

Challenges in designing virtual environments training social skills for children with autism

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ABSTRACT

The purpose of the study is to explore particular challenges faced when designing virtual environments for children with autism, with the purpose of training social skills. Our findings are based on studying autistic behaviour during three years (primary and secondary sources), analysis of related system and other computer mediated assistive technology, as well as general game design. From these studies we have identified eight critical design parameters that need to be adjustable in a system suitable for autistic persons. The parameters importance, their variation range, as well as the need for *independent* adjustment of these were estimated and verified by experienced expert pedagogues.

1. INTRODUCTION

Autism refers to a collection of symptoms, related to disabilities or difficulties in social interaction (Steindal, 1997). There are large variations in capabilities and severity, but the lack of social understanding common in this group often lead to social exclusion (Parsons et al, 2000). Autism including less severe autistic disorders is estimated to affect around 1% of the population in Sweden (Steindal, 1997). Only the minority of these autistic children will manage an independent life as adults. However, social training and increased social competency increase quality of life and reduce the need of care.

General educational software is rarely suitable for this target group, since even though the content might be at an appropriate level, the context in which it appears is often too childish. It must be appropriate for the age of the users, because even though a 15-year old is functioning on the level of a 4-year old, he is still 15. Moreover, many traditional educational games give feedback on erroneous answers, i.e., by running an animation or providing an "error" sound, whereas nothing happens when a correct action is taken. This interaction model is inappropriate for autistic users, since it tend to encourage incorrect behaviour rather than preventing it (Eliasson et al, 1999). Therefore, there is a need for specialized educational software.

Using computer assisted training has become increasingly common to support learners with autism and autistic disorders in their skill improvement. Computer assistance has been used for various purposes, including using robots to enhance social skills (Robins & Dautenhahn, 2004), the use of Excel to improve planning activities (Hart, 2005), a training program for mouse interaction skills (Eliasson et al, 1999), as well as emotion recognition (Blocher, 1999). In particular, Virtual Environments (VE's) has shown great potential for training social skills (Charitos et al, 2002; Kerr et al, 2002; Kerr, 2002; Leonard, Mitchell, & Parsons, 2002; Parsons et al, 2003; Parsons et al, 2000). Many such systems are based on everyday social situation scenarios, such as going shopping, taking the bus or visiting a café. The main benefit of using VE's is, according to Parsons et al, (2000), that users can practice skills and social interactions safely, without experiencing potentially dangerous real world consequences and that the scenario can be controlled. Moreover, complexity of the scene can be controlled, and progress pace can be determined by the user. One of the challenges for the VE developer is how to construct the VE to allow freedom of exploration and flexibility in interactive behaviour, without the risk of users missing important learning goals (Kerr et al, 2002). According to (Grynszpan et al., 2005), requirements for software design remains poorly documented in this area.

The aim of this work is to identify critical design parameters, which need to be considered when designing scenario-based VE's training social skills for users with autistic behaviour. The challenges are due to the heterogeneity of needs and capabilities combined with the intolerance to improper levels of difficulties typical for this target group.

2. AUTISM AND SOCIAL TRAINING

Autism is a collection of symptoms that limits the ability to interact with and understand the surrounding world. These symptoms include reduced social skills, difficulties in understanding contexts and abstractions and a distorted sense of perception. Autistic behaviour often includes a reduced natural interest for human faces and voices (Hadwin & Howlin, 2001). The understanding of other people's emotions and minds is limited (Baron et al., 1988), and both understanding and application of flexible, context dependent rules are problematic (Steindal, 1997). Since they often have problems discriminating between important and unimportant details, care should be taken when designing Virtual Environments (VE) so that important objects and desirable actions can be identified easier. They often have a strong desire to organize their environment around comprehensible routines and regularities. Sudden changes, unpredictable events, unfamiliar environments or demands that are too hard or too easy can appear extremely frustrating, causing undesirable behaviour (Steindal, 1997). They also have a low degree of self-initiative and difficulties in understanding implicit instructions. Implicit choices, i.e., choices without providing alternative responses are generally not appropriate.

Social training is a method for rehabilitation with the purpose of increasing the participant's social skills. Studies show (Lieberman & Drake, 1994, Falloon, 1997) that increased social skills have several advantages, including subjective increase in life quality, shorter periods of residential care and longer periods of outpatient care, reduced risk of re-entry to residential care and decreased symptom intensity. One important aspect of social training is to master everyday tasks, like shopping or going to a café.

Routines and behavioural patterns are important for persons with autism, and having to break such habits and rules can cause anxiety and stress. However, part of the social training is to learn to loosen such behavioural patterns in a controlled and cautious way. Finally, the low tolerance for improper levels of challenge and demands means that the VE needs to be adaptable to individual needs and preferences.

Earlier studies show that knowledge acquired in the VE can be transferred into real life situations (Parsons, 2003). Users did however ask for more realistic scenarios since they found the behaviour the computer-controlled characters were too predictable in the VE. Being "just" a simulation, users found it unproblematic to behave in ways inappropriate in real life (for instance traversing private backyards). Therefore, we see a challenge in designing a game-like virtual environment based on realistic social scenarios for training social skills for a wide range of users with autistic behaviour.

3. RESEARCH APPROACH

This work is part of a larger project, aiming at development of a VE training social skills for children and adolescents in the spectrum of high-functioning autism. We have an explorative, user-centric approach to design, and our research team has experiences from interaction design, educational software design, game design, 3D animation and programming, as well as experiences from health and social caretaking of individuals with special needs. One of the team members have worked with autistic children during 4 years. Yet, in the process of trying to understand the needs and requirements of such a system we have realized that the project is far more complex and challenging than we first envisioned. In this paper, our goal is to describe and discuss the particular challenges we have identified to be critical design issues, which are related to special needs of this target group.

We have conducted the following studies: (1) analysed literature concerning autism, related system attempts, other computer mediated assistive technology, as well as general game design; (2) an ethnographic study during three years in a specialized caretaking centre; (3) and 15 in-depth interviews with personnel, teachers and relatives. From this we have derived 8 critical design parameters. Finally, (4) these parameters have been validated by 7 experienced expert pedagogues through estimation tests and interviews.

The ethnographic study took place during four years following 21 autistic children and adolescents, ranging from 6 to 21 years of age, in a caretaking centre. The caretaking centre specializes in children and adolescents with autism and autistic disorders, and they have been in operation since 1981. The centre is unique in the sense that it offers full-time accommodation as well as short-time day care activities. It is one of the most experienced centres in Sweden, and their pedagogical work has attracted attention nation-wide. During this period, we have cautiously observed participants during social interaction and computer usage, trying not to intrude and affect their doing by our presence more than necessary. Being aware of that the presence of strangers can have a strong influence on the behaviour of persons with autistic disorders, these observations was mainly used for an general understanding of relevant issues and as starting points for further explorations.

The first set of interviews took place during 2004 and 2005, and they were all open-ended in-depth interviews of informal qualitative nature. 10 of the interviewees were school personnel, 3 personnel from special accommodations, and 2 were families with autistic children. The age of the involved children ranged from 3 to 21 years. School personnel and accommodation personnel were selected because of their professional experience (2 - 34 years in service with the target group). They had various professional roles, including habilitation assistants, social and special pedagogues. The interviews were aimed at achieving a better understanding of the consequences of autistic symptoms, and their relationship and experience with using technology. The purpose of the study was to acquire understanding and information concerning design issues relevant for a virtual environment training social skills.

To verify the parameters appropriateness and the estimated variation in range, 7 additional interviews were conducted with experienced personnel and teachers, including one member of a national board for evaluating software for children with disabilities. The estimation test was arranged around visual illustrations of the parameters, where the illustrations represented different levels of the proposed parameters. The extreme points were used to create a scale, on which the interviewees were asked to plot the estimated appropriate level for all individuals they knew within the target group. The purpose of the test was to discuss the needed variation span and the importance of the different parameters. The interviews were recorded and analysed and is summarized in this paper.

4. CHALLENGE: VARIATION IN CRITICAL DESIGN PARAMETERS

Autistic people can have a number of different disabilities that are important to take into consideration when designing products adapted to their needs. These include a limited attention span in social situations, distorted sense of perception, difficulties understanding implicit instructions, difficulty discriminating between important and unimportant details, and a low degree of self-initiative. The limited span of attention in social situation influences the ability to recognize and interpret non-verbal communication such as gesture and facial expressions. This is of concern when designing interaction with virtual persons. To compose compound understanding from details can be problematic as well as discriminating between which details are important and which can be ignored.

In (Neale et al., 2002), the importance of flexibility within an educational VE was discussed, regarding allowance of different behaviour in different situations. Forcing different behaviours in successive use of the same situation may also be of interest. Their observations indicate a need to introduce much more randomness within these systems, perhaps by presenting the user with a number of VEs that are (superficially) different. The authors conclude by inquiring systems which allow for a more gradual progression in terms of introducing new concepts, increasing complexity as well as a greater variation in scenarios to prevent habitual actions and ritual behavioural patterns.

Our approach to these problems is to think in terms of a VE with *adjustable parameters*, which can be altered to suit the individual level of each user. Due to the variation in abilities and skills of the user group, and the importance of providing a proper level of challenge in the tasks to be performed, these parameters need to be adjustable as independently of each other as possible. Autistic children do not necessarily follow developmental patterns and can be very skilled in specific areas and yet have great problems with related tasks. Therefore, a model of progression where all lower levels proceed to more advanced levels simultaneously, which is the most common way of making tasks more difficult, is not fine-grained and flexible enough for this user group. The goal is to provide low granularity of change (as also noted by Neale et al, 2002), and a wide range of each parameter, to meet various needs. For this purpose, we have identifying a set of critical design parameters, which can be independently adjustable in a scenario-based virtual environment. These parameters could be adjustable by users, supervisors or intelligent agents in the environment. In the explanation of the parameters below, a shopping scenario is used as illustration.

4.1 Level of variation in scenarios

This parameter represents how much the scenarios change between each session. A low variation of scenarios is equivalent to the scenario looking exactly the same each time it is played, whereas a high variation means that different aspects of the scenario change with each replay. The intended variation is slight transformations of principally the same scenario. Aspects that can vary include, but are not limited to, layout of the scenario, items on the shopping list, number of merchandise in the store as well as their respective location, and different looks and behaviours of the computer-controlled characters. Some aspects of randomness ought to be considered (Neale et al., 2002), which for instance can mean to include additional incidences not in the

core path of the scenario, or different formulations of responses to the same action. These kinds of transformations and randomness can be controlled and manipulated as parameters.

4.2 *Level of alternative paths through scenarios*

Scenarios can have different number of choices along the way towards the goal. The easiest scenario consists of a linear path from start to finish, with no branching or deviation from that path. If the number of choices and alternatives in the scenario increases, the difficulty also increases correspondingly. This parameter does not state whether the different choices are more or less correct in the context, just that more choices are introduced in the scenario. These choices can be either geographical (“Do I go to place A or place B”) or more abstract (“Do I pay with money or do I use my Visa?”). A shopping scenario with a low level of alternative paths could be that the user enters a store with only one aisle and one possible path through it, or a shelf with only one kind of apples, whereas a high level can be a store with several parallel aisles or several kinds of apples to choose between.

4.3 *Level of difficulty in scenario content*

Different and clear levels of difficulty concerning scenario *content* should be considered when designing scenarios. The shop can be small or large, contain few or many merchandise, one or different compartments, one or many cashiers, be empty or crowded to give a few examples. More difficult examples include situations where items on the shopping list are difficult or impossible to find, for instance if the sought items are hidden far away in a corner or the store has ran out of milk for the day.

4.4 *Number of steps to complete task*

Each scenario contains a number of tasks, e.g. paying at the cash desk. These tasks can either be solved with a single click on a button or icon, or be subdivided into more steps. For instance, when paying for the merchandise, the simplest version just displays a button with the text “Pay for my items” or a picture representing the same. Click the button and you are free to leave the store. The opposite could include clicking a wallet-symbol, drag money-icons from your wallet to the counter representing the correct amount to be paid and then, if the correct amount of money is used, leave the store.

4.5 *Level of explicitness of goals*

If scenarios are clear with easily describable goals, they are usually manageable for most subjects (Parsons, 2003). Each scenario should have a goal that has to be met. The instructions on how to meet these goals can either be specific or described in general terms. At one end of this parameter, the expectations on the user are very clearly expressed, e.g. “Go in, get an orange, go to the cashier, pay for the orange, and then leave the store”. The far end of the range represents more vague instructions such as “Go in and get something tasty to eat”. Clear, explicit and apparent goals are recommended for autistic users, and this is an ambition worth striving for. However, in real life this is almost never the case, so such recommendation is in conflict with an ambition of realism. Therefore, this can be seen as a parameter objective to adjustment, where the goal can deliberately be made more “fuzzy” to achieve a more realistic situation and to train the user in acting on such situations.

4.6 *Level of richness in details*

The difficulty to discriminate important details can be facilitated in at least two ways: by removing details in objects (simplify the appearance of objects) or by removing unimportant objects and details. Both these can be used as parameters by setting attributes describing detail level to objects as well as to visual components of objects, and then only present scenes in the appropriate level of detail. The level of detail in the shopping scene can be altered by increasing the number of items in the store (either total amount or per item), the selection of items to be labelled, or how crowded the store is. Naturally, the level of detail in each object can also vary.

4.7 *Level of exploration freedom*

According to (Kerr, 2002), actions dependent on free exploration of the VE are not recommended for autistic users. However, since in real life many situations are open for exploration and experimentation where inappropriate actions are possible, this is an aspect that need to be trained nevertheless to become more realistic. Since it is often a difficult task for the users, it must be introduced gradually at an individual pace. This parameter sets the amount of explorative freedom within the scenario. Here we refer to how much the user is geared, explicitly or implicitly, towards a goal. When this parameter is set at its lowest, there is no

explorative freedom at all, and the user is only allowed actions leading to progression in the task. In the shopping scenario, this would among other things mean that it's only possible to pick up items that correspond with the items on the shopping list. At the other end of the parameter's range there is total explorative freedom, where the user must by own initiatives explore the environment to discover the goal as well as the possible actions. The former can be accomplished by preventing the user to undertake any inappropriate actions (such as leaving the store without paying). Intermediate levels could be to allow passing by the cashier but that this actions result in explicit or implicit indications of its inappropriateness. This aspect is also discussed in Kerr et al, (2002).

4.8 Level of built-in scaffolding support

Educational VEs need support and supervision by teachers/supervisors according to Kerr (2002) and Parsons (2003). Kerr mean, however, that such supervision can be performed by intelligent agents, and need not necessarily be human. Help and supervision can be provided by the system, as help instructions or as intelligent agents guiding the user to make progress in the task. For instance, if an erroneous action is taken by the user, help can be given by explaining why this was inappropriate, by explaining alternative (better actions), or by showing an alternative (better) action. Scaffolding can be built both within the confines of the VE world and as a meta-component. In the shopping scenario the clerk behind the counter can work as an in-world support. He can compare the items in the shopping cart with the items on the shopping list and check if there is something wrong. He can also help with the process of paying for the items.

4.9 Feasibility of adjustable parameters

In order to control the performance within the scenario and to observe the actions of the user, a control system must be included. We are currently developing and evaluating a two-part system that sends information on user behaviour in the VE world to the decision-making-engine. Information is sent at predetermined checkpoints, representing important steps towards completing the scenario. The checkpoints can also query the game engine regarding what action to take. By consulting the scenario dependent set of rules, the game engine can respond appropriately. In this way, personalized and adjustable critical design parameters can be incorporated in the environment

5. VERIFICATION OF CRITICAL PARAMETERS

To verify the parameters appropriateness and the estimated variation in range of the different parameters, an estimation test was conducted. To illustrate the parameters and their possible values in an example scenario, pictures of extreme scenes where created and arranged as end points on a scale (see below). The task for the interviewee was to judge the importance of the parameter as such, and to estimate appropriate levels on the scale corresponding to their experience with autistic children. They were asked to give estimations in terms of where on the scale the appropriate level for the lowest performing and the highest performing child they could think of would be, and to give ranges and estimations in percentage where on the scale would be appropriate for other children known to them. The rationale for this procedure was to collect and incorporate all the experience and knowledge the interviewees have with and about autistic children, and all seven interviewees were chosen because of their long experience in the field. The purpose of the test was to discuss the needed variation span, the distribution of abilities and the importance of the different parameters.

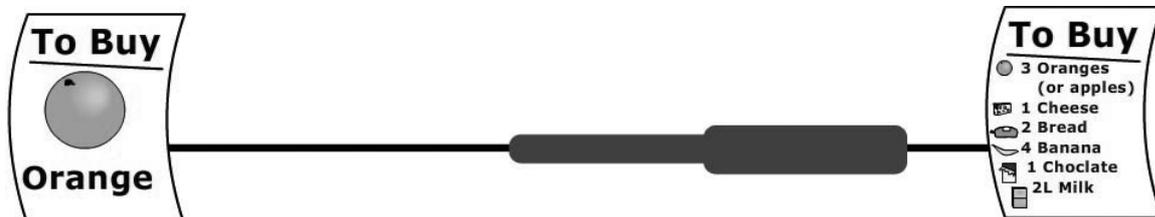
All interviewees confirmed that the full spectrum of levels represented by the parameters is definitely needed, as long as it is possible to adjust. They repeatedly expressed the importance of flexibility and adjustment, from the simplest possible to as close to reality as possible. The idea with independent adjustment of the parameters was much appreciated by the software evaluator.

In the diagrams below, the scale and the pictures used in the estimation test is shown. The leftmost picture represents the lowest level in the example scenario, whereas the right most represents the highest. The markings on the line between indicate approximately where the target individuals' needs are located on the scale, according to the estimation test. Two of the parameters where explained without illustrating pictures, and the range was discussed verbally instead.

5.1 Level of variation in scenarios

Variation in scenarios in general is seen as necessary and the possibilities to change variables accordingly are of great importance. To vary the scenario by changing the numbers of products on your shopping list seems to be the most important parameter, while the possibility to change look on the store or the cashier is desirable but not as necessary. The user group often have difficulties with variation since it makes them

insecure and unsure of what is expected from them. In a real situation this anxiety can lead to frustration and outbursts. However, since our environment in real life is constantly changing, it is considered very important to practice handling variations. Division in different levels is recommended where the lowest level is with no variations over time, and where the most difficult varies every time. Most autistic children are considered to benefit from training variation in at least one aspect of the scenario, preferably the shopping list, every time the game is played. Variations of the store and its content should be altered by time. The diagram below indicates that the estimation is that most children can manage a shopping list with a few items, if the text is accompanied with illustrative pictures.



5.2 Level of alternative paths through scenarios

In the left-most scenario, the path is completely determined by the layout of the store, whereas in the right-most the store is large with many possible pathways to choose. The majority of the children (indicated by the markings on the line) needs to be accustomed to an environment where path choices can be made and where the store is possible to investigate.



5.3 Level of difficulty in scenario content

To include various difficulties in the scenarios is considered good, on a more advanced level. Since shops can actually run out of products, this situation is realistic and need to be trained, but the interviewees agreed that this may cause problems for the users. On the other hand, they all agreed that it is good to include these kinds of difficulties, since it can be the starting point for discussions on how to handle unexpected situations in a safe training situation.

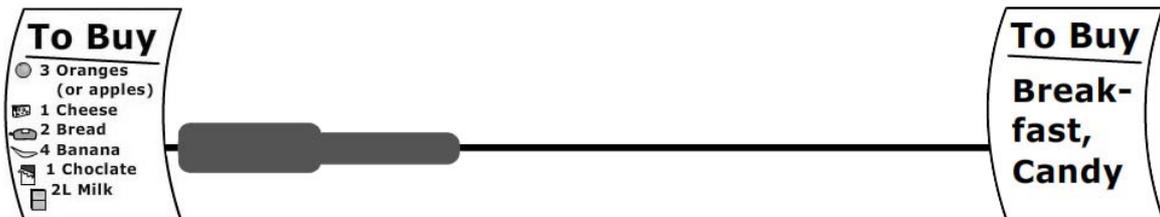
5.4 Number of steps to complete task

Explication should be given to almost everyone because one task will normally involve several steps of acting. A level based explanation is strongly desirable. The possibility to simplify complex tasks by automation of actions is considered an important feature of a virtual environment, since this is something which is more difficult to practice in real life. For instance, the left picture illustrates an automated payment action, where the user only need to click on an icon to get it done. The right picture represents the possibility to leave the exact amount of money asked for by the cashier. However, understanding the value of money is difficult for many autistic children.



5.5 Level of explicitness of goals

In general, an explicit description of the goal needs to be given to most children, to a more or less extent. In the shopping scenario, most children will need to know exactly which products they are expected to buy, one reason being that they need to practice variations in the list and also because making an active choice is often difficult for the autistic child. An implicit goal such as “buy breakfast” involves not only an understanding of the concept of breakfast, but also planning skills, implicit choices and decision making which are difficult.



5.6 Level of richness in details

The leftmost picture represents a scenario where the product to be bought in the store is the only that is visible, which means that all objects not involved in the action to be performed is removed from the scene. The rightmost picture illustrates a store with several surrounding items not involved in the action. The majority of the target group copes with that fact that several items exist around them in the store and they will still be able to get the product which was ask for, according to the interviewees. Despite this, they claim that the entire scale from the simplest possible case to a realistic situation is required to cover all various needs. The marking symbolise approximately where most individuals' needs are located.



5.7 Level of exploration freedom

The possibility of exploration freedom, i.e., a world where you can investigate your environment on your own, is considered to retain the player's interests longer. On the other hand, such freedom could be problematic for autistic children, since it requires self-initiatives and self-direction and the ability to concentrate on the task. To mimic reality some exploration freedom is required. For instance, on the higher levels is considered good if an ball can be picked from a shelf, even though it is not on the shopping list (as in real life). It should be possible to kick the ball, but a clear indication of the inappropriate behaviour should be given, preferably accompanied with a suggestion of an accepted alternative way of behaviour.

5.8 Level of built-in scaffolding support

In general, built-in scaffolding support is considered valuable as a complement to human instructors. Software that can be managed by the children without assistance is good for their self esteem and independence. The left-most picture represents no explicit help from the clerk, whereas the right represents an interactive help given by the system. The target group in general have difficulty handling money so built-in scaffolding in this example is definitely needed for most users.



6. CONCLUSIONS AND FUTURE WORK

Our conclusions are as follows:

- The proper level of challenge and difficulty is essential for autistic children, for a successful outcome of their training. Reinforcement of positive behaviour is crucial, so activities should always result in positive emotions and any kind of failure avoided.
- There are no similar games out on the market in Sweden around social training for this particular user group, according to the interviewees. The potential of the suggested VE as a pedagogical tool is considered high, and will likely invoke discussion around social situations among players or adults.

- The estimation test of experienced personnel verify the importance of the critical parameters, and that the suggested variation span is needed
- In contrary to many other level based games, the parameters here need to be *adjustable as independently to each other as possible*, since autistic children can vary extremely in their ability and capacity in different areas, so to adopt to individuals specific needs some parameters may have to be at the lower levels whereas another can be more advanced. Normally, the levels follow each other so that all parameters go from simpler to more advanced levels, which is not fine-grained enough to support this user group.

Future work includes developing the prototype further so that the respective values of the parameters can be tested in a direct manner with autistic users and their companions.

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