Emotionally Expressive Avatars for Chatting, Learning and Therapeutic Intervention

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Abstract. We present our work on emotionally expressive avatars, animated virtual characters that can express emotions via facial expressions. Because these avatars are highly distinctive and easily recognizable, they may be used in a range of applications. In the first part of the paper we present their use in computer mediated communication where two or more people meet in virtual space, each represented by an avatar. Study results suggest that social interaction behavior from the real-world is readily transferred to the virtual world. Empathy is identified as a key component for creating a more enjoyable experience and greater harmony between users. In the second part of the paper we discuss the use of avatars as an assistive, educational and therapeutic technology for people with autism. Based on the results of a preliminary study, we provide pointers regarding how people with autism may overcome some of the limitations that characterize their condition.

Keywords: Emotion, avatar, virtual reality, facial expression, instant messaging, empathy, autism, education, therapeutic intervention.

1 Introduction

The word avatar comes from the Sanskrit language and can be translated as *God's Incarnation on Earth*. In the virtual reality community, avatars are 3D humanoid characters inhabiting virtual space, with varying degrees of animation and behavioral abilities. Avatars typically represent humans who visit the space *virtually*. Each visitor controls their avatar and is aware of other visitors' avatars and their actions [3].

In this paper we present our work on emotionally expressive avatars. Our avatars are able to show expressions corresponding to the following emotions: happiness, disgust, sadness, surprise, anger and fear [cf. 12]. These avatars are animated and highly distinctive in their appearance. Because humans are so adept at reading facial expressions in the real world, any avatar that plausibly displays emotions in a virtual world can be utilized in a range of applications.

In the first part of the paper we discuss the use of avatars in computer mediated communication. We have developed and tested an Instant Messaging tool called the *Virtual Messenger,* which allowed two users to virtually enter a meeting place in order to communicate and collaborate on a given task. Users see each others' virtual representations and chat with each other, as well as visibly express emotions via their

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animated avatar heads. We develop an evaluation framework for the user's subjective experience and discuss study results.

In the second part of the paper we then look into a potential application area for the Virtual Messenger, or for tools derived from the interaction paradigm employed. People with autism often display behavior that is considered socially or emotionally inappropriate [15], and find it hard to relate to other people [40]. There is evidence that virtual environment technology can address some of these impairments [5,6,31].

However, any technology using avatars has to be designed so that people with autism can readily understand the avatar's expressions, and potentially ascribe a mental and emotional state to the avatar. We present results from a study that explored the extent to which children and youth with autism could recognize, and make inferences from, emotions displayed by a humanoid avatar. The positive findings support the optimism that such avatars could be used effectively as a) an assistive technology such as the Virtual Messenger to help people with autism to circumvent their social isolation, b) as a means of educating the person with autism where the avatar may in some sense become a "teacher", and c) as actors in virtual reality role-playing where people with autism may practice their mind-reading skills.

1.1 Why Emotions Are Important

From the real world we know that whenever one interacts with another person, both monitor and interpret each others emotional expressions. Argyle [2] argued that that the expression of emotion, in the face or through the body, is part of a wider system of natural human communication that has evolved to facilitate social life. Emotions can also have an influence on cognitive processes, including coping behaviors such as wishful thinking, resignation, or blame-shifting [21]. Findings in psychology and neurology suggest that emotions are also an important factor in decision-making, problem solving, cognition and intelligence in general. Picard [37] pointed out that the emotional state of others influences not only our own emotional state, but directly the decisions we make. Another area where emotions can be critical is that of learning. It has been argued that the ability to show emotions and empathy through body language is central to ensuring the quality of tutor-learner and learner-learner interaction [7]. Acceptance and understanding of ideas and feelings, criticizing, silence, questioning – all involve non-verbal elements of interaction [27]. Emotions can motivate and encourage, they can help us achieve things [7].

2 Avatars for Chatting – The Virtual Messenger

The 'Virtual Messenger' is a communication tool designed to allow two spatially separated users to meet *virtually* and discuss a topic (Fig. 1). It is probably best described as an Instant Messaging tool with the added facility of representing interlocutors as avatars. The tool allowed investigating how a user's experience is different when the avatars representing users are emotionally expressive, as opposed to being non-expressive. Giving virtual characters expressive abilities has long been considered beneficial as it potentially leverages the observer's real-life experience with social interaction [37,8]. A choice of six avatar heads was available, each

capable of displaying the "universal" facial expressions of emotion *happiness*, *surprise*, *anger*, *fear*, *sadness* and *disgust* [12] and a neutral face. Expressions were designed to be highly distinctive and recognizable [14]. All characters were based on identical animation sequences to ensure consistence and validity.

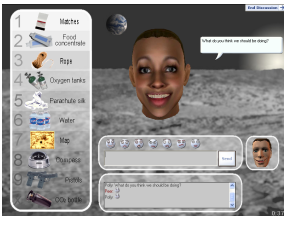

Fig. 1. The Virtual Messenger Interface

2.1 Experimental Setup

The Virtual Messenger was evaluated in a between-groups experiment conducted in pairs. Participants were given a classic survival scenario (*You are stranded in the desert about 50 miles from the nearest road…)* and had to debate what course of action would be best for their survival. During the experiment, their only means of communication was the Virtual Messenger. There were two versions of the Virtual Messenger tool, corresponding to the experimental conditions:

1. **Condition (NE):** Users could click on emoticons which then appeared in the chat log of both participants. Participants were represented by avatars, but there was no change in avatar appearance other than random idle animations such as blinking.
2. **Condition (EX):** Featured the same emoticons and avatar representations. When a user clicked an emoticon, it appeared in the chat log and also caused their avatar in the partner's messenger window to display that emotion.

By making *emotional expressiveness* the intervention, we were able to investigate its effect on the user's experience. Conditions were assigned to participant pairs, i.e. interlocutors either could both use their avatar's expressions, or neither of them could.

2.2 Evaluation Framework

In order to evaluate the user's experience effectively, we introduced the concept of **"richness of experience"** and hypothesized that a user's experience is richer when avatars are emotionally expressive, compared to non-expressive avatars. It was postulated that a richer experience would manifest itself through:

1. More **involvement** in the task
2. Greater **enjoyment** of the experience
3. A higher sense of **presence** during the experience
4. A higher sense of **copresence**

In addition to these four measures, participants were observed during the experiment, and given the opportunity to comment on any aspect of their experience

after the task was completed. These qualitative measures formed an important part of the data analysis. At the time of the experiment no comparable study combining all four factors of *richness* existed. Various researchers have looked at these in isolation [39,29,38,17,20] and their interpretations informed the definition and the choice of evaluation tools. Below we explore each characteristic in detail:

1. **Involvement:** Defined here as an objective measure of the number of user-initiated actions and communications taking place. These were automatically recorded.
2. **Enjoyment:** Designers of consumer products have long been aware of the potential that quantifying *enjoyment* and *pleasurability* of use can yield for a product's success [25,22]. We used Nichols' [32] mood adjective checklist, a self-report tool specifically designed for measuring aspects of interaction in virtual reality systems.
3. **Presence:** Defined as *"a psychological state in which the individual perceives oneself as existing within an environment"* [4]. Several instruments for measuring presence were available varying from technological [41] to psychological, introspective approaches [39]. We used the fully validated 43-item ITC-SOPI questionnaire [29] because of its generic applicability. ITC-SOPI considers four distinct factors of presence: a) Being in a physical space other than the actual place one is in (spatial), b) the user's interest in the presented content (engagement), c) believability and realism of the content (naturalness), and d) .negative physical effects of the experience such as headaches or eyestrain.
4. **Copresence:** Refers to the sense of being together with another person in a computer-generated environment, sometimes also referred to as *social presence* [20,39]. For the Virtual Messenger investigation, other researchers [17,38] were followed by measuring the phenomenon of copresence via a short post-experiment questionnaire covering aspects of space, togetherness and responsiveness.

2.3 Results and Analysis

32 volunteers took part in the study. They were aged 21-63 with equal gender split (average age 28.2 years, stdev 13.4). Participants were computer literate, well educated and skilled in the use of keyboard and mouse. Few had experience of using console games, virtual reality, or other 3D applications. Several had used Instant Messaging tools before. In summary, results confirmed that the avatar faces used were effective and efficient. It is worth looking at each measure in detail because not all characteristics of richness did produce equally conclusive results:

1. **Involvement:** Sessions lasted between 8 and 35 minutes (average 21.2) excluding questionnaires. (EX) participants were significantly more involved in the task ($p<0.05$). They wrote considerably more messages, messages were longer, nearly twice as many items were moved, and there was 8 times more use of emoticons.
2. **Enjoyment:** High enjoyment scores were recorded in both conditions (averaging 71.22% for (EX) and 72.01% for (NE)). The difference was not statistically significant (one-way ANOVA, $p<0.05$).
3. **Presence:** The subjective sense of presence was consistently high across both conditions with no significant difference between the two conditions overall, or when testing for individual factors (one-way ANOVA, $p<0.05$). As an indication,

presence scores for the (EX) condition were 3.06 (Spatial), 3.61 (Engagement), 2.61 (Naturalness) and 1.63 (Negative Effects), all based on a 5-item Likert scale.

4. **Copresence:** Participants using expressive avatars (EX) reported a significantly higher sense of copresence ($F(1,32)=3.5$, $p<0.05$). Average scores were 4.13 for condition (EX), and 3.73 for (NE), again based on a 5-item Likert scale.

2.4 Discussion

Whilst *involvement* and *copresence* showed significantly higher scores in the (EX) condition (supporting the hypothesis), the *enjoyment* and *presence* showed no significant difference in response to the two conditions. The consistently high *enjoyment* scores can arguably have been influenced by the novelty of the application.

When looking at quantitative factors in combination with the qualitative data, interesting patterns emerged: The greater activity under condition (EX) which was logged as well as visually observed could be attributed to a *richer* experience. However, the way these discussions developed would have been counter-productive in a real life-threatening situation. (NE) acted in a more task-oriented and efficient way. It is possible that the introduction of emotional expressiveness may not be appropriate for all types of avatar applications, or in all communication contexts, as they may distract users from the task at hand. An alternative possibility is that by focusing on emotional expressions alone the environment may become "hyper-emotional", leading to a distracting rather than constructive collaborative experience.

There was a tendency by some participants to mimic emotions displayed by their partners. This was particularly relevant to the (EX) condition where it affected predominantly the happiness expression. The mimicry of communicative cues is well-documented for real life social interaction, typically as a regulator of trust and rapport [26,28]. Imitative behavior is also considered a good indicator for the existence of empathy [34]. From the observations we infer that such mimicry may have taken place during the task, when participants appeared to have copied their partner's facial expressions. This in turn may have led to more *likeability* between partners as they sensed that there was an interlocutor who *empathized* with them, which is congruent with post-experimental feedback by these participants. There is, then, some evidence that mechanisms fostering the emergence of empathy in the real world may apply equally to interaction through the Virtual Messenger, despite the somewhat artificial setup. It is quite conceivable that deliberate use of mimicking in future system has the potential to be a useful means of communication – and potentially persuasion.

In the next section we consider the further application of emotionally expressive avatars, such as those used here. Our main concern is to find ways to help people with autism overcome at least some of the limitations that characterize their condition.

3 Avatars for Learning and Therapeutic Intervention

Wing [40] considers autism involving a "triad of impairments": 1) A social impairment: the person with autism finds it hard to relate to and empathize with other people; 2) a communication impairment: the person with autism finds it hard to understand and use verbal and non-verbal signals, and may display behavior

considered socially or emotionally inappropriate [15]; and 3) a tendency towards rigidity and inflexibility in thinking, language and behavior. Research suggests that this triad is underpinned by a "theory of mind deficit" [24]: people with autism may have difficulty understanding other people's mental and emotional state, or ascribing such a state to themselves. Given this understanding of autism, we argue that virtual reality systems utilizing emotionally expressive avatars can potentially benefit people with autism in three ways – as an assistive technology, as an educational technology, and as a means of helping address any Theory of Mind deficit.

3.1 Avatars as an Assistive Technology

Concerning its potential role as an *assistive technology*, our argument is that people with autism may be able to use the Virtual Messenger to communicate more fruitfully with other people. This is important since people with autism may experience social exclusion because they find it difficult to make friends [6]. Indeed, the difficulty to relate socially to other people is seen as a hallmark of autism [33]. Any means of addressing these issues, we argue, is therefore worthy of investigation. Tools such as the Virtual Messenger have the potential to enable communication that is simpler and less threatening to people with autism than its face-to-face equivalent, thereby avoiding many of the potential pitfalls [35]. The direct and active control over interactions may also increase confidence of people who otherwise feel out of control in social situations [35]. Users can communicate at their own pace and, if needed, slow down the rate of interaction in order to gain time to think of alternative ways of dealing with a particular situation. Thus, tools like the Virtual Messenger can potentially help people with autism who cannot or do not wish to come together physically, but who wish to discuss common interests. It may provide a means by which people with autism can communicate with others, and thus circumvent, at least in part, their social and communication impairment and sense of isolation.

3.2 Avatars as an Educational Technology

Concerning the potential *educational* use of the Virtual Messenger, the idea is to use the technology as a means of educating the user with autism, possibly in an attempt to help overcome their autism-specific "deficits". Thus the conversational partner of a user with autism may be in some sense their "teacher". One specific way in which this might be used is for the purposes of practice and rehearsal of events in the "real world", for example a forthcoming school visit, family gathering or interview.

Programmes that allow people with autism to practice social skills are often advocated, partly on the grounds that social impairments can affect general educational progress [1]. The argument for the use of avatar-based communication in such programmes is that it enables social skills to be practiced and rehearsed in realistic settings in real time [6,35,36]. Tools like the Virtual Messenger offer a safe and controlled environment which can be used repeatedly under the same conditions in order to learn appropriate social rules, without having to deal face-to-face with other people [6]. Users' interactions can be recorded and used for subsequent educational discussion. This creates an opportunity for people with autism to learn by making mistakes but without suffering the real consequence of their errors.

3.3 Addressing Theory of Mind Issues

Another interesting possibility is that of using tools like the Virtual Messenger to help people with autism with any Theory of Mind (ToM) deficit. Although the status of this alleged deficit is controversial, with for example some research suggesting that the perception of emotions in others is not systematically or specifically deficient in people with autism [19], many advocate its explicit teaching [e.g. 24,33]. It is argued [24] that children with autism can be successfully taught to interpret mental states.

We argue, then, that tools like the Virtual Messenger can potentially play a valuable role concerning ToM. Being able to express their emotions through a choice of appropriate facial expressions for their avatars., and being required to interpret the emotions displayed by their interlocutors' avatars, may help address the ToM issue in users with autism. McIlhagga and George [30] suggest that users who see other avatars' behavior and facial expressions may build a model of the emotional state of the underlying agent or user. Enabling people with autism to work in such environments provides them, in principle at least, with an opportunity to practice their mind reading skills and address ToM issues.

4 Avatars for People with Autism – An Exploratory Study

In order to investigate whether and how people with autism may interact with emotionally expressive avatars, we conducted a preliminary study with two aims: to establish whether a) the chosen avatars were readily recognizable, and b) participants could relate events in simple social scenarios to the relevant emotions. We developed a single-user computer system, incorporating avatar representations for 4 emotions – *happy, sad, angry, frightened* – and involving 3 stages [5]. It should be noted that the development of the system happened in parallel to the Virtual Messenger development. While the action units underlying all facial expressions were identical in the two systems, for technical reasons different avatar models were used.

In **Stage 1** the avatar representations of the 4 emotions were sequentially presented in isolation. Users were asked to select the emotion they think is being displayed, from a list. In a second activity, users were told that a particular emotion is being felt and asked to select the avatar head they believe to correspond to that emotion. These two activities form part of a standard procedure to establish the baseline of emotion recognition [24]. **Stage 2** attempts to elicit the possible emotions in the context of a simple social scenario (Fig. 2). It requires users to predict the likely emotion caused by certain events. In **Stage 3** of the system the user is given an avatar representation of one of the emotions and asked to select which of a number of given events they think may have caused this emotion. Throughout the system, the avatar "face" is used as the means of attempting to portray the emotions. A problematic issue when developing the system concerned the range of emotions to consider. The literature suggests that there are 6 *universal* expressions of emotion [12] as used with the Virtual Messenger. However, autism researchers [18] argue that it is debatable when and if children utilize all 6 emotions. Instead, work with individuals with autism tends to concentrate on a subset of emotions. While subsets vary in the literature, we followed [24] and used *happy, sad, angry* and *frightened*.

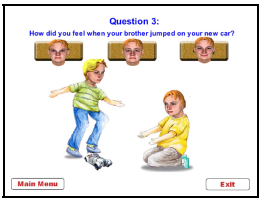

Fig. 2. Stage 2 of the system

4.1 Results and Discussion

The study involved school-aged participants with a diagnosis of autism. Of 100 potential UK-based participants contacted, 34 replied. 18 participants were reported as children with Aspergers Syndrome and 16 as children with severe autism. The age range was from 7 to 16 years (mean 9.96). 29 participants were male, 5 female.

Each participant was sent a pack consisting of a CD containing the system outlined above, a blank diskette, a questionnaire asking participants for their views about the software, a parent questionnaire asking for the participant's age and autism diagnosis, and for the parent's views about the software, brief instructions and a stamped addressed envelope. Participants were asked to work through the 3 stages of the system described above. The software logged their work onto the diskette. Once the task was completed, participants and their parents were each asked to fill in the questionnaires. The diskette with log data and the questionnaires were then returned.

Results from analyzing the log files suggest that, for all but one of the questions, the participants were demonstrating responses significantly above those expected by chance. Of the 34 participants, 30 were able to use the avatars at levels demonstrably better than chance. Concerning the four participants who did not demonstrate a significant difference from chance, it appears that these participants had a real difficulty in understanding the emotional representation of the avatars. These four participants were in the group that described themselves as having severe autism as opposed to Aspergers Syndrome. In general, however, for the participants who responded, there is very strong evidence that the emotions of the avatars are being understood and used appropriately.

5 Summary and Further Work

We have outlined two empirical studies concerning emotionally expressive avatars. The first investigates how the ability to express and perceive emotions during a dialogue between two individuals in the *Virtual Messenger* tool affects their experience of the given virtual world scenario. The study has also led to the development of guidelines for making emotionally expressive avatars effective and efficient [see 13]. The second study can be seen as an application of the first study to the specific potential user group of people with autism. We believe that this study gives grounds for optimism that avatars can help addressing one or more of the impairments of people with autism.

We are currently conducting a third empirical study to investigate whether and how the avatars used in the Virtual Messenger are recognizable, and their emotional expressions understandable to children with more severe autism. By studying the pre-validated emotion representations with such a user group, we are arguably testing the standard in extremis, and hence potentially enabling the standard to be strengthened. This is an example of an "off-shoot" argument for assistive technology – lessons from the use of the technology in extraordinary human computer interaction might lead to helpful development of the technology for "general" use [11,23]. Similarly, our work can be expected to contribute towards clarifying the noted lack of guidance in the literature [cf. 18] regarding how children might understand the behavior of virtual characters and their emotional signals.

Much remains to be done, therefore, and we hope that the studies reported in this paper may play a part in moving forward the important area of emotional expressiveness in avatar-based communications, as well as the use of avatars as an educational and therapeutic tool.

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