Chapter

Social Orthotics for Youth with ASD to Learn in a Collaborative 3D VLE.

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INTRODUCTION

A multi-disciplinary team including special educators and learning technologist at the University of Missouri are developing a 3-Dimensional Virtual Learning Environment (3D-VLE) to assist youth with autism spectrum disorders (ASD) in their development of targeted social competencies. The project, iSocial (http://isocial.rnet.missouri.edu/), seeks to take a successful face to face program delivered over a 10 week period by a trained guide to groups of 4 to 5 youth, and deliver the program online via a 3D internet-based virtual world (Laffey, et al. 2010; Laffey, et al. 2009; Schmidt, et al 2008). A key goal of building an online program is to increase access to the program. To engage in iSocial the youth must work cooperatively in the online environment, including following directions from an online guide and collaborating on many online learning activities with other youth with ASD.

While a key goal of iSocial is for the youth to transfer lessons and competencies learned in the online environment to their traditional face-to-face settings with parents, teachers, friends and classmates, in planning for iSocial the developers recognized a need for design features to help the youth interact and be social during the online learning processes. Youth who do not readily take turns, attend to social cues and expectations nor cooperate effectively in face-to-face settings are also likely to struggle with social practices in the online setting. The challenge, of course, is to assist youth with ASD, who have deficiencies being social, to be social while learning competencies to be social. This is a key feature of the face to face curriculum and an essential requirement in the translation to the online environment. We articulated a concept of social orthotics to represent types of structures that might be needed to facilitate social interaction and social learning in iSocial. The vision of social orthotics in a 3D VLE is to be both assistive and adaptive for appropriate social behavior when the student, peers and guide are represented by avatars in a 3D virtual world designed to support learning and development. This chapter describes how we are thinking about and developing early implementations of social orthotics. The chapter also shares what we are learning about these ideas and their potential to support appropriate online behavior. Additionally we discuss some key challenges for design and development of social orthotics.
BACKGROUND

Literature

As a collaboration of researchers in the field of Special Education with researchers in the field of Learning Technologies we consider the role of technology in assisting social performance as an integration of both traditions. In special education assistive technology refers to devices that increase, maintain or improve capabilities of individuals with disabilities for those performances. In learning technologies all technology is seen as a means for augmenting human capabilities. Donald Norman, a noted guru about human interface, wrote a book about “Things that make us Smart” (Norman, 1994) articulating the view that the quality of design of devices impacts human capability both for good and for worse. These two world views of technology assisting individuals to overcome disabilities and augmenting individuals to enhance their abilities combine to sensitize the design of iSocial to the general impact of all design decisions on human capability and the specific potential of a class of devices that may shape targeted social behavior.

Researchers in the field of assistive technology for individuals with ASD pay particular attention to communication functions and have asserted the value of augmenting language input through visual devices (Hodgdon, 1995; Quill, 1997; Mirenda, 2001). Mirenda’s (2001) review of literature from prior to 1999 showed the potential of visual cues to support comprehension of speech, managing activity, and choice making. Methods to stimulate language production with symbols and augment language by using voice generation devices also showed some evidence of support for communication. Two conclusions seem apparent from the review: (1) communication-related behaviors can be augmented and visual cues seem especially promising for individuals with ASD, and (2) the benefits of any assistive technology is highly dependent on the fit between the form of the technology intervention and the individual’s needs and capabilities. The importance of the fit between technology and individual needs has been further supported by research in the promising domain of using robots to foster communication practice for youth with ASD. Examinations of robots as assistive technology (Roberts, Dautenhahn, te Boekhorst & Billard, 2004) confirm the need to fit the technology to the individual characteristics of the child. More recently (Mirenda, 2009) the evidence for assistive technology for communication and social skills has increased and the forms of devices have become more sophisticated and integrated. Another review and effort to guide the application of assistive technology (Pierangelo and Giuliani, 2008) emphasizes matching technologies (both low and high technology) with the needs of the child and attending to developmental progression in the use of forms of the technology. In addressing the use of assistive technologies for the development of social skills Pierangelo and Giuliani recommend low-tech strategies such as reading social stories, using comic strip conversations and having social scripts. Numerous software systems have been developed as high tech ways to enhance these low-tech strategies.

Some researchers in the field of assistive technology for youth with ASD have also examined the capability of youth with ASD to work and learn in a 3D VLE as a means for developing social skills and competencies. These studies have demonstrated that participants with ASD can use and interpret VLEs successfully and use VLEs to learn simple social skills (Cobb et al., 2002; Mitchell, Parsons, & Leonard, 2007). However, this prior work has addressed the teaching of skills, but not structures and mechanisms (orthotics) for actually being social in a 3D environment. For example Parsons et al. (2006) use a café scene to teach skills of finding an appropriate seat, but the scene is a single user context and only implements a set of rules for finding a seat, rather than possibly providing opportunities for greeting others, leaving others or practicing how to act in a café with peers taking on other roles in the scene. The majority of 3D VLE prior work has viewed VLEs as an experience of a single user sitting at a computer to take on a specific task with a physically-present adult assistant. iSocial, however, seeks to immerse the
youth in a VLE for multiple and integrated experiences as well as support these youth as they learn collaboratively with and from other members within the VLE.

Since Douglas Engelbart wrote the seminal work on augmenting human intellect with technology (Engelbart, 1962) the idea of technology assisting or augmenting human capabilities has been a core principle in the field of designing computer systems for learning and performance. In this sense the notion of assistive technology is much broader and general than in the field of special education and is viewed as amplifying human capacity rather than as compensating for disabilities. However, in the practice of design the blending of affordances and constraints to customize support for unique forms of human capability is common to both special education and more general design work. Two tracks of work in computer systems design for learning and performance seem appropriate to mention as foundations for our conceptualization of social orthotics: performance support and scaffolding. Performance support has been a design approach since the late 1980’s and early 1990’s in response to the growing presence of computers in the workplace and the need to improve productivity. We do not often speak of this approach now as a separate form of design because it has generally been incorporated into most approaches to the design of modern computer systems. Tax preparation software, such as TurboTax by Intuit, represents a canonical example of the application of performance support in that it is meant to act as a butler assisting with tasks that the user knows how to perform and act as a coach for tasks unfamiliar or challenging to the user (Laffey, 1995). Scaffolding is the other construct from learning technology that shapes our thinking about social orthotics. Collins, Brown, and Newman (1989) characterized instructional scaffolding as a process where an expert performs part of a complex task for which a learner is unprepared, thereby allowing the learner to engage in work that would normally be outside his/her grasp. Scaffolding can take the form of a suggestion or other discourse based assistance or specialized devices such as the short skis used in teaching downhill skiing (Burton, Brown, & Fischer, 1984). Explicit forms of instructional scaffolding - those delivered primarily through interaction with an advisor or expert - represent only one kind of scaffolding. Procedure and task facilitation, realized through physical and structural supports that are implicit to the design of an interface, are also forms of scaffolding. This extended notion of scaffolding (Quintana, et al, 2004; Hmelo, 2006; Lin, 2004) which includes both advisor-like expertise delivered via agents in the 3D VLE and structures designed to constrain and invite appropriate behavior are a basis for conceptualizing and designing social orthotics.

**Early Field Experience for iSocial**

One unit, a unit on conversational turn taking, from the five-unit SCI-CBI curriculum (Stichter, et al. in review, Randolph, Gage & Schmidt, 2007) was developed for delivery in the iSocial VLE prior to our implementation of explicit devices for social orthotics. Four youth in pairs of two (boys on the autism spectrum, ages 11-14) undertook the lesson facilitated by an online guide. For each pair, the unit consisted of two training sessions of one hour and then four one-hour lessons delivered in a two week period. Our findings for system usage show iSocial to be easy to use and enjoyable. However we also found many challenges for social interaction and specifically for executing appropriate turn-taking behavior and the coordination of activity. During the lessons there were numerous instances when youth would interrupt each other, fail to initiate conversation when needed, and fail to respond appropriately. The online guide had difficulty facilitating these exchanges as she could only see avatar behavior and it took time to determine if the youth were participating appropriately, inappropriately or were just not attending. The online guide also had trouble coordinating activity in the VLE, due to a lack of traditional control mechanisms, such as nonverbal cues. For example in the classroom the guide notices subtle cues from students as they are starting to drift from instruction, and she can use those cues to start processes to bring the student back to attention. However, when learners would engage in
undesirable behavior in their physical environment such as gazing out the window or excessively clicking mouse buttons or keyboard keys, the online guide often did not know these behaviors were occurring and could only try verbal prompts to keep the youth on track. In addition, the youth were both curious about the environment and uncertain about how to move effectively. As a result, learners often were missing in action, sometimes out exploring and sometimes trapped in walls or other dead ends in the iSocial environment. Such issues of navigation and inappropriate behavior were distracting, which typically slowed the rate of instruction and impeded the flow of the lessons. Consequentially, the online guide was unable to address the same amount of instruction in one hour in the VLE as is typical in a face-to-face class, causing instruction to be sometimes rushed.

SOCIAL ORTHOTICS

In our early conceptualization of iSocial we envisioned devices for mediating the learning activities in ways that scaffolded the youth in the learning process. For example, figure 1 shows an early prototype of how a conversation console could be used to both constrain and support turn taking and facilitate empathy during various interactive exercises that made up the curriculum. This form of scaffolding was directly linked to the instructional objectives of the curriculum, such as to support appropriate turn taking and trying to understand what others might be thinking or feeling. You might imagine the conversation console operating like an expert coach or advisor helping the youth make sense of the situation and suggesting attention to certain aspects of the situation. Following from our review of literature, which showed the potential of visual representations and the need for tailored assistance, we envisioned varying the implementation and intensity of the visual representation so as to customize the mediation to the individual youth’s needs.

![Conversation Console](image)

**Figure 1. A conversation console as an early prototype of social orthotics.**

Based on our early field tests of the turn-taking unit, the need for support for core aspects of social engagement and interaction became apparent. We still envision scaffolding for learning such as the conversation console, but we turned our immediate attention to devices that might help keep students together, focused, and provide errorless learning (Something not available in natural contexts) to better scaffold instruction and hence avoid initial excessive and distracting behavioral errors such as interruptions. Our primary focus in developing *social orthotics* was to assist the youth in being social and to support the online guide whose role it was to manage youth
behavior and facilitate learning in the 3D VLE. Since the nature of a computing environment affords the potential to vary the implementation and intensity of the implementation our view was to customize orthotics to the individual youth’s needs, present and future and provide the orthotic in the most appropriate way for the youth, social competency development level and activity.

**Conceptual Framework for Social Orthotics in iSocial**

Social orthotics are pieces of software tools and customizations to the virtual environment which are integrated into the interface and virtual world in such a way as to support social interaction and mediate acquisition of social competency from coaching, on-demand assistance and just-in-time feedback. A goal of these orthotics is to enable learners to engage in effective social practice for which they do not have full competence. Figure 2 provides a schemata for how these tools pair pedagogical strategies for teaching social competency with software mechanisms geared towards facilitating pro-social behavior. For our second round of prototyping and field testing to be undertaken in 2009 and early 2010 we are focused on two essential skills for basic social practice: (1) avoiding interruptions (iTalk) and (2) exhibiting proper adjacency, distance and orientation behavior (iGroup).

![Figure 2. Conceptual diagram of social orthotics for iSocial – round 2](image)

All activity in a 3D VLE is mediated by designed spaces and devices. Since it is the intention of the design work to make all elements work toward the desired ends of competent social practice within the system and practice for social competency beyond the system, it is important to distinguish between 3 major design aspects related to assisting social practice. The three design elements related to the role of social orthotics are general environment, physical devices for targeted behavior, and dynamic agents. We will illustrate these three design approaches by work we did from round 1 to round 2 of the design in addressing the problem of youth getting lost or wandering in the space thus delaying the progress of lessons. As an approach to general environment design we went from an environment that had numerous rooms related to specific elements of the curriculum to a more open layout. In this new environment it was easier for the online guide to see where the students were and it was less likely that students would get lost in rooms or stuck in walls. An example of physical devices for targeted behavior can be seen in
Figure 3. Here the circle indicates a space for the youth to enter which in turn changes their perspective from a third-person view of themselves and others in the scene to a point of view perspective of the materials of the lesson. Entering the circle can also have other properties such as not allowing the user to leave until the guide permits it as well as managing orientation to other members in the circle and focus on aspects in the user view. An example of an agent for being in the appropriate place and keeping an appropriate focus will be described in the next sections, but includes monitoring user behavior and providing feedback and guidance. While all three of these approaches are meant to be “assistive” for social practice, we consider the latter two to be social orthotics and for the purposes of this paper we will focus solely on agent-based forms of orthotics.

Figure 3. An example of a “virtual” physical social orthotic

iGroup: Avatar Orientation, Adjacency and Distance

A key problem observed during the field test was the difficulty of having the target youth learn in a group when they struggled with rudimentary behaviors and orientations necessary for group activity, such as facing one another and not invading each other’s space. In the case of our field test the group was very simple, two youth and an online guide, but we anticipate groups of 5 to 6 youth with a guide so mechanisms are needed for helping users manage the non-verbal aspects of group interaction. iGroup is a software-based means to reinforce desired adjacency, distance and orientation behavior and constrain undesirable behavior. By orientation, we mean the directionality of the user’s avatar towards a speaker. For instance, a user having his or her avatar’s back turned to a speaker (undesirable behavior) as opposed to looking at the speaker (desirable behavior). By adjacency, we mean how close users’ avatars are to one another. For example, a user having his or her avatar directly in front of the speaker’s avatar or touching the speaker’s avatar (undesirable behavior) as opposed to having the avatar approximately within one
virtual meter of the speaker (desirable behavior). By distance, we mean the area between users’ avatars. For example, a user having his or her avatar across the room from the speaker’s avatar (undesirable behavior), as opposed to having the avatar within three or four virtual meters of the speaker (desirable behavior).

The iGroup tool provides users with mechanisms that constrain inappropriate adjacency, distance and orientation behavior and encourage users to follow the rules for appropriate adjacency, distance and orientation when holding a conversation. iGroup monitors users’ avatar adjacency, distance and orientation in respect to other users, notifies users when they are displaying inappropriate adjacency, distance and orientation behaviors, and constrains their ability to continue these behaviors. In addition, iGroup provides coaching and assistance by sending notifications to users such as, “Someone is speaking, but my back is turned. I should turn around and face the speaker or else they may think that I am not interested or I am being rude.” Finally, iGroup can be fit to users’ differing abilities for managing their avatars’ orientation, adjacency and distance. As an example of fitting the functionality to the individual needs of the youth, one child might be provided text messages reminding him of more appropriate behavior while another child with a record of inappropriate behavior might be “virtually” physically restrained from moving outside the circle or have a specific orientation imposed on his avatar in response to a series of undesired behaviors.

Given a conversation between users with the iGroup tool enabled, inappropriate adjacency, distance or orientation behaviors during a conversation will be identified and the user exhibiting these behaviors will be provided with a notification. From the user’s perspective, iGroup sends notifications to the user’s screen when undesirable adjacency, distance or orientation behaviors are detected. From the guide’s or administrator’s perspective, iGroup is configured using a settings panel which can be selected from the iSocial client window’s menu.

**iGroup Use Case**

The guide has set the time before notification for orientation, adjacency and distance to three seconds. If one user remains too close to another user for three seconds, that user will receive a notification. If a user begins speaking and another user is too far away and does not move to within an appropriate distance of the speaker within three seconds, that user will receive a notification. If a user begins speaking and another user’s avatar is not oriented towards the speaker and does not turn his or her avatar to face the speaker within three seconds, that user will receive a notification.

Joe and Ryan are present in a virtual space and are approximately 8 virtual meters apart and are facing away from one another. Joe begins speaking to Ryan. Ryan listens to Joe, but does not turn to face him or move any closer to him. Joe continues speaking for more than three seconds. Ryan then receives two notifications, one prompting him to orient his avatar towards Joe (see figure 4) and the other prompting him to move closer to Joe. After the notification Ryan then moves very close to Joe and properly orients his avatar. Because Ryan is too close to Joe, he receives a notification of this after three seconds have elapsed. Because his avatar is correctly oriented to Joe, Ryan does not receive a second notification regarding orientation.
Over time Ryan improves his orientation and adjacency behavior and receives fewer and fewer notifications related to these behaviors. The iGroup software detects this change in behavior and decreases the frequency of notifications that Ryan receives for these behaviors. However, Ryan continues to move away from the speaker and receive notifications related to distance. The iGroup software detects this and increases the frequency of notifications that Ryan receives regarding his distance behavior.

Settings Panel

The guide or administrator configures iGroup using a settings panel. This settings panel is used to set the orientation settings, adjacency settings and distance settings, as well as to set notification messages customized to the pedagogical levels of learning for the youth. Figure 5 shows the options for setting orientation controls.
The orientation settings make it possible to set the amount of time that can elapse when a user exhibits undesirable orientation behavior before a notification is sent. Acquisition, maintenance and fluency are pedagogical levels which will be discussed in the section on pedagogical strategies, but the mock-up in figure 4 shows that they have default duration settings which can be overridden manually. The notifications area toggles notifications on/off, sets the duration that the notification is displayed on the client’s screen, and sets custom notification messages. In practice the iGroup tool determines if others’ avatars are appropriately or inappropriately oriented to the speaker (see figure 6). Based on the value provided in the settings panel for “Time before notification,” the software waits that amount of time before sending a notification to any users exhibiting inappropriate orientation behavior. This delay provides users the chance to appropriately orient their avatar without receiving a reminder notification from the system. For example, if a user hears someone speaking and turns to face the speaker within the given time limit, that user would not receive a notification. However, if the user does not turn his or her avatar to the speaker within the given time limit, that user would receive a notification. The delay also constrains the system from sending a notification if, for example, the speaker is only making a brief statement and not beginning a continued discourse.

Figure 5. Mock-up of the iGroup Settings panel

Figure 6. Top-down view of avatars exhibiting inappropriate orientation behavior (left) and appropriate orientation behavior (right).
The settings under the adjacency tab define a personal space for the avatars, such as a diameter of one virtual meter from the center of the avatar. A proximity trigger is activated in the iGroup tool if another avatar enters and stays in the space beyond the threshold time. The settings under the distance tab control the behavior or pop-up notifications related to users’ avatar distance from one another. The distance settings make it possible for an administrator or instructor to set the distance diameter and the amount of time that can elapse when a user exhibits undesirable distance behavior before a notification is sent. The distance diameter is defined as a space around an avatar that is speaking. When one user begins speaking, the iGroup tool determines if others’ avatars are appropriately or inappropriately distanced from the speaker, based on the value provided in the settings panel for “Distance Diameter.”

**iTalk: Speaking/Listening Tool**

iTalk is a software-based means to reinforce desired speaking and listening behavior and constrain undesirable behavior. The first iteration of iTalk focuses specifically on eliminating audio interruptions. This tool will monitor conversation, will inform users when they are interrupting and, if needed, will constrain their ability to continue speaking out of turn. Moreover, iTalk will provide coaching and assistance by sending notifications to users such as, “I just interrupted my partner. Maybe I should wait for a pause in conversation before I speak.” In addition, iTalk will be able to dynamically adjust its settings to fit users’ differing conversational abilities. From the user’s perspective, iTalk displays the frequency of conversational interruptions to the screen and presents the user with a notification when a specified threshold of interruptions is met. From the instructor’s or administrator’s perspective, iTalk is configured using a settings panel which can be selected from the iSocial client window’s menu. The iTalk tool monitors audio by hooking in to the microphone channel on user’s clients. Assuming silence, when one user begins speaking, that user is assigned the speaking floor. If another user begins speaking but does not have the speaking floor, the utterance is detected on that user's microphone channel and is counted as an interruption. Obviously, this is a gross oversimplification of conversation dynamics and turn-taking behavior, and has the potential for falsely identifying interruptions if, for example, a user accidentally brushes his or her microphone, there is a loud noise in the background, or the user makes a common interjection such as "uh huh" or "yeah." To control for this, the sensitivity can be adjusted within the tool. The tool can be configured to allow for a certain degree of conversational overlap, for instance, if one user interjects for less than one second, that would not be considered an interruption. In addition, using frequency thresholds, which allow the user to make a few interruptions before the system sends a notification helps to control for falsely identified interruptions.

**iTalk Use Case**

The instructor has set an interruption threshold of 5 interruptions in 30 seconds in the iTalk settings panel. If a user interrupts 5 times in 30 seconds, a notification will be displayed on his or her screen informing that the interruption threshold has been met and providing coaching hints and tips for avoiding future interruptions. Joe and Ryan begin speaking, and a progress meter that shows the amount of time left until the interruption threshold resets begins to count down. Joe interrupts frequently during the conversation. Each interruption causes a separate progress meter showing the number of interruptions to increment by one. When Joe makes 5 interruptions within 30 seconds, a notification pop-up is displayed on his screen that states that the user is interrupting too frequently and provides tips on avoiding interrupting. If Joe continues to receive notification pop-ups for three consecutive 30-second intervals, iTalk dynamically adjusts the interruption threshold to meet Joe’s level of ability. Ryan does not interrupt frequently. In this case, iTalk hypothesizes that Ryan’s threshold was too easy for his level of ability. The exact way that iTalk
will work is not completely specified, but in this case Ryan may receive a token as a reward for his good performance and is dynamically moved to a more challenging threshold.

Settings Panel
The iTalk settings panel shown in figure 7 is used to set the interruption threshold, enable/disable progress meters, set a custom notification message, and enable/disable user muting.

![Mock-up of iTalk settings panel](image)

**Figure 7. Mock-up of iTalk settings panel**

The interruption threshold makes it possible for the instructor or administrator to set the number of interruptions that are allowed within a given time period before a notification is sent. The three pedagogical levels have default settings which can be overridden manually. The progress meters check box toggles the visibility on the client’s display of interruption progress meters. Notifications can be toggled on/off, can be set for a display duration on the client’s screen, and have custom notification messages. In addition to the interruption threshold, progress meters and notifications, the settings panel allows the instructor or administrator to mute a user for a given time duration when an interruption threshold is met.

Figure 8 shows how the progress indicators and pop-up notifications are displayed on the user’s screen. When iTalk is enabled, the user sees two progress meters on the bottom-right portion of the iSocial client window. The meter on the right is a timer and represents the time interval set by the administrator or the instructor in the settings panel. The meter on the left indicates the number of times a user has interrupted in a given time interval. When the time interval reaches zero, both
meters reset.

Figure 8. Mock-up of iTalk progress meters and pop-up notifications as seen by the user.

The meters indicating the interruption threshold are color coded (green, yellow, red) in order to convey how close a user is to receiving an interruption notification. Given an interruption threshold of five interruptions in 30 seconds, for the first interruption, the progress meter displays in green. For the next two, the progress meter displays in yellow. For the fourth and fifth interruption, the progress meter displays red. Green indicates a lower interruption frequency, yellow a moderate interruption frequency, and red a severe interruption frequency.

**Pedagogical strategy**

The social orthotics tools are designed with a three-phase model of capability. The phases are (1) acquisition, (2) maintenance and (3) fluency. The acquisition phase is for users who have not yet acquired the ability; hence, the times that elapse before a notification is sent are short and the goals for appropriate behavior may be lower or less refined. The maintenance phase is for users who have acquired rudimentary ability, so the times that elapse before a notification is sent are moderate. The fluency phase is for users who have become adept at the competency and long times can elapse before a notification is sent. By the fluency phase goals for appropriate behavior are quite refined and expectations are as close to those in typical environments as possible. The support, prompts and scaffolding provided by the orthotics fade across the phases of acquisition, being heavy yet tolerant during the acquisition phase, moderate during the maintenance phase, and light during the fluency phase. An overview of how fading works across phases of acquisition is provided below:

- **Acquisition**
  - Shorter times before notifications are sent
More specifically and clearly worded notifications (e.g., “You are too close to the speaker.” “You have interrupted.”)

- Additional hints and strategies for avoiding inappropriate behavior
- Specific hints and strategies provided to avoid inappropriate behavior (“precorrects”)
- More tolerant expectations

- Maintenance
  - Moderate times before notifications are sent
  - Less specific worded notifications (e.g., “If you stand so close to someone, you might make them uncomfortable or they might think you are being rude.”)
  - Some hints and strategies (“precorrects”) for avoiding inappropriate adjacency, distance, orientation and interrupting behavior

- Fluency
  - Longer times before notifications are sent
  - Few notifications
  - Occasional and generalized “precorrects”
  - Expectations most resemble those of typical environments

Unless there is some basis for choosing a different phase, at the beginning of the curriculum orthotics are set to the acquisition phase. Thereafter the behavior of the orthotic is dynamically adjusted within a phase and when moving to another phase based on the youth’s performance. The orthotic tool is able to determine a user’s ability by the number of times a user receives a notification of inappropriate behavior. For instance, if a user is in the acquisition phase and receives five notifications of inappropriate adjacency behavior, iGroup will adjust in order to increase the frequency of notifications that user receives. If a user is in the acquisition phase and receives very few or no notifications, iGroup will adjust in order to decrease the frequency of notifications that user receives.

The social orthotic tool also maintains a log of user’s behavior related to that orthotic and is able to create a report for the guide at the end of a lesson or for review before the next session. The online guide can use this report to determine changes over time for a given user’s social behavior. For instance, if a user is not making progress and exhibits little or no change in behavior over time, the guide can be made aware of this through the reporting functionality. The guide and researchers can also use the social orthotic reports to determine specific times or parts of lessons that cause difficulty for users and use this information to specifically focus on these issues.

**USABILITY TESTING**

In the Spring of 2009 a usability test was undertaken for the iTalk social orthotic. Two youth from the previous field test were invited to participate. The study included an online guide and both participants simultaneously and collaboratively working through two usability protocols. The screens of the participants were recorded using ScreenFlow screen-recording software that allowed for keyboard and mouse tracking. ScreenFlow also enables the computer’s web camera to record the physical behavior of the participant working at his computer. Each protocol lasted approximately one hour. During each usability test, the iTalk software tool was enabled for the full duration of the test. A default setting for receiving pop-up notifications from iTalk was used for the entirety of protocol one. Three different notification settings were used for protocol two: high notification frequency, medium notification frequency and low notification frequency. Participants received no training on iTalk for the first protocol, but did receive training for the second protocol. In the second usability protocol, participants first reviewed a short video of their experience in the first usability protocol and then received training on using iTalk. Following this,
participants engaged in a conversation intense game-like activity using the iTalk software set at a high notification frequency. After this the notification frequency was set to medium and the participants worked through the activity a second time.

Participants were able to complete all of the tasks from both protocols in the iSocial environment, although not without help. Participant one needed more help than Participant two. Both participants characterized their participation as easy and enjoyable, and both said they would like to return to continue using iSocial. During protocol one both subjects noticed the popup text notifications and the meters. They understood the text messages, but expressed confusion about the meaning and purpose of the meters. They both saw changes in the meters but did not readily understand how changes in the meter representation related to their own behavior. When asked about their opinions about the meters, Participant two said that “they’re distracting, and they’re bright. I hate bright.” Participant one agreed with the negative sentiment saying “They get annoying too.”

Participant two thought the social orthotic was too sensitive and gave too many notifications. He stated that the pop up message appeared when he “didn’t mean to interrupt,” explaining that he was just “moving the microphone.” Indeed, Participant two touched his microphone to get the pop up message deliberately several times. Participant one seemed to take the orthotic more seriously. At one time, he tried to say something while the Online Guide was talking, but when he noticed a change in his meters, he gave up the attempt and kept quiet. Participant two, on the other hand, appeared to be enjoying getting the pop up window by moving or touching his microphone. When asked about whether they tried to interrupt less, Participant one first claimed that he did not try, but Participant two claimed, “I tried. Didn’t work.” And Participant one, then, corrected himself by saying that “I tried too. But it didn’t work.”

Prior to protocol two, the two participants watched a video of some of their activity in protocol one with the guide using the video to show how iTalk worked. After the guide illustrated the functionality of the two meters, Participant two acknowledged, “it makes sense.” And Participant one was able to restate the functionality of the two meters correctly. He explained that “when you speak when other person spoken, then this timer [the yellow bar] goes down. The green one goes up.” Upon prompting from the physical facilitator, both Participants understood that they were going to try to not interrupt during the session.

After the first activity in protocol two, neither participant received any pop up text notifications for verbal interruptions. They reported that they attended to changes in the meters, and they tried not to interrupt. Participant two said, “That’s [the change of the meters] why I was silent for a few times.” Participant one also reported “when I noticed the yellow one went down, that means I was interrupting. So I shut up my mouth and just pay attention.” After the second activity of the protocol, both participants reported that the orthotics were less sensitive than before. Participant two described it as “the thing didn’t pop up, but it still says that I’m talking”, and he also described it as “looks like if I did it multiple times, it just says ‘you have interrupted’ once”, which indicated that he understood the functionality of the meters. However, Participant one thought the orthotics were shut down.

Key Lessons for Social Orthotics

The purpose of a usability test is to develop insights for improving the human-computer interaction of a system and not to draw conclusions about the value of the concepts and principles in play. Keeping this purpose in mind the findings from the usability test suggest several results
about the use of iTalk. In protocol one, although the participants did not fully understand the mechanisms they did attend to them. However, there did not seem to be any substantial regulation of interruption behavior even from text that specifically told the participants they were interrupting. In protocol two the participants better understood the mechanisms and seemed to self-regulate their interruption behavior by attending to the physical cues from the meters. It is hard to tell if there was any impact from the text messages but the meters seemed to establish a feedback loop that was attended to and used in regulating verbal behavior. Additionally in protocol one the participants complained that iTalk was annoying and too sensitive. However, in protocol two they no longer complained about iTalk being annoying and saw it as less sensitive or even turned off (although it was not). These assertions suggest that as the youth were able to understand and thus use the visual cues from the meters that iTalk started to become effective and accepted by the participants.

Taken together, our lessons from the reviews of literature and from the usability results suggest several assertions about the design and development of social orthotics for youth with ASD in virtual environment for learning social competence. First, the visual nature of the representation seems to have some impact. This assertion is strongly suggested in the literature and seems to be borne out with the role of the meters in iTalk. The text messages from the popup notifications provided information to the participants and may have provided some regulatory influence on their behavior, but the regulatory influence of the meters in protocol two seemed much more profound. A second assertion is that when the participants understood the relationship between the visual meters and their behavior they created a feedback loop that was a dynamic mediator of their own behavior. In this sense they seemed to take ownership of the meters as their own tools. In Mind as Action, James Wertsch (1998) characterizes “ownership” or “appropriation” as one of the most profound relationships that users can have with the tools they use to interact in their socio-cultural milieu. Having ownership of the tools gives the user a sense of power and authority to act. While we may not want to make too much of the small set of data we have collected in the usability test, it makes sense to use a “sense of ownership” as an attribute to be examined and strived for in the design, development and implementation of social orthotics. Is the orthotic appropriated as empowering by the user or seen as a constraining annoyance in the service of others? A third lesson suggests the relevance of customization and adaptability in orthotics. We see this lesson in three forms, the first being that the youths have different capabilities relevant to the social practices and that they experience the VLE in different ways, thus the participants need orthotics that fit their individual profiles. The computer environment affords the potential to match orthotics to profiles, but we still have much to learn about just what is relevant in the student profile of experience and capability and how best to match characteristics of the orthotic, such as duration and form of feedback, to meet individual needs. A second form of lesson three is that the orthotics should also match the task and environment. For example, orthotics for not interrupting during turn taking in game playing may require different features than for not interrupting when the youth is talking with a teacher or counselor. A third form of this lesson is that in the iSocial context some of the capabilities that the orthotics are supporting are also the target of the curriculum. Thus one might expect an upward trajectory for these capabilities as the youth progress through the curriculum. What is the relationship between the curriculum and the orthotics? For example, if the youth gets to a later unit in the curriculum but the orthotic is still needing to apply methods from the “acquisition” phase are new approaches needed from the curriculum, orthotics or both?

**Future Research & Design**

It is quite obvious that there is much more “future” than “past” in research and design for social orthotics in support of social practice and learning in a 3D VLE by youth with ASD. Our designs
for iTalk and iGroup, while quite exciting to us, are still fairly rudimentary. We will continue a process of research and design iteration as we seek to articulate our vision into software tools. A first step is to take the lessons learned from the usability test and re-implement iTalk and implement iGroup for a next field test. Fortunately with support from AutismSpeaks and the Institute for Educational Sciences of the U.S. Department of Education we have resources to both investigate best approaches to social orthotics and to develop a full implementation of iSocial. The social orthotics we have described and specified need to be fully and well implemented, but we also need to think beyond the current aspects to see if there are other important features to grouping beyond adjacency, distance or orientation and to talking beyond interruptions. Obviously there are but can we find effective ways to monitor and provide feedback for them. Beyond extending the capabilities that orthotics can help regulate we also need research into how best to implement the orthotics. For example, under our lessons learned we speculate that the meters had a special prominence in regulating interruptions because of their visual cues and the match that visual information has with the ways the individual’s with ASD process information. However, the influence on interruptions may also have come because the meters represented a scoring-like function that made the action game-like. In our results both mechanisms may have been at work. Can we isolate the impact of visual representation from game-like challenge? Can we find the best ways to harness both mechanisms for the power of orthotics? Is there something else going on that we have not considered? These questions are quite exciting and iSocial is a good laboratory for exploring these and other design principles. A final area for continued research and development stems from the lesson described above related to customization and adaptability. These concepts seemingly hold great promise, yet we are just at the beginning of imagining how to best support individual differences, contextual relevance and trajectories of development.

**Conclusions**

The many special education researchers who have contributed to advances in assistive technology do so because they see the potential of design and engineering to overcome disabilities and provide more normal functioning to those otherwise limited or deprived. For individuals with ASD these designs and engineering efforts primarily attend to mechanisms for communication and social interaction. As computers have moved from devices that simply calculate and word process to environments that support communication and being social, attention to how software design best supports social behavior is warranted and is especially important for individuals who are non-typical in the way they interact and process information for social interchange. These new computer environments will increasingly be called upon as supplements to traditional forms of work and learning or in some cases entirely replace traditional forms of work and learning. For example, K-12 education is increasingly being delivered online and outside of traditional schools. The Sloan Consortium estimates that over one million K-12 students were engaged in online learning in the 2007-8 school year (Picciano & Seaman, 2008). Further, Clayton Christensen, author of “Disrupting Class” (Christensen, Horn & Johnson, 2008) predict that by 2013 10% of all K-12 school enrollments will be online and that by 2018 the number will be 50% of all enrollments.

Our particular interest in social orthotics is to build a custom 3D VLE for youth with ASD to develop social competence in a way that overcomes limited access to these forms of educational support. However, as suggested by the statistics on the growing use of online education in K-12, social orthotics offers great potential to assist students with special needs to participate in new and more effective ways with others in many forms of online education. For example, can social orthotics help a student and his mathematics teacher achieve better teaching and learning using online aids for lessons? However, while we are excited about what we are learning about how to
do social orthotics in a 3D environment for youth with ASD, speculation must be tempered by how much we still need to learn about how youth will use these tools, what impact they may have on social interaction and learning, and the potential for unintended consequences. Clearly though, social orthotics in 3D VLE is an area for further research and development, and our abilities to use visual cues appropriately, customize and fit the orthotics to the individual, the task and the environment, provide orthotics in a way that gives ownership to the youth, and see the use of orthotics in a virtual world as part of a developmental trajectory will be key to innovation and achievement.

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References


**Key Terms**

**3-Dimensional Virtual Learning Environment (3D-VLE):** A software system representing dimensionality for simulating physical movement and interaction with objects and other members designed to support teaching and learning activity.

**Avatar:** A user’s representation on a computer. In a 3D VLE avatars are usually virtual representations of humans that can move throughout a virtual space.

**Dynamic agents:** Used here to represent social orthotics that monitor user behavior and intervene based on a set of variables that may change through the interaction and over time.

**iGroup:** A form of software-based social orthotic to reinforce adjacency, distance and orientation behavior and constrain undesirable behavior such as looking away from the speaker.

**iTalk:** A form of software-based social orthotic to reinforce desired speaking and listening behavior and constrain undesirable behavior such as interrupting others.

**Pedagogical strategy:** A method for supporting learning outcomes. In iSocial we implement a method for differentially constraining and providing feedback for behavior based on a users learning phase of (1) acquisition, (2) maintenance or (3) fluency.

**Scaffolding:** Types of structures that support advanced performance when the users may be novice or in a learning process.

**Social orthotics:** Types of structures that facilitate social interaction and social learning when there is an expectation that a natural and effective process is unlikely. Used here to represent unique computational functionality to support talking and orientation to others in a 3D VLE.

**Brief Biography of Authors**

Dr. James Laffey is a Professor in the School of Information Science and Learning Technologies and a former researcher and systems developer at Apple Computer, Inc. Dr. Laffey has a Ph.D. in Education from the University of Chicago and has won awards for the design of innovative, media-based computer systems. Through his design work and scholarship he is internationally recognized as an expert in the area of human-computer interaction. He currently teaches graduate level courses on development of systems to optimize HCI and learning, including methods to improve the social nature of online communities. He has received over $6 million of funding during the past 10 years, and is currently the principal investigator for grants from AutismSpeaks and the Institute of the Education Sciences to research and develop iSocial.

Janine Stichter, Ph.D. is a Professor in the Department of Special Education and has worked with schools and students with Autism and behavioral needs for over 20 years. Dr. Stichter presents
nationally and conducts research in the following areas: functional analysis, social competence and the correlation of instructional variables with in prosocial and academic behaviors. She has published over 50 peer reviewed articles and provided over 70 national presentations on her research. She currently directs or co-directs 4 federally funded grants over 4.5 million targeted at partnering with educational personnel to train educators and social competence programming in school-based contexts.

Matthew Schmidt is a PhD candidate in the School of Information Science and Learning Technologies at the University of Missouri. His current research interests focus on designing and implementing 3D virtual environments for individuals with autism spectrum disorders. He holds a BA and MA in German Language and Literature with an emphasis on Computer-Assisted Language Learning (CALL). He has designed and developed educational technologies and curricula for diverse disciplines including special education, second language acquisition, veterinary medicine, biological anthropology, nuclear engineering, and health physics. Matthew also serves as the project coordinator on a 3 year project funded by IES to advance methods for supporting youth with ASD to learn within 3D VLEs.

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