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Interactive Technology: Teaching People with Autism to Recognize Facial Emotions

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1. Introduction

In daily life, we interact with others by exchanging a huge quantity of information, including our current states of emotions, through facial expressions. Thus, faces are crucial for the recognition and understanding of emotions and for assisting communications and interactions between people. Individuals with autism tend to avoid looking at others' human faces and find it hard to recognize facial expressions and emotions in themselves and in others (Baron Cohen, 1995). This incapacity to read emotions on the human face impairs their ability to communicate with other people (Baron-Cohen et al., 2007).

Previous work has shown that children and adults with Autism Spectrum Disorders (ASD) can improve their emotion recognition skills with computer-based intervention. An increasing number of studies show that computer technologies used in teaching and in therapy are well accepted by individuals with ASD (Golan et al., 2007; Moore et al., 2000; Tanaka et al., 2010). However, most of the current computer-based solutions train patients with ASD using drawings or photographs (Bernard-Opitz et al., 2001; Bolte et al., 2002; Tseng & Do, 2010). When the autistic people try to apply the acquired knowledge to recognize emotions in real life, they are still unable to communicate properly (Golan et al., 2006).

This paper gives an overview of existing methods that have been used for teaching emotion recognition to individuals with autism. We identify some technological limitations that difficult their interpersonal interactions. Lastly, we present our contribution: a different approach to teach autistic people to recognize emotions from facial expression. Our idea is based on real-time facial synthesis of 3D characters. We also suggest a different interaction model to involve the autistic patient more deeply in the process of learning emotions. Creating a solution to solve this problem requires a joint effort from many research fields, such as computer vision, computer graphics, human computer interaction and facial behaviour and emotions.

2. Emotions and facial expression

Facial expression should not be confused with emotions. Human emotions are a result of many different factors, like feelings or convictions (Ekman, 1999). Human beings' emotional states might be revealed through a number of different channels, such as emotional voice, pose, gestures, gaze direction and facial expressions. Facial expressions deal with facial features deformation (purely based on visual information) and emotions are not the only source for facial expression.

In 1971, Ekman and Friesen (Ekman & Friesen, 1971) postulated six primary emotions: happiness, sadness, fear, disgust, surprise and anger. These basic emotions seem to be universal across human ethnicities and cultures. However, not all of researchers agree with this classification. Ortony and Turner (Ortony & Turner, 1990) collated a wide range of research on the identification of basic emotions.

Facial expressions are generated by contractions of facial muscles, which results in temporally deformed facial features such as eye lids, eye brows, nose or lips, often revealed by wrinkles and bulges. These facial movements convey the emotional state of the individual to observers and involve three main concepts: intensity, length and valence.

Intensity: subtle expression vs. strong expression. Emotions usually vary in intensity. Strong expressions involve the whole face in large facial movements that can be obvious. Subtle expressions involve small facial movements that often appear only in one region of the face, such as just the brows, eyelids, cheeks, nose or lips. These small movements occur gradually when an emotion begins, when an emotion is repressed, or when an emotion is deliberately masked.

Length: micro expression vs. macro expression. Emotions vary in how long they last. A micro expression can be as short as 1/25 to 1/5 of a second. On the other hand, (Ekman & Friesen, 1975) gives the average time for an emotion to unfold to be 2-4 seconds (surprise is the shortest universal emotion). Micro expressions are signs of emotions just emerging, emotions expressed before the person displaying them knows what she is feeling, or emotions the person is trying to conceal.

Valence: positive expressions vs. negative expression. Some expressions are termed positive, such as joy. Other expressions are termed negative, such as anger, fear, sad, and disgust. Some expressions are neutral in this spectrum, such as surprise.

2.1 Facial expression analysis

In order to analyse and classify facial expressions it is crucial to know the facial signals that imply each facial expression. In this context, it is necessary to accurately describe the *location* of facial features, their *intensity* and their *dynamics* (Fasel & Luettin, 2003). For example, when someone is happy, the implied facial features are: smiling (an open or closed mouth); possible laughter; crows-feet wrinkles at the sides of sparkling eyes; slightly raised eyebrows and head level. Facial expression intensity may be measured by determining either the geometric deformations of facial features or the density of wrinkles appearing in certain face regions. For example the measurement of a smile intensity is conveyed when cheeks and lip corners rise, as well as wrinkle display. Dynamics is related to the timing of a facial expression: not only the nature of the deformation of facial features conveys meaning, but also the relative timing of facial movements and their temporal evolution.

In the past, facial expression analysis was primarily a research subject for psychologists but, in 1978, Suwa et al. (Suwa et al., 1978) presented a preliminary investigation on automatic facial expression analysis from an image sequence. In the nineties, this research area gained great awareness. The reasons for this renewed interest in facial expressions are multiple, but one major motivation is due to the advances in related research areas, such as face detection, face tracking and face recognition, as well as the recent availability of relatively cheap computational power (Fasel & Luettin, 2003).

Most of automatic facial expression analysis approaches (Fasel & Luettin, 2003; Pantic & Rothkrantz, 2000) code facial motion and deformation into visual classes. Facial actions are hereby described by their location and intensity but do not take profit from the temporal component, which is essential in classifying a facial expression. Therefore, a complete description framework would ideally contain all possible perceptible changes that may occur in a face. This is the goal of FACS (Facial Action Coding System) which was developed by (Ekman & Friesen, 1978) and has been considered as a foundation for describing facial expressions. This was designed for human observers to describe changes in the facial expression in terms of observable activation of facial muscles. FACS became a standard used to categorize the physical expressions of emotions, and it was widely adopted by psychologists and animators.

FACS parameterizes facial expressions in terms of Action Units (AU). AUs represent various minimal facial changes, like raising the right eyebrow, and are based on anatomical muscle and bone movements. Along with the definition of various AUs, FACS also provides the rules for AU detection in a face image. By using these rules, it is possible to encode a facial expression that produces the expression. For example, combining the AU1 (Inner Brow Raiser), AU4 (Brow raiser), AU15 (Lip Corner Depressor), and AU23 (Lip Tightened) creates a sad expression (Deng & Noh, 2007).

Despite its popularity, there are some drawbacks of using FACS (Ekman, 1993; Essa et al., 1996; Pelachaud et al., 1994): AUs are purely local patterns while actual facial motion is rarely completely localized; FACS offers spatial motion descriptions but not temporal components. In the temporal domain, co-articulations effects are lost in the FACS system.

The MPEG-4 Facial Animation standard is a direct implementation of FACS and specifies and animates 3D face models by defining a set of Feature Points (FP). The main purpose of the FPs is to provide spatial reference to specific positions on a human face such as major muscles and bones. The MPEG-4 Facial Animation specification was the first facial control parameterization to be standardized into MPEG-4 FBA (Face and Body Animation) (Koenen, 2002; Pandzic & Forchheimer, 2002).

3. Autism spectrum disorder background

Autism is a developmental disorder with onset prior to age three and is characterized by cognitive and behavioural difficulties in communication and social interaction (Association, 1994). This psychological illness is characterized by the presence of restricted, repetitive, and stereotyped patterns of behaviour, interests and activities. Autism is part of a range of disorders that include Asperger's Syndrome and other pervasive developmental disorders. These syndromes are jointly referred to as Autism Spectrum Disorders (ASDs).

A fundamental part of these disorders is the failure to recognize emotions in due time (Baron Cohen, 1995). Individuals with autism tend to avoid looking at human faces and find it hard to understand why facial features move in the way that they do. This inability to read emotions on the human face impairs their ability to communicate with other people.

The human face is fundamental in both the expression and communication of emotions, so the majority of studies have focused on the face and tested the recognition of basic emotions (Ekman & Friesen, 1971). Studies assessing recognition of these emotions report inconclusive findings. Some studies report difficulties in recognition of basic emotions from facial expression, voice recordings, and from the matching of stimuli from the two modalities (Deruelle et al., 2004). Other studies have found no such difficulties (Baron-Cohen et al., 1993), and that the deficit only becomes apparent when testing recognition of more

"complex" emotions, such as jealousy, embarrassment or pride. These studies have reported that autistic individuals have deficits in complex emotion recognition from photographs of eyes (Baron-Cohen et al., 2001), facial expressions, short voice recordings (Capps et al., 1992), pictures (Bauminger, 2004) and linguistic contextual cues (Happe, 1994).
In contrast to these difficulties, individuals with autism show good and sometimes even superior skills in "systemizing"(Baron-Cohen, 2003). Systemizing is the drive to analyze or build systems, to understand and predict the behaviour of nonagentive events in terms of underlying rules and regularities. Autistic individuals are hyper-attentive to details and prefer predictable rule-based environments, features that are intrinsic to systemizing. In addition, individuals with autism are superior to control on various tasks that involve searching for detail, analyzing and manipulating systems (Shah & Frith, 1993).
Assuming that autistic people possess good systemizing skills, it is possible to explore them to compensate for some of their empathizing difficulties. This might be hard to implement because the socio-emotional world is a context-related open system (Lawson, 2003), often unpredictable and difficult to conceptualize with strict rules. However, if provided with a system of emotions, it is plausible that systemizing skills could be harnessed to help individuals with autism learn to recognize emotions.

3.1 Traditional learning tools

Past attempts to teach emotion recognition to adults and children with autism have either focused on the basic emotions (Hadwin et al., 1996), or have been part of social skills training courses, usually run in groups (Barry et al., 2003). These training programs do not focus on systematically teaching emotion recognition, instead, they address other issues, such as speaking, reducing socially inappropriate behaviour, and so forth. In such groups it is difficult to accommodate the individual's specific pace of learning.
Other attempts to teach emotion recognition to individuals with autism have used computer-based solutions (Bernard-Opitz et al., 2001; Bolte et al., 2002; Grynszpan et al., 2005). The use of computer software for individuals with autism has several advantages. First, individuals with autism favour the computerized environment because it is predictable, consistent, and free from social demands, which they may find stressful (Williams et al., 2002). Second, users can work at their own pace and level of understanding (Powell, 1996). Third, lessons can be repeated over and over again, until mastery is achieved (Williams et al., 2002). Fourth, interest and motivation can be maintained through different and individually selected computerized rewards (Moore et al., 2000). Previous studies have found that the use of the computer can help individuals with autism to recognize basic emotions from cartoons and still photographs (Bolte et al., 2002; Tseng & Do, 2010), and to solve problems in illustrated social situations (Bernard-Opitz et al., 2001). However, participants find it hard to generalize their knowledge from learnt material to related tasks (Golan et al., 2006).
A common feature of the computer-based interventions mentioned above is that they use drawings or photographs, rather than more lifelike stimuli, for training. It is possible that the use of more realistic stimuli could improve the knowledge transfer.

3.2 Digital media learning tools

Recent approaches to teaching emotion recognition to individuals with ASD use interactive game solutions.
Mind Reading (Baron-Cohen et al., 2004) helps children and adults to learn about emotions and their expressions, especially in human faces. It provides an interactive guide and a

video library of real people expressing emotions, as well as quizzes and games to check the individual's progress.

The Transporters (Baron-Cohen et al., 2007) is an animation series designed to help children with autism to discover the world of emotions. The series involves characters who are mechanical vehicles with human faces, that show emotional expressions in social context.The aim of this project is to attract the children's attention with mechanical motion in order to encourage incidental social learning and increase attention to the face. The evaluation of this project shows that there was greater progress in emotion recognition skills in the autistic children intervention group.

Children with ASD often avoid eye contact with others which prevents them from perceiving and understanding the emotions of others. *FaceSay* is an interactive computer software program that features interactive games that let children with ASD practice recognizing the facial expression of an avatar, or software "puppet". Specifically, this computer game shows these children where to look for facial cues, such as an eye gaze or a facial expression.The study found that children with ASD made significant improvements in their ability to read facial expressions and recognize emotions (Biasini & Hopkins, 2007).

The *Let's Face It! (LFI!)* program is a series of interactive computer games designed to improve the face recognition abilities, including inatention to the eyes (Wolf et al., 2008), and failure to understand faces (Gauthier et al., 2009). This set of games aims reinforce the child's ability to attend to faces, recognize facial expressions and interpret facial cues in a social context. The study of Tanaka (Tanaka et al., 2010) with *LFI!* shows considerable improvements in the face recognition skills of children with autism.

The *SmileMaze* is a face expertise training prototype that teaches children how to recognize and produce facial expressions via a web cam. The program uses state-of-the-art computer techniques in expression recognition and are incorporated into the *LFI!* treatment program. The study of Cockburn (Cockburn et al., 2008) suggest that including real time expressive production into the *LFI!* program is a great benefit to help childrens with ASD to recognize emotions from own facial expression.

The present game solutions indicate that emotion recognition can be improved over a relatively brief training period, when more lifelike stimuli are employed.

3.3 Challenges in trainning methodologies

A facial expression is a result of a muscle contraction that produce different facial movements. Assuming these movements as being important in the context of non-verbal communication, it is necessary to ponder methods that include facial motion. Several researchers have claimed that not only the movement itself, but also the timing associated with facial motions are critical parameters in recognizing emotions (Cockburn et al., 2008; Ekman, 1993; Fasel & Luettin, 2003; J. Reilly, 2006).

Nowadays, most methods for teaching facial emotions are based on static photographs of facial expressions. According to the above, those methods present some limitations, as interactive applications to teach emotions recognition.

Another problem that affects the learning process of autistic people is the user interface and interaction model. There is not much research that addresses such an issue, but most of the solutions that have been applied to ASD are based on the traditional style of WIMP interaction (Window, Icon, Menu, Pointing device). This kind of interaction allows the children and adults with autism to input commands using keyboards, mice or touch screens, like the examples presented in previous solutions.

However, it is possible to explore the autistic people's unique learning style: typically, they are much more attracted by the details of a tangible user interface, such as a steering wheel used in a computer game, than by a standard mouse.
Sitdhisanguan et al. (Sitdhisanguan et al., 2007) made a comparative study between the use of both WIMP and tangible user interface. The study shows that autistic childrens' behavior are restricted, by the WIMP interface. Such interaction style could easily lead to boredom. At the same time, autistic children had difficulties in performing point and click actions. Different, when using a tangible user interface, they were more agile in manipulating the interface. The study also concludes that autistic children enjoy technology that supports physical activities.
Most of the computer-based solutions that have been used to help autistic people to learn about emotions aim at a teaching environment. They make use of some of the benefits afforded by computer technology, but are often based on exactly the same concepts as "tried-and-true", lower-tech solutions (Michel, 2004). One could argue that the rather traditional approach of these technologies fails to exploit some of the most novel and interesting properties of computer-based technology.
Are there ways of extending the use of technology beyond a teaching scenario to help people with autism to look at the human face and learn about emotions?

4. LIFEisGAME: A modular interactive learning system

Based on the review of the findings of past research, we are developing the LIFEisGAME (Learning Facial Emotions Using Serious Games) project, a facial emotion recognition learning system, based on the interaction between humans and 3D avatars. The system, with a game like structure, has a set of activities that will reinforce an understanding of emotions, their causes and consequences, and their associated facial expressions. To define a user interface and a set of interactive activities, a psychotherapy background was necessary.
This project will be based upon a LEGO-like structure. In one hand, we have the possible technologies that can be used, such as motion capture, virtual and augmented reality, digital tables, mobile devices, computers, etc. In the other hand, we have the game concepts, ideas and tasks that must be completed throughout the game. In order to achieve a flexible and expansible platform, it is necessary to consider that the game can be easily adapted to the needs and specifications of the therapists, parents and children. So, both the technology and the game modules will be developed and used as LEGO pieces. For example, imagine that a therapist wants to use the game mode A with a digital table. He will be able of simply choosing the desired module and, if the game is compatible with the digital table, it will be automatically ready for being played. Afterwards, if another therapist wants to play the same game with, for example, motion capture he simply chooses the correct module and the game is auto-reconfigured. The same concept can be used the other way around, i.e., different game modules (LEGO pieces) may fit upon the same technology modules (other LEGO pieces).

4.1 Game design

The goal of the game is to help children with ASD recognize emotions through facial expressions. Based on the experiential lerning cycle defined by Kolb (Kolb, 1984), we defined the following pedagogical modes for the game:

1. **Recognize the Expression.** In the first mode, children are encouraged to watch and recognize facial expressions.

2. **Build a Face.** In the second mode, they are encouraged to learn by doing, that is, actively experiment with different possibilities of constructing a desired facial expression.
3. **Become Your Avatar.** In the third mode, children are not only encouraged to recognize and mimic, but also to concretely experience how to make the expression with their own faces.
4. **Live a Story.** Finally, the children are encouraged to generalize or transfer their knowledge of facial expressions to real-life situations, requiring them to understand each emotion.

The four modes differ in their interactivity and engagement. Children will be encouraged to play these modes in a sequential manner, but customizations could be made to allow them to begin with any mode.

Recognize the Expression.
In this mode, the player is presented with a sequence of random facial expressions and required to identify a specific (pre-selected) expression from the set. Each session is time-limited, as determined by a therapist, to maximize player attention.
The therapist can create different exercises for facial expression recognition based on the core mechanics embedded in the game. The core mechanics are based on identifying micro and subtle expressions and analyzing the three concepts: intensity, length and valence. Each type of exercise can have different configurable scenarios where the avatar appears with a full face, half face or a mix face:

1. **Full face**: uses all the face to display the expressions. This scenario allows teaching expressions associated to a specific type of avatar.
2. **Half face**: either the upper part or the lower part of the face is hidden. This scenario allows teaching a specific section of an expression.
3. **Mix face**: uses half of the face from one character and the other half of the face from another character. This scenario allows teaching expressions by dissociating them from the type of avatar.

Build a Face. This mode asks the player to construct a facial expression on a 3D avatar to match a defined emotion. This mode has two levels. The first level is a free play mode. The player must choose a 3D avatar to play with and an emotion. Then, a drawing area and a 3D model of the chosen avatar will appear. The player must draw on the first area to create a 2D representation of the expression. The system will automatically apply the 2D sketch to the 3D avatar. In this mode, the player can save the expressions that were drawn and create a sequence that can be animated and played. Also, it will be possible to edit these expressions and sequences to create new animations or, for example, change the 3D avatar maintaining the animation sequence. The player can build several models that can be used to produce an animation sequence. The second mode makes use of a webcam to take a picture of the player that may be performing some facial emotion. Then, the player will be able of drawing on the special area, by using the sketching feature, to match the expression of a 3D avatar with the expression from the photo. When the player finishes drawing, the system will calculate the final score of the game based on how close the drawing was to the expression in the photo.
Become Your Avatar. The objective of this mode is to improve the children's capabilities of reproducing facial expressions. The player controls a 3D avatar simply by moving his own face. When the player performs a given facial expression, the 3D avatar will mirror its movements. When the game starts, a target expression is presented. The player must

try to achieve this target by performing it with its own face. When the target expression is achieved, the player must hold it for three seconds. This time is used to ensure that the player consciously achieved this expression. This game is divided in three sub-games. The first is a free-play mode in which the 3D avatar simply mirrors the player's expressions; in the second game mode, called "Train an expression" , the player chooses an expression and must achieve it as described above; finally, in the third mode, the player will have to follow the same game mechanics throughout a random sequence of expressions to finish the level.
Live a Story. In this mode the player is invited to perform a role in a certain story. The story will unfold until a certain event occurs. At these moments, two things can happen. In the first case, it is expected that the player performs a given facial expression, which will be captured by a camera or motion capture system. For example, we can imagine that at some point in the history, the player can be given a gift. In this situation, it is expected that the player smiles because he was happy. If the expression is not the same as the one that was expected, the story may take a different course. In the case depicted above, the person who gave the player a gift may be sad and the story will have a different ending. In the second case, the player may have to make another type of action, such as choosing an answer from a predefined set of possible answers or performing a physical action such as picking something or doing a movement.

4.2 Game technology

The core technology behind our solution is based on the facial synthesis of 3D characters. It strives to solve the synchronization and realism problems, support reusability of facial components, and have an avatar-user interaction model with real time response.
The technology we have developed is capable of not only creating smooth facial deformations in a friendly way, but also making avatars respond to it in real time. It is prepared to reproduce facial animations with cinematographic quality and accepts avatars that range from photorealistic to cartoon. The 3D characters in the game were created by an artist and are intentionally made to be likable and agreeable to children. Therefore, the avatars possess some attractive features such as healthy skin and symmetrical faces. Also, some avatars have child-like traits to appear warmer and more trustworthy for the player (Isbister, 2006).
The technology behind the game mode **Recognize the Expression** is based on keyframe animation. This type of animation is the most commonly used technique in facial animation practice. It consist first on creating different poses and interpolate them to generate animation. We have defined six basic expressions: anger, disgust, fear, happiness, sadness and surprise (Ekman & Friesen, 1971). For each 3D model, an artist custom created these basic expressions.
In the game mode **Build a Face** we aim to develop an interaction model to *draw* facial expressions in an easy and intuitive way, by exploring the emerging domain of interaction usability. Inspired in the way people draw, this interaction model will allow the player to *sketch* smooth facial deformations in a friendly way (Miranda et al., 2010).
The game mode **Become Your Avatar** is based on facial motion capture (MoCap). This technology allows capturing the complex deformations of a human face. The information captured is then mapped to a 3D model and reproduced to animate synthetic characters. Traditional MoCap techniques are based on facial markers. This solution is not suitable for our approach, because is unpleasant and "unnatural" , due to the need of using markers on the face. In order to overcome these problems we sugest using a markerless facial motion capture system based on low cost hardware, like a webcam, to capture the facial features of the player.

In the game mode **Live a Story** we want give the freedom to the player to interact in the digital environment by performing physical actions. These types of actions will be captured by using hardware such as the Wii Remote, Microsoft Kinect or the motion capture system.
The ultimate goal is to allow patients and therapists to create and adapt the contents of each game mode to the patient profile. Creating specific content is expensive, time-consuming and requires highly artistic skills. Thus, the technology presented in this section was designed to allow automatic user content generation.

5. Results and discussion

In this article, after describing some emotions and facial expression issues, we reviewed several computer-based solutions that have been used to teach autistic people to recognize facial expressions. The review suggestes that emotion recognition could be improved when systematic methods, with lifelike stimulus, are employed. We then present the basis of a new approach, whose novelty is the interactivity of the process, as opposed to previous methods that use still images and traditional interaction models. We believe that the generalization of the acquired knowledge to real life can be attained with a more natural interaction between the human (patient and/or therapist) and realistic expression 3D avatars. In this approach, we considered that a facial expression plays an important role in the transmission of emotions, so teaching autistic people to recognize emotions requires believable facial animations. However, generating realistic face movements is hard because there are many subtleties to control.
Our approach introduces a novel and sophisticated interaction model that enables patients to learn facial emotions by recognizing and imitating the avatars' movements. It is being developed with a game like structure in a modular way.
We have implemented the first game mode, "Recognize the Expression". Figure 1 shows a young children playing the game and a screenshot of the user interface. The 3D models used in the game were created by an artist.

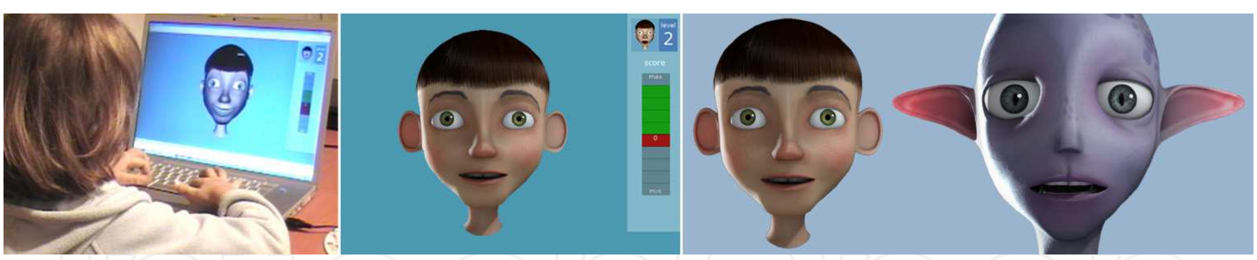

Fig. 1. A young children playing the game (left). User Interface of game mode "Recognize the Expression". Main window with the current expression and left panel that shows the score status, the expression to identify and the difficulty level (middle). Two examples of 3D avatars from the game: a boy and a fantastic creature, all in cartoon style (right).

We are developing a novel sketching control system to draw facial expressions, inspired in the way people draw. The method will be exploited in game mode 2, "Build a face", to speeding up the creation of facial expressions in an easy, natural and intuitive way. Figure 2 shows a screenshot of our sketching system.

5.1 Preliminary user study

In order to evaluate our game design, we conducted a user study. Nine participants, seven boys and two girls, ranging from four to eleven years old, with ASDs, participated in the study. Their ASD diagnoses varied. Six were identified as having high-functioning autism

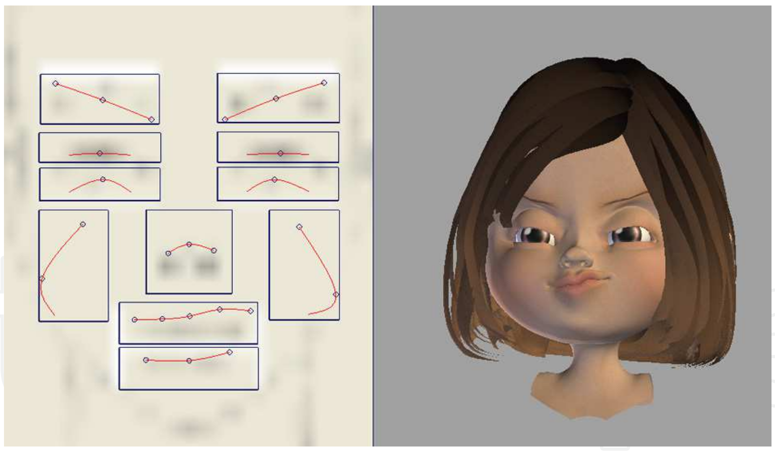

Fig. 2. Sketching System. Drawing area: the boxes represent the canvases where the user can draw the strokes; the background is a 2D image of a generic face (left) ; 3D area: shows a facial expression of the 3D character; the facial expression corresponds to the strokes on the drawing window (right).

or Asperger's syndrome. Two were in the middle of the spectrum. The testing sessions took place at the children's home or cafes designated by the parents. Every child was accompanied by at least one parent, mostly mothers. In the sessions, participants were asked to play two testing versions of the game with only the first game mode, "Recognize the expression", implemented. The first version of the game begins by asking players to select an avatar. After making this selection, the player must choose one of six basic emotions. The available emotions are based on Ekman and Friesen's (Ekman & Friesen, 1971) six primary and cross-cultural emotions. After choosing the emotion, the player must recognize and correctly identify the emotion on the avatar, which randomly cycles through facial expressions representing the six emotions. Players also select from three levels of difficulty. The second version of the game differs in that players are given the option to play additional modes where particular facial features, such as the eyes or mouth, may be covered on the avatar. Participants were instructed to play as long as they wanted. After ending play, the children were interviewed about what they liked and disliked about the game and how we could make the game more enjoyable. The parents were also interviewed with similar questions. In situations where the children did not wish to talk, we only interviewed the parents. The game play sessions were video recorded, and the interviews were audio recorded. The testing results suggest that overall, the children responded favorably to the game. When selecting avatars, all of the male participants preferred to play with the young-boy avatar, while the girls expressed a preference for the young-girl avatar. The majority of male participants requested to play with the alien-like avatar. Several parents discussed the importance of game context. They expressed an interest in a game that included storylines involving social scenarios. In terms of feedback, all of the participants enjoyed the auditory feedback; however, several children deliberately made wrong selections because they preferred the wrong-answer feedback. This suggests that the game design should allow for customization, including the ability to turn off or adjust colors and sounds, or provide a less engaging wrong-answer response. Additionally, in the testing version of the game, players had to choose the correct facial expression of an emotion, which is selected, in the current game design, from a series of images. One issue we observed was that children selected the correct answer by matching rather than by recognizing the expression. In order to reinforce learning and avoid matching, the correct answer image should be changed to text or represented by a different face.

Changing the correct answer image not only has the ability to reinforce a player's learning, but also enhance a player's ability to generalize the expression to other faces.

5.2 Future work

One future extension of our interaction model includes tangible user interfaces. In this context, several studies can be done to implement an interface where users interact in the digital environment with real objects in a natural way. We believe this kind of physical interaction will involve autistic patients more deeply in the emotions learning process and, consequently, improve their interaction with other people.

We will attempt to develop a set of facial synthesis algorithms and a classification method for facial emotion analysis. The classification method, in an extended way to the FACS system, will be used to analyze which facial movements, produced by the 3D character, correspond to the rules that define the different facial expressions.

We will perform future user studies to validate the game design and the usability enabled by the methodologies we are developing.

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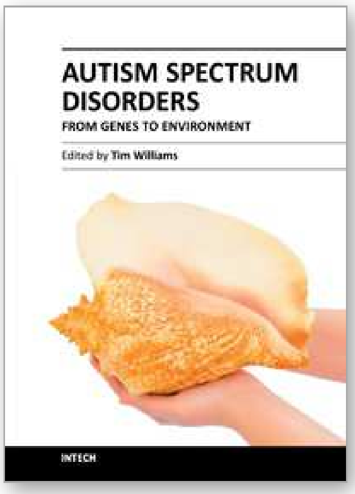

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Autism spectrum disorders are a major topic for research. The causes are now thought to be largely genetic although the genes involved are only slowly being traced. The effects of ASD are often devastating and families and schools have to adapt to provide the best for people with ASD to attain their potential. This book describes some of the interventions and modifications that can benefit people with ASD.

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