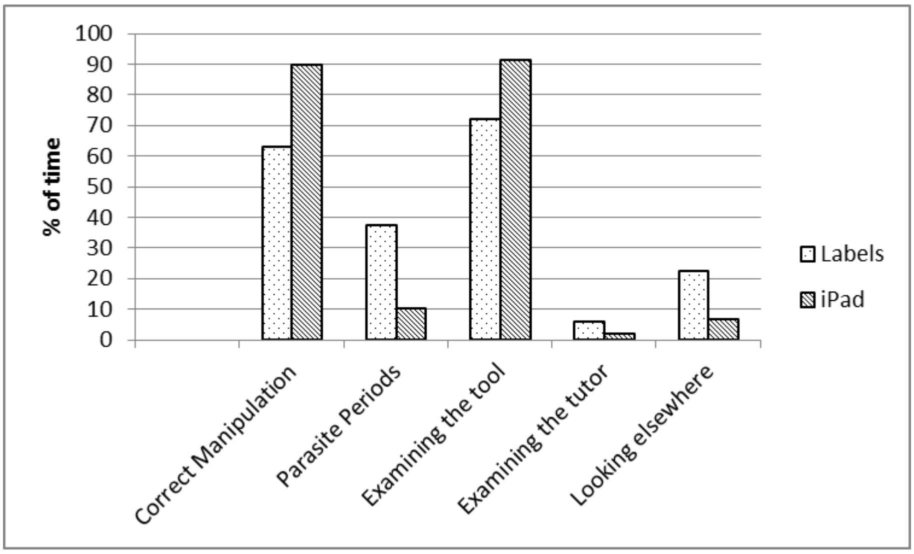

Figure 3. Relevant actions according to the tasks

information and theoretical demonstrations, see Le Roux and Rouanet (2004) or Corroyer and Wolff (2003).

Correct manipulations are more efficient for the iPad condition (90%) than the labels condition (63%) and children are more interested in examining the tool when they have a tablet in their hands (92% vs 72%). We also observe that “parasite periods” and “looking elsewhere” appear when children use paper illustrations (the item “examining the tutor” is not significant for an interpretation: < 5%).

We can draw the assumption that signs of negative contributions and atypical behaviors were more frequent when the task was carried out using the paper format because the child experienced boredom and weariness. The children regularly partake in activities using paper illustrations in the clinic. Moreover, time spent with the labels include more down time as the group leader must take the time to choose and set out the labels on the table. These few seconds are sometimes enough to lose the children’s attention. The increase in the signs of positive contributions observed during time spent on the iPad is probably due to the children’s attraction to this new device. Moreover, some of the children were already interested in computers and certain used them at home. We must therefore put these results into perspective as the time spent with the seven subjects was nonetheless slightly distorted for the reasons set out below.

Moreover, we noted that with the subject with the highest developmental age, the interactions were of a different nature. Although he drew the attention of the researcher by regularly saying *Look* while he manipulated the iPad, the time spent with the labels gave him the opportunity to joke with the researcher by associating images from different categories. This interaction was only observed with one subject, but many of the other children used the labels for purposes other than the assigned categorization task, by playing with the labels as one would play with cards, by setting them out to form triangles, squares, etc. These manipulations, considered as parasite as part of this experiment, are typical behavior observed in all children and are part of the essential creative phase in their stimulation and their cognitive and motor development.

The iPad proved an undeniable attraction for children with autism and the *LearnEnjoy* software provided structured exercises suitable for a wide range of children with PDD. However, the use of labels, despite not being as efficient for the categorization tasks, showed a range of “parasite” behavior which were inherent to childhood and knowledge indicators (the theory of mind, in this case).

A great disparity was noted in intra-individual performances depending on the time of day for certain children that the session was carried out. The first three subjects used the iPad first at the beginning of the morning and carried out the experiment using the labels at the end of the morning, which was some two hours later. We noted that even before the session the children were agitated. Although the iPad provoked an undeniable interest, the effect of the time at which the session took place must be taken into account in order to avoid drawing premature conclusions regarding the significant contribution of the iPad as a new learning tool.

Another methodology flaw which follows on from the first is that it was not possible to have the exact same time lapse between both sessions for each subject.

We believe that numerous sessions spread over numerous days per subject would have provided us with more sound data for both tools.

Most of the children experienced some difficulty in using the tablet correctly: they tended to touch the screen with the flat of their hand or randomly touch the screen, which led to the application closing down, meaning that the group leader needed time to restart the application which could suffice to lose the children's interest or to frustrate them as they had to hand back the device. Loss of attention and irritation were also observed when the tablet no longer reacted to the child's actions or if the software malfunctioned. From an ergonomic point of view, these comments lead us to conclude that the iPad presents robustness issues for individuals with ASD, issues which have also been noted in other fields and under other circumstances.

4. Discussion and conclusion

The aim of these two studies was to highlight the contribution of tablets as support and learning aids for children and adolescents with autistic disorders and/or Asperger's syndrome.

The results from the two studies point in the same direction: the tablet attracts the interest of the subjects taking part in the experiments. In subjects with autism, this interest is characterized by less negative and atypical behavior during the use of the iPad than when the labels were used, thus allowing better learning of categorization.

Interest for the tablet among subjects with Asperger's was expressed orally independently of the handling of the device. The adolescents confirmed their wish to have more sessions with the iPad. As highlighted by the therapists, the tablet quickly revealed the profile of each participant and, for one subject, provided a means to respond differently to a request than orally.

Although the results cannot be generalized, these studies provide an insight into the use of tablets as an educational tool for individuals with ASD. Other studies could focus on this topic using subjects with autism and a higher developmental age than the children we met of the Policlinique Ney, as well as with subjects with Asperger's syndrome. It would also be beneficial if the protocol dictating the time lapse between the two sessions was stricter for the comparison of the iPad/label media.

However, although the young subjects with autism like the tablet, they find it fun and easy to use, it does not only present advantages. This device raises issues in terms of robustness. We observed that the use of the iPad was not optimal for children with ASD mainly due to the capture of involuntary gestures on the touchscreen (for example if the hand is simply placing on the iPad, the application moves another exercise without possibility to cancel this interaction). These inconveniences can be particularly disconcerting for individuals with autism who have great trouble dealing with breaks in routine. People with ASD also present sensory disorders still not easy to evaluate (Degenne, Wolff, Acef, Fiard, & Adrien, 2012) and the use of less sensitive touchscreens might be best adapted.

Hence the necessity for a tool that has no sensitivity or malfunction issues, even in a wide range of conditions. Other larger devices might be more suitable for this specific population, such as a tabletop (Battochi *et al*., 2008; Kubicki, Borgiel, Lepreux, Wolff, & Kolski, 2012) or tangible and DUI (de la Guia, Lozano, & Penchet, 2012, 2013). However, touchscreen technology will, without a doubt, improve to provide better usability for specific populations.

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