Inducing Behavior Change in Children with Autism Spectrum Disorders by Monitoring their Attention

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Abstract: Children with Autism Spectrum Disorders (ASD) generally suffer from disorders which affect multiple behavioral aspects, such as communication, emotional awareness, social interaction, lack of attention, among many others. Modern technologies, are opening up new possibilities for computer-mediated interactions with increased outcomes, enabling both children and tutors to have a more effective work in the development of communicative and cognitive skills. In this article we introduce a module implemented in a platform for human-computer interaction, specifically designed for children with ASD, to control their levels of attention and test inducing behavior change. This allows us to shape new behaviors and learning strategies both in tutors and children.

1 INTRODUCTION

The constant evolution in information and communication technologies, opened a wide range of new possibilities for helping people with learning disabilities to have access to new opportunities for learning, entertainment and personal development. Children with Autism Spectrum Disorders (ASDs) are included in this group, and although many approaches have been tested, few have been adopted or successfully integrated in the day-to-day life of the children, their tutors or caregivers. This lack of appropriate tools is aggravated by the unique specificities of autistic patients. They have restricted interests and can become very fixated on them, which sometimes can be used as motivation tool. Also, general social interaction tools are usually too complex for them to use, have excessive stimuli, or are considered boring, leading to lack of interest or loss of focus. This factor makes it impossible to make generalizations about what is better for this kind of patients, creating a practical problem in software development.

With these issues in mind, we developed a multimedia platform called myTroc@s.net. The myTroc@s.net system is focused on developing the communicative competence in autistic children; all the activities are targeted at communication skills training, and are based in multimedia content: images, videos, audio and stories. These are activities familiar to the children, facilitating the platform inclusion in their lives. A detailed description of the platform can be found in (Lucas da Silva et al., 2012). Some experimental results can be found in (Lucas da Silva et al., 2011).

With the purpose of keeping children motivated and engaged in the activities proposed by their tutors, in particular targeting the improvement and shaping of new behaviors, we developed an attention management module, that provides feedback whenever the childs behavior is indicative of lack of attention.

Our goal with the attention detection module was to analyze the child attention while using myTroc@s.net. This technique was tested in an experimental evaluation where we automatically try to recover the user's attention when he looks away from the computer by triggering an auditory feedback stimuli, and evaluating if this kind of feedback contributes to have the children more engaged in their activities with the platform.

2 BACKGROUND

myTroc@s.net translates from Portuguese (the native language of the authors) to English language as *ex-*

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changes, since the root of our project was the creation of a tool to develop new communicative behaviors in children with ASD. The myTroc@s.net platform is now focused on: a) Promoting new communicative behaviors between the child and her peers, tutors and parents; b) Addressing the individual specificity of each child through fully adaptable contents and screens; c) Improving the attention and engagement through the automated analysis of behavior patterns and inducing behavior change; and d) Stimulating new social interaction patterns in the child that might otherwise not be possible, by using the computer as a mediator.

Face-to-face interpersonal communication and interaction skills of children with ASD can be very limited, creating the need for alternative approaches for their integration in social life. Having a computer as a mediator breaks several of the barriers which arise from the child being faced with a human peer. Our platform provides several tools to address this need, with the twofold objective of gradually encouraging socialization and developing communication behaviors among children with ASD. Besides the multimedia content (images, videos, audio, and stories), that children can autonomously browse through and use in their educational experience as we can see in Figure 1, there is also a message board, and content preference sharing options associated with each multimedia content item. These are important contribution of our work to the field, when compared to existing work, as they induce the social component in the child.

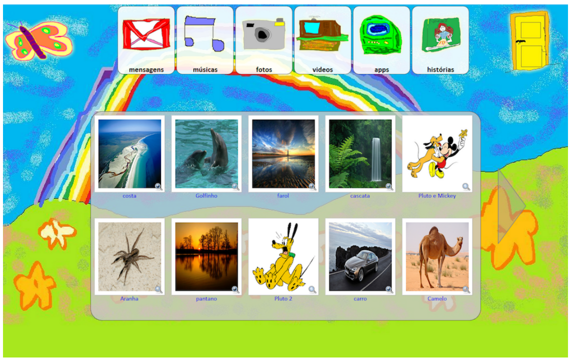


Figure 1: Picture thumbnails listing in myTroc@s.net.

In the message board (Figure 2), the child can post messages to her colleagues. The sender child has a *buddy list* with names and photos of all counterparts, from which the receiver colleague can be chosen from. The message can then be written either through text, picture exchange, or a combination of both methods. When the receiver colleague accesses the platform, he will automatically be prompted that there are new messages sent to him by others, waiting

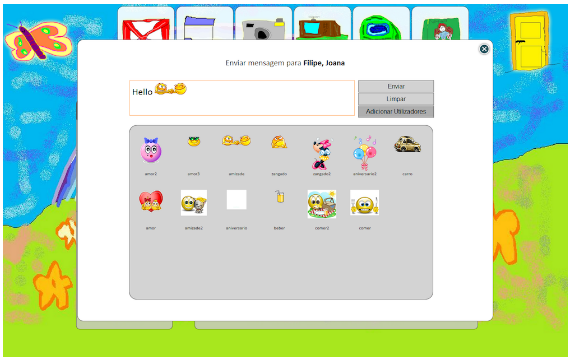


Figure 2: Message composition screen in myTroc@s.net.

to be seen in the message board.

For content preference sharing, associated to each multimedia content item (image, sound or video), there is a positive and a negative preference option. These allow the child to express and share with its counterparts at any time, his/her preference regarding the individual content item. This information is associated with the content and shown every time it is accessed, allowing all children to see the opinion of their colleagues. Figure 3 illustrates one of the activities with the content preference-sharing pane on the right side of the screen.

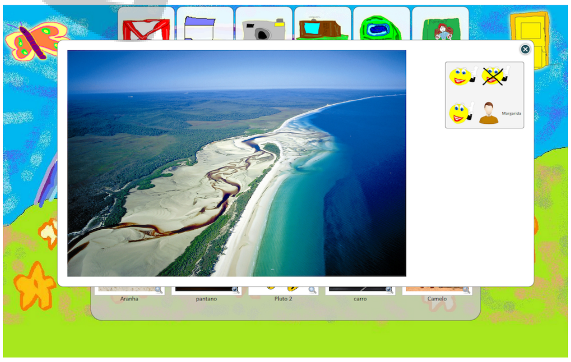


Figure 3: Message board.

The application can be fully customized with icons, background images and the contents, that allow each child to be more effective while using it. The tutor can define a user profile for each child, or use a default profile; this is done with simple drag and drop operations. Each user profile may have independent and distinct UI files, such as the HTML structure files, the CSS, the background images, the menu icons, and even the contents shown to the user can be differentiated: the images, videos and audio listing.

These features of myTroc@s.net have already shown some positive results in previous work from our group (Lucas da Silva et al., 2011), where 2 children which didn't talk to each other (despite the fact that they were colleagues for more than 2 years), began to bear each other and to show basic interaction traces after starting to use these features of the platform. Furthermore, children not only accepted myTroc@s.net as part of their daily work routines with the tutor, but also frequently requested the use of the platform.

3 RELATED WORK

The study and management of attention has been a highly active, yet poorly understood research topic over the past years.

In the context of ASD, although attention management is of paramount importance to understand how children can be engaged, few studies are found, especially in a pervasive computing framework. Most of the work to date has focused on the control of eye gaze and eye movement to understand how stimuli are processed.

This is used so it is possible to detect what interests the child has, and what strategies we can take to improve the attention levels, and is especially useful when the child possess fixation patterns or circumscribed interests. Some studies focused on orienting the object of attention in response to eye gaze with the purpose of helping draw attention (Leekam et al., 1997), or giving cues about where the object was located, having the purpose of studying the child's reaction time (Posner et al., 1984) which has been the inspiration for a vast number of studies developed throughout the years. Also, eye tracking was also used to perform tests of emotion recognitions from photographs of facial expressions (Pelphrey et al., 2002), and used in conjunction with Functional magnetic resonance imaging (fMRI) (Dalton et al., 2005) for facial discrimination tasks where researchers concluded that there was a diminished eye region fixation from subjects with ASD.

Other techniques build upon the idea of finding differences in experiments settings that are presented to the children, so that they have to find a single change introduced in the setting that it was showed, or by having an object out of context in that setting (Jones et al., 2008). These studies try to support the idea that the user suffers the influence of his preferences in the direction of attention.

In a more recent study from Kinnealey & Pfeiffer (Kinnealey et al., 2012), the authors create an installation of sound-absorbing walls and halogen lighting to increased sensory comfort for the users thus affect their engagement in classroom learning activities, having denoted an increased frequency on attendance.

Other possibilities concern targetting their interests to keep their focus. Boyd performed a study where he compared the effects of circumscribed interests to less preferred tangible stimuli on the social behaviors, and the results showed an increase in social interactions in tests with circumscried interests (Boyd et al., 2007), showing that using the target of their interests, helps to keep them attentive and motivated.

Still, many studies present contraditory findings, highlighting the diversity of disturbances in children with ASD, and the need to perform further studies (Ames and Fletcher-Watson, 2010). Our work explores a new methodology, based on real-time attention sensing and on the use of immediate feedback to improve attention and engagement.

4 ATTENTION DETECTION MODULE

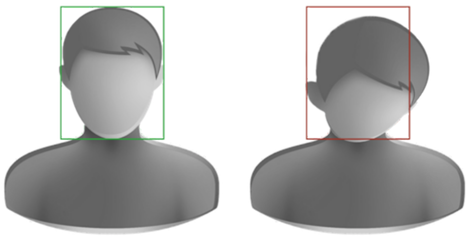
To detect the user attention while using myTroc@s.net, which will be used to evaluate the child's engagement in the platform, we used the Python OpenCV wrapper[1]. For this feature the myTroc@s.net framework uses the computer's camera, together with a Haar Feature-based Cascade Classifier for Object Detection for automated detection of the face of the child. Using the frontal and profile face cascades, if the child is not in front of the computer, or not looking at the screen, the platform detects it, and records the distraction state in the log file; on the other hand, when the child returns to the computer or looks again at the screen, the attention state is detected and recorded in the log file. Figure 4 illustrates the attention and distraction cases.

For the tests, a log system was implemented in the myTroc@s.net platform, which saved the current user, together with the timestamps in which we looked at the screen, and in which he looked away. Taking into account a physiological head movement frequency limit of 0.5Hz (Calais-Germain, 2007; Ber, 1992), the OpenCV was setup to only check for the head position every 2 seconds.

5 PROCEDURE

Trying to gather attention on children with ASD can be problematic, since that can cause them stress, making them uncomfortable or even become violent. To

[1] http://opencv.willowgarage.com/documentation/python/index.html



(a) The child is in front of the computer and looking at the screen. (b) The child is in front of the computer but is not looking at the screen.

Figure 4: Attention detection while using the myTroc@s.net platform.

Table 1: Children evaluated.

	Number of Sessions	Number of Children	Number of Computers
Sound	12	6	1
No Sound	12	6	1
Total	**24**	**12**	**2**

prevent this, we decided to use a sound that was familiar for the children, and that was already validated as acceptable for them for the children, without any negative reaction. So for our experimental tests on attention management, we used a recording with the sentence *"Hi, I am Troc@s"*, which is a part of the welcome sound played whenever the platform is launched, thus being a familiar and recognizable element for which they may respond without triggering any unexpected or unwanted reactions. Our hypothesis for this part of the work was that when feedback is provided to the child, he/she will be more attentive.

For our tests, we evaluated 12 children over the course of 24 sessions, 2 per user, in 2 computers (both with the same look-and-feel and content configuration): an experimental group of 6 children used the platform on one computer for a total of 12 sessions, with the automated attention management module activated to try and recover the child's attention; a control group of 6 children used the platform on the other computer for a total of 12 sessions, with the attention management module disabled. We can see a summary in Table 1. This setting allows us to assess the impact that the attention detection and real-time acoustic feedback has in re-engaging the child and changing the focus behaviors, after the child's attention is diverted.

The sessions are organized and assisted by the tutors, which help the children to perform the tasks that they think are suitable for them; as previously mentioned, all of the tasks are mostly related with communication development. A statistical occurrence analysis of the logs was performed, to characterize the frequency of distraction events, and the latency between the detection of a distraction event and the recovery back to an attentive state.

Table 2: Percentage of sessions in which a child having a type of distraction.

	Momentary (%)	Recovered (%)	Absent (%)
Sound	23%	65%	11%
No Sound	42%	54%	3.5%

Table 3: Percentage of sessions in which a child is focused.

	Focused (%)
Sound	50%
No Sound	25%

We classified distraction events into three categories: *a) Momentary:* events with less than 3 seconds duration, corresponding to scenarios such as momentarily looking at a colleague or the tutor; *b) Recovered:* events where the user looks away for more than 3 seconds, but recovers the attention within up to 30 seconds; and *c) Absent:* events where the user looks away for more than 30 seconds, to perform tasks that may not be necessarily related with the myTroc@s.net platform such as personal hygiene and others.

6 RESULTS

The metrics to measure the results, that we have adopted are as follows:

- **Focused (%):** the percentage of sessions in which the child begins and ends the session without diverting the attention from the computer;
- **Momentary (%):** the percentage of identifiable momentary events within the collected data;
- **Recovered (%):** the percentage of identifiable recovered events within the collected data;
- **Absent (%):** the percentage of identifiable absent events within the collected data;

As we can see from Table 2 and Table 3, results show that there are more children focused with the real-time acoustic feedback, with 50% of the sessions corresponding to cases where the child always looks at the screen during a session. Also, there is a lower number of distractions per session. Another interesting aspect is the fact that momentary distractions are less frequent in the group that uses the acoustic feedback. Despite the percentage of the focused children being higher, the group with acoustic feedback exhibits more moments where they are distracted for more than 3 seconds, the most frequent case being distractions of up to 30 seconds (65% of the cases).

7 DISCUSSION

With the sound to trigger the child attention, results show that the users look away from the screen less times, distracting themselves less often. Also they have less momentary distractions (less or equal to 3 seconds without looking at the computer screen), and less absent distractions (more than 30 seconds without looking at the computer screen). Despite the fact that there is a higher number of sessions where the child is focused from start to finish in the experimental group, in the computer without sound, they regain their attention more quickly, which can result from external action of the teacher in instructing the child to return to an attentive state.

Although during a normal session with the platform there might be external factors that we do control automatically, like absence from the computer to go to the bathroom, to answer a tutor, or performing a non computer-mediated task that a tutor told the child to do during a session, acoustic feedback can be an important feature to induce a behavior change in the child toward improved attention. When no feedback is provided, the use of the computer flows as in a normal session, and often the teacher might need to support the child in regaining attention.

8 CONCLUSIONS

In general, children have been able to achieve significant outcomes, and shown increased interest in using the platform, with clear increases in autonomy and proficiency in its use. Several comments and manifestations were registered on this respect, such as: a) Frequent requests to share the platform with other colleagues, tutors, and technicians; b) Requests to use the platform event out of their assigned schedule to use it; c) Refuse to attend classes to keep using the platform; and even d) Interest on behalf of student without special educational needs to use the platform to interact with their colleagues with ASD.

From the tutors evaluation, the message board seems to favor the capability of understanding messages and orders, and students revealed a higher level of initiative and autonomy in exchanging messages, as well as greater capacity of interpreting information and producing adequate responses; two of the students that have not yet developed reading and writing competences, manifested a growing curiosity in deciphering the written code as a communication means. Automations such as the attention detection module have also been showing a meaningful positive impact in the everyday routines performed by the children. In our attention tests the number of times in which the children look away from the computer is higher in the control group (without acoustic feedback). This experimental analysis allowed us to conclude that the attention detection module would be an important add-on while evaluating the children using a computer.

Today, society is increasingly supported in social interaction and communication, which are both fundamental pillars for the complete integration of all individuals. In this sense, children with special needs present novel and remarkable challenges due to their condition, in particular in the context of ASDs. Still, computer-mediated approaches, can help reshape the learning strategies, induce new behaviors, and contribute to the inclusion of these subjects. myTroc@s.net has been contributing for this change, by providing tutors with a versatile and easy-to-use platform to explore the individual specificities of each user, and by giving children additional tools to overcome some of their barriers and stimulate new communicative and social interaction behaviors.

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REFERENCES

(1992). *The Head-Neck Sensory Motor System*. Oxford University Press, USA, 1 edition.

Ames, C. and Fletcher-Watson, S. (2010). A review of methods in the study of attention in autism. *Developmental Review*, 30(1):52–73.

Boyd, B. A., Conroy, M. A., Mancil, G. R., Nakao, T., and Alter, P. J. (2007). Effects of circumscribed interests on the social behaviors of children with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*, 37(8):1550–1561.

Calais-Germain, B. (2007). *Anatomy of Movement (Revised Edition)*. Eastland Press, revised edition.

Dalton, K. M., Nacewicz, B. M., Johnstone, T., Schaefer, H. S., Gernsbacher, M. A., Goldsmith, H. H., Alexander, A. L., and Davidson, R. J. (2005). Gaze fixation and the neural circuitry of face processing in autism. *Nature Neuroscience*, 8(4):519–526.

Jones, W., Carr, K., and Klin, A. (2008). Absence of preferential looking to the eyes of approaching adults predicts level of social disability in 2-year-old toddlers with autism spectrum disorder. *Archives of general psychiatry*, 65(8):946–954.

Kinnealey, M., Pfeiffer, B., Miller, J., Roan, C., Shoener, R., and Ellner, M. L. (2012). Effect of classroom modification on attention and engagement of students with autism or dyspraxia. *The American journal of occupational therapy*, 66(5):511–519.

Leekam, S., Baron-Cohen, S., Perrett, D., Milders, M., and Brown, S. (1997). Eye-direction detection: A dissociation between geometric and joint attention skills in autism. *British Journal of Developmental Psychology*, 15(1):77–95.

Lucas da Silva, M., Gonçalves, D., Guerreiro, T., and Silva, H. (2012). A Web-based Application to Address Individual Interests of Children with Autism Spectrum Disorders. *Procedia Computer Science*, 14:20–27.

Lucas da Silva, M., Simões, C., Gonçalves, D., Guerreiro, T., Silva, H., and Botelho, F. (2011). TROCAS: Communication Skills Development in Children with Autism Spectrum Disorders via ICT Human-Computer Interaction INTERACT 2011. volume 6949 of *Lecture Notes in Computer Science*, chapter 103, pages 644–647. Springer Berlin / Heidelberg, Berlin, Heidelberg.

Pelphrey, K. A., Sasson, N. J., Reznick, J. S., Paul, G., Goldman, B. D., and Piven, J. (2002). Visual scanning of faces in autism. *Journal of autism and developmental disorders*, 32(4):249–261.

Posner, M. I., Walker, J. A., Friedrich, F. J., and Rafal, R. D. (1984). Effects of parietal injury on covert orienting of attention. *The Journal of neuroscience : the official journal of the Society for Neuroscience*, 4(7):1863–1874.