REACT: Intelligent Authoring of Social Skills Instructional Modules for Adolescents with High-Functioning Autism

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Abstract
Difficulties in social skills are generally considered defining characteristics of High-functioning Autism (HFA). These difficulties interfere with the educational experiences and quality of life of individuals with HFA, and interventions must be highly individualized to be effective. For these reasons, we are interested in exploring the way technologies may play a role in assisting individuals with the acquisition of social skills. In this article we present an approach to developing an authoring tool designed to help parents and other caregivers to create social problem solving skills instructional modules. The authoring tool, which we call REACT, will help non-experts create interactive social scenarios personalized to individual adolescents with HFA. The technology will assist by advising the author on instructional strategies, and on scenario creation.

Introduction
Adolescents with high-functioning autism (HFA) are a heterogeneous population with a wide range of needs and abilities. Difficulties in social skills, however, are generally considered defining characteristics of HFA. Because deficits in socialization interfere with the educational experiences and quality of life of individuals with HFA, and because interventions must be highly individualized to be effective, we are interested in exploring the way technologies may play a role in assisting individuals with the acquisition of social skills. Indications are that our target population, adolescents with HFA, responds well to computer-assisted instruction [Williams and Wright, 2002]. Furthermore, there was a general call for more technologies that specifically target social skills training [Putman and Chong, 2008].

We explore the use of interactive software to provide social skills training. We choose to target adolescents because they are underrepresented with respect to applicable therapies, they are more likely to have complex social skills needs, and research indicates that they should be targeted for social skills intervention [Rao et. al, 2008]. For example, an adolescent with HFA may want to go to a movie theatre without the assistance of a parent. Can a software module be developed to help that individual prepare for that social context? Furthermore, can a system be developed that helps parents and caregivers to author these modules themselves? Such a system would address one of the most challenging aspects of teaching children with autism; the need for individualized instruction for a highly heterogeneous population. These are questions that we would like to answer with our research.

It is our goal to develop a system that can help teachers and caregivers author and share instructional modules that adolescents with HFA can use to practice their social problem solving skills. In an earlier study, Refl-ex, a computer-based system was built and tested [Boujarwah et. al 2010]. Refl-ex is designed to allow the individual with autism to practice these skills by experiencing social situations and choosing appropriate responses to unexpected events. This study yielded promising results with respect to the effectiveness of

the instructional approaches used. In addition, the study logs showed that the participants did not all struggle with the same social situations. These findings support existing knowledge of the importance of individualizing interventions for this population of users.

We present an approach to creating an authoring tool designed to help parents, teachers, and other caregivers to create Refl-ex instructional modules. Our approach to aiding authors in creating these modules uses automated critiquing and collaborative problem solving techniques. The authoring tool, we call the Refl-ex Authoring and Critiquing Tool (REACT), will help non-experts (i.e. authors who have who have little or no knowledge of instructional strategies) create interactive social scenarios personalized to individual adolescents with HFA. The technology will assist by advising the author on instructional strategies, and on scenario creation. For clarity, throughout this document, the user of Refl-ex will be referred to as the student, and the individual using REACT will be referred to as the author.

This article is arranged as follows. We begin by presenting some background on autism and describing our prior work on the Refl-ex instructional modules, which are the goal output of REACT. Next, we present related work in the areas of computer-assisted instruction and automated critiquing. Finally, we present our approach to creating REACT, and a plan for its evaluation.

Autism Background and Prior Work

Autism Background

Kanner [1943] and Asperger [1944] are generally credited with first identifying and describing individuals with autism in the 1940's. Today we have improved our understanding and awareness of autism and recognize it as a spectrum, clinically referred to as autism spectrum disorders (ASD). Individuals who are diagnosed with ASD, but do not exhibit language impairments, are often referred to as having high-functioning autism (HFA). Impaired social functioning is the central feature of HFA. A lack of social competency can result in significant difficulties in daily living, academic achievement, and poor adult outcomes related to employment and social relationships [Howlin, 2003]. Researchers and educators have attempted to develop and implement interventions that lead to social competency. The results of one recent meta-analysis, however, suggest that current school-based interventions were minimally effective for children with autism [Bellini et. al., 2007]. In order to improve the status quo they recommend increasing the intensity or frequency of the intervention, and developing interventions that address the individual needs of the child. Our research provides the means to implement these changes; the child can practice these skills as frequently and for as long as necessary via Refl-ex, and REACT will enable the parent or other caregiver to easily create modules that address the child's needs.

Social Skills Interventions

Social skills training interventions are an important part of the education of children with HFA. Educators use a variety of techniques, often in combination, to teach these skills. In Social Stories™, which is a commonly used paradigm, parents or teachers develop stories that are related to some event in the child's life. Each story is meant to help the child to learn appropriate behavior for the particular situation. These stories are written in a manner that is instructive, however they do not demand active child involvement [Reynhout and Carter, 2009]. Refl-ex augments this approach by engaging the student in the creation of the story and guiding them as they practice social skills.

Several interventions exist that incorporate technology. The Junior Detective Training Program [Beaumont and Sofronoff, 2008], for instance, consists of group social skills training, parent training, teacher hand-outs, and a computer game. The "I can Problem-Solve" program [Bernard-Opitz et. al., 2001] is a software based intervention used with children between the ages of 5 and 9 in which they are presented with problem situations and asked to verbally produce solutions. In the evaluations of both interventions the children with ASD showed improvement as a result of the intervention. These findings reinforce the importance of developing such software systems, and confirm that they are an effective way to teach social skills. The student cannot use these systems independently, however. Refl-ex enables this independent practice.

Other experimental technological approaches to ASD intervention include virtual reality simulations, and virtual peers for language learning, an important aspect of social interaction. In several studies researchers use virtual animated characters to invite language learning [Tataro and Cassell, 2008]. Researchers have also created virtual reality environments designed to familiarize individuals with ASD with social settings [Parsons et. al., 2004]. This work involved learning to identify roles and procedures in a social environment. Refl-ex differs by simulating the progression through a social situation in which the student must exhibit social problem solving skills.

Prior Work

Refl-ex is designed such that each module presents the student with a real life social situation in which an unexpected obstacle arises, using language and visuals inspired by Social StoriesTM [Gray 1995]. These modules are the target output of REACT, and each has two parts; an experience section and a reflection section. In the experience section the student is guided as they navigate a social scenario and overcome an unexpected obstacle. Then, in the reflection section, the student revisits the decisions they made during the experience portion. In this work we will only address authoring the experience portion. Throughout the module, an invisible recording system logs the student's interaction with the system. This data-gathering feature allows the system to keep track of how the individual progresses and particular difficulties they may be having. This information will be used to augment the knowledge base of the critic in REACT thereby allowing it to advise the parent or teacher of particular problem areas. Following is a description of the important characteristics of the instructional modules.

The Experience Section

In the experience section Refl-ex presents the social scenario through text, audio narration, and picture book style images that correspond to the specifics of the situation (fig. 1). This is similar to the approach used in Social Stories™, which uses cartoon figures and text-bubbles to represent speech. One advantage of this visual presentation is that it allows for the inclusion of the meaningful information, and the exclusion of distracting material. In addition, the system presents the scenarios in the first person perspective. This is intended to help the student to identify with the character, and immerse herself in the storyline. Individuals with HFA prefer environments with high degrees of certainty, repetition, and predictability. Dealing

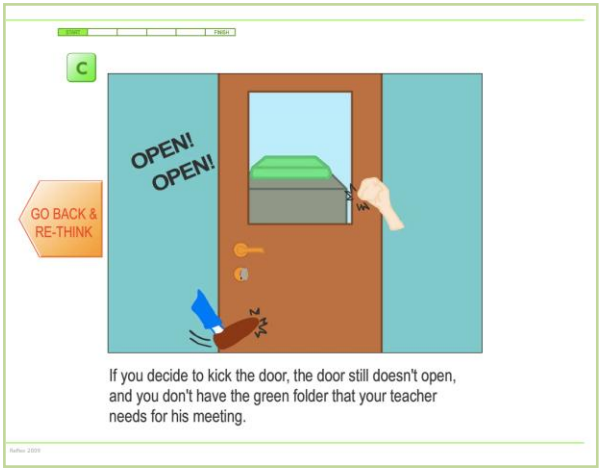

Figure 1. Rethink Screen in Refl-ex

with others in social settings introduces a high degree of uncertainty for those with autism. It is common for individuals with HFA to rehearse situations before hand. Unfortunately, rehearsal is not always effective as those with HFA might learn cues specific to only one environment or person [Heflin and Alberto, 2001]. Our visual design choices are meant to help avoid the learning of incorrect cues by limiting the information in each picture.

Scenario Representation. Each scenario is represented as a narrative with multiple paths, where a narrative is defined as a series of actions that describe how a situation unfolds. All the paths together resemble a graph, or branching story, where nodes are scenes and edges are branching points. The canonical branching story systems are Choose-Your-Own-Adventure novels. However, recent research has resulted in a spate of computational approaches to branching stories [Riedl et. al., 2008]. Refl-ex can be considered to be an interactive narrative where each possible narrative is based on productive, unproductive, and counter-productive possible executions of social problem solving skills in specific contexts. The student has to make a series of choices to proceed to the obstacle that is introduced and ultimately successfully navigate the social situation. REACT will help the author to create this interactive narrative by leading the author in the creation of narrative, and decision pages.

Errorless Learning. We follow an approach of errorless learning, which means that the student is not allowed to fail. When the student makes a choice that is considered unproductive or counter-productive the system explains the possible consequences of that action without using negative language, and directs the student to rethink their choice (fig. 1). When the student returns to the decision point the undesirable choice that they have already explored is grayed out to prevent it from being chosen again. In this way the system provides immediate feedback and helps the student to correct their error. Errorless learning is often used with individuals with HFA to avoid the possibility that they acquire incorrect skills; individuals with HFA are extremely prone to repetition so it is essential to avoid reinforcing anything other than the desirable execution [Heflin and Alberto, 2001]. REACT will also aid the author in the creation of the rethink pages.

Related Work from Artificial Intelligence

Computer-Assisted Instruction

Computer-assisted instruction (CAI) refers to any use of software in the instruction of students. Research in this area has evolved significantly in the more than 50 years since it began, and has been shown to effectively augment traditional instruction and interventions [Suppes and Morningstar, 1969; Anderson et. al. 1995]. When the software incorporates artificial intelligence to model real human tutoring practices, it is referred to as an Intelligent Tutoring System (ITS). ITSs employ models of instructional content that specify what to teach, and strategies that specify how to teach. Intelligent Tutoring is a subclass of CAI that is theoretically more suited for personalized interactions.

Refl-ex shares many similarities with ITSs. In particular, both Refl-ex and ITS require labor-intensive authoring of new content and problems, requiring knowledge from diverse teams of experts. To facilitate the development of these systems, a great deal of research has been done on ways to develop ITS Authoring Tools (ITSAT). Blessing and his co-authors [2008], for instance, have developed and evaluated an authoring tool to aid in the development of model-tracing ITSs. The aim of the work described in this article is to facilitate the authoring of social problem solving skills instructional modules. While our work is not strictly considered an ITS, it is greatly informed by research in ITSs and ITS authoring.

Authoring tools that aid users in the creation of instructional stories for children with autism have begun to appear, both for the classroom and for parents to use at home. Intellitools [Intellitools, 2010] is an example of a tool developed for use in the classroom that is currently being used to develop instructional stories. Stories2Learn is one of many iPad apps that have recently been developed for use with children with autism [Stories2Learn, 2010]. It is designed for use both by teachers and parents, and facilitates the creation of personalized instructional stories in the standard sequential narrative approach. These systems enable the creation of the story, but do not guide the author with respect to the content. REACT will not only provide feedback on the content, but will also allow the creation of interactive multi-path scenarios.

Critiquing and Cooperative Problem Solving Systems

The design of the interaction between the author and the system in REACT is modeled after that used in critiquing and cooperative problem solving systems. Such systems have been designed for varied applications ranging from architectural design to education. In a cooperative problem solving system, instead of simply providing input, and waiting for the system to provide answers, the user is an active agent and works with the system in the problem solving and decision making process [Fischer, 1990]. The precise roles played by the user and the system are chosen based on their different strengths with respect to knowledge of the goals and the task domain. Critics are an important component of these systems, and can be designed such that they detect inferior or inappropriate content, provide explanations and argumentation for their "opinion," and suggest alternative solutions.

JANUS, for instance, is a critiquing system for architecture design that distinguishes "good" designs from "bad" designs based on design rules. After the user changes a design, the critic's messages are displayed, and the user can click on them to be shown alternative designs that have been successful [Fischer et. al., 1991]. One approach to developing critiquing systems that is of particular interest is the incremental model used in Java Critiquer [Qiu and Riesbeck, 2008]. In addition to providing students learning to program in Java with individualized critiques, this system allows teachers to refine existing critiques and author new critiques, thereby creating a system that is always evolving and improving to meet the user's needs (i.e. getting smarter). We will employ this approach in the design of REACT.

REACT

The Refl-ex Authoring and Critiquing Tool (REACT), will help non-experts create interactive social scenarios personalized to individual adolescents with HFA. We envision the REACT authoring experience proceeding as follows. The author will be presented with a simple user interface that allows them to create the various types of screens needed for Refl-ex (decision, rethink, etc). The author will also be presented with suggestions for what could happen next in the scenario, including appropriate instances in which the obstacle may be introduced, what that obstacle is, and possible solutions to populate the decision point. The author can choose to either drag the suggestion to the text field and use it as is, drag the suggestion and then modify it as they see fit, or use it as inspiration for their own text. Once the author has inputted text, the critic will provide feedback on the appropriateness of the text. This process will continue until the author is satisfied with the text. In this way, the author and the critic will collaborate in the creation of the module. Following is a more detailed description of the interaction, including a description of how the suggestions are generated.

The Critiquing Rules

In REACT we will use an analytic critiquing approach. Analytic critiquing requires that a system have sufficient knowledge to detect possible problems. Such a system offers critiques by evaluating a user's solution against stored rules [Robbins, 1998]. In REACT the critiquing rules will be made up of rules based on correct and complete cognitive scripts of the situation to be presented, and instructional strategies for teaching social problem solving skills to adolescents with HFA.

Script Rules. How do neurotypical individuals organize their knowledge in such a way that allows them to know what appropriate behavior is in a particular situation? For instance, how do you know that you are supposed to pay for your food before you sit down at a fast food restaurant, but not until after you have eaten at other restaurants? Schank and Abelson [1977] present the notion that we develop scripts, or standard event sequences, which enable us to subconsciously know what to expect. These scripts are not rigid, and instead contain multiple contingencies. They explain that people develop these scripts early in life, based on their experiences. Research has shown that these scripts develop early in childhood, and that children with autism generally generate fewer well-organized scripts [Volden and Johnston, 1999].

We are currently conducting a study where we use crowd-sourcing techniques to elicit the cognitive scripts of many neurotypical individuals for every day tasks, like going to a restaurant. In addition, we are asking participants what could go wrong at each step, and how they would handle these situations. In a manner inspired by Orkin and Roy's [2009] Collective Artificial Intelligence, the data collected will be analyzed to develop a model similar to a Plan Network. A Plan Network is a graph showing probabilistically how events follow each other; as illustrated by the Restaurant Game, a plan network shows all the ways in which a restaurant experience can unfold. The introduction of an obstacle is salient to our pedagogical approach. For this reason our model will also enable REACT to provide the author with ideas for obstacles and possible solutions to insert into the modules. This model will be used to develop the critiquing rules. For instance, one rule might be "wait in line then order food" or "restaurant runs out of [favorite food]." This class of rules will address the completeness, and sequencing of the content in the instructional module and will be called script rules. The steps in these scripts will also be modified in accordance with the instructional strategies described in the next section to generate suggestions for the author. We will begin by developing scripts for a subset of situations, and progressively develop more scripts to incrementally increase the REACT knowledge base.

Strategy Rules. Rules will also be developed based on research validated guidelines and strategies for teaching social skills to this population of students. For instance, in order for an instructional story to be considered a Social StoryTM, it has to follow specific guidelines [Gray, 1995]. In particular, the story must include several types of sentences, including descriptive statements used to describe the situation and people involved in it, perspective statements that describe the reactions, feelings, and responses of others, and directive statements that identify an appropriate response and guide the student's behavior. Gray recommends using the ratio of one directive sentence for every two or more sentences of another type. Other researchers provide additional strategies for social skills instruction. Klin and Volkmar emphasize the importance of teaching theory of mind; explicitly explaining what others are feeling and doing [Klin and Volkmar 2000]. Others indicate that the story should be presented in the first person, use vocabulary that is of an appropriate level of difficulty, and avoid terms like "always" (because of the literal mindedness of individuals with HFA) [Heflin and Alberto, 2001; Bernard-Opitz et. al., 2001]. This is only a subset of the

guidelines, but it can be seen how they can be used in combination with the steps in the cognitive scripts to generate suggestions for the author on every screen. The guidelines will also be transformed into rules we will call strategy rules, and will address such factors as reading level, the use of first person language, and the avoidance of problem words and phrases.

The User Interface

In a cooperative problem solving system, the user is an active agent and collaborates with the system in the problem solving and decision making process. Our tool is designed such that the role of the user is to act as the author of the modules, and contribute social skills expertise, and knowledge of the particular needs of the student. We assume that, as neurotypicals, the authors have social problem solving skills expertise. Our system will employ the incremental approach used in Java Critiquer [Qiu and Riesbeck, 2008], and will evolve and improve incrementally, both as a result of the data collected by the logging system on the student's interactions with the modules, and the knowledge provided by the author.

In our system the author will be provided with an interface that facilitates the creation of the branching structure, and prompts them to input the content. As described earlier, the instructional modules are made up of three different screens; the narrative screens that present the scenario, the decision screens where the student chooses a solution, the rethink screens where they are explained the consequences of an unproductive or counterproductive solution.

The interaction for the three types of screens will be similar. Imagine the author is working on a scenario related to going to a restaurant and they are currently working on a narrative screen. It can be very intimidating for an author to be presented with a blank screen and asked to input content. In REACT we try to make the process as easy as possible for the author. We do this by offering the author several suggestions for text they can use. REACT generates these suggestions based on its knowledge of the instructional needs of students with HFA, and of the most commonly taken next step in the script. The suggestions are ranked based on their appropriateness for the student. For instance, imagine the author has just completed a screen in which the student has ordered their food, the suggestions in this case might be:

1. ou ask the cashier to repeat your order so you make sure she heard you correctly.
2. ou listen as the cashier repeats your order. This lets you make sure she heard you correctly.
3. You ask the cashier how much your food costs. You know you have $10, and you want to make sure you didn't order too much.
4. The cashier tells you your food costs $8.50. You take out your wallet, and hand the cashier a $10 bill to pay for your food.

In this case the first suggestion is ranked highest because it involves the student taking initiative to prevent a potential problem situation. The author can choose to either drag the suggestion to the text field and use it as is, drag the suggestion and then modify it as they see fit, or use at as inspiration for their own text. Once the author has inputted text, REACT provides feedback on the appropriateness of the text based on any script or strategy rules that have been broken. This process will continue until the author is satisfied with the text. REACT will similarly lead the author in the creation of the other screens, (e.g.

indicating options for when to introduce obstacles, and providing suggestions for possible solutions on a decision screen).

On each screen the author will be asked to record the narration, or import previously recorded audio files. As in existing systems, authors will be able to import pictures they have taken to use as the visuals in the module. In addition, REACT will aid the user in creating picture-book style images by providing the user with a drag and drop interface that will allow them to construct the image using various components.

Plan for Evaluation

The goal of REACT is to enable novice authors to develop expert-like social skills instructional modules for adolescents with HFA. Our plan for evaluating REACT will involve asking parents to develop Refl-ex instructional modules with and without REACT and acquiring expert evaluations of the various modules. In order to evaluate REACT, a second interface, called Refl-ex Builder, will be developed that simply allows the author to create the Refl-ex instructional modules, but provides no feedback on the content.

Participants will be recruited from our target author population; neurotypical parents or other caregivers of adolescents with HFA who have little or no knowledge of instructional strategies. After a brief presentation of the Refl-ex instructional modules the participants will be asked to create their own modules. Each participant will be asked to create 3 modules, one each using REACT, Refl-ex Builder, and Stories2Learn [Stories2Learn, 2010]. The order of using the systems will be such that it counterbalances any learning effects. We ask the authors to create stories using Stories2Learn in order to compare REACT to a system that is currently available. All of the modules that are created will be presented to experts in social skills instruction for evaluation. The experts will be asked to rate the modules on their instructional soundness, and their appropriateness for the target student population. For instance, are the situations presented with an appropriate level of detail, and using appropriate language? This study design should enable us to evaluate the influence of the intelligence in REACT.

Conclusions

Adolescentswith HFA can function effectively and independently, but they need assistance learning to handle the complexities of society. We believe that the approach to creating REACT described in this article will put the ability to easily create individualized instructional modules in the hands parents and other caregivers. This will empower the parents to develop modules of whose quality they are confident. Most importantly it will enable adolescents with HFA to have access to a larger variety of modules that they can use to practice social problem solving skills independently.

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