HoloType-CR: Cross Reality Communication Training for Minimally Verbal Autistic Persons

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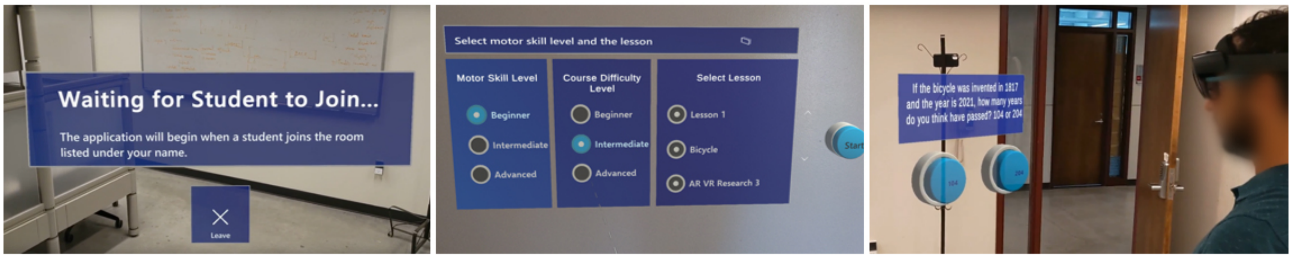

Figure 1: Selected screenshots of the CRP mode. Left) CRP waiting for student to join a room. Middle) CRP setting up a session based on the student's motor skills and difficulty level. Right) MVP student interacting with the system as seen from the CRP perspective

Abstract

About one in three autistic individuals cannot reliably communicate using speech. Such Minimally Verbal Persons (MVPs) can thus benefit from alternative, text based communication techniques such as typing. Many MVPs employ trusted Communication and Regulation Partners (CRPs) who impart training to communicate by pointing at letters on a letter board. The CRP holds the letter board and helps an MVP acquire motor, i.e., pointing, skills while helping the individual with attentional and emotional regulation issues. While one-on-one CRP support has helped many individuals move on to independent typing leading to dramatically improved social and educational outcomes, it remains expensive and out of reach for many. Recently, immersive typing training systems have been developed for MVPs. Such systems are designed for an MVP to independently improve their pointing and spelling skills in the context of highly engaging, age-appropriate and customized educational modules. However, to be successful, these systems would benefit from a transitioning period where a CRP imparts training on the use of such systems. We outline the first attempt at developing such a system by leveraging cross reality. We build the cross reality application on top of HoloType, a HoloLens 2 typing training application we developed earlier. With this system, an MVP can interact with an educational lesson delivered by HoloType. Simultaneously, a CRP can join in the session using another HoloLens or a tablet. Both the CRP and the MVP can access the same virtual world, e.g., holographic buttons to interact with a lesson. The CRP can observe how the MVP interacts with the virtual objects. Based on this, the CRP can help the MVP interact with the virtual world better. Our initial trials show that aspects of the traditional CRP-MVP letter board interaction can be simulated by this system thereby improving the likelihood of the adoption of systems such as HoloType by the MVP community.

Index Terms: Cross reality—Mixed reality—Assistive technology—; Human-computer interaction—User-centered design—minimally verbal autistic persons

1 Introduction

For the 30 percent of autistic people who cannot communicate effectively using speech [5], typed communication offers a viable alternative [9]. Such Minimally Verbal Persons (MVPs) who type have graduated from college [2, 3, 15], written best-selling memoirs [8], and served on the U.S. Interagency Autism Coordinating Committee [4]. We do not yet know why some autistic people cannot communicate effectively using speech. But given the ubiquity of motor challenges among autistic people [6, 7, 17] and the precise motor control that is required to produce intelligible speech, motor differences may play an important role [16]. Indeed, MVPs who have learned to type have explained that spelling is much less effortful than speech [7].

MVPs who have learned to type have described a protracted process that crucially involves regular, individualized, and systematic opportunities to practice the required skills (e.g., coordinating gaze and pointing to letters) in contexts the involve meaningful and age-appropriate educational content [13]. They have additionally described having to find ways to compensate for the significant sensory-motor and attentional challenges they face [6, 7, 11, 12, 14]. Finally, they have described the importance of receiving support from a trusted person, i.e., a Communication and Regulation Partner (CRP). These trusted persons can provide attentional, sensory, and psychological assistance that is required during the motor skills training for pointing and typing communications [13], see Figure 3, Picture B for an example of this practice.

Computer-based typing systems can benefit the MVP community immensely as they can facilitate a higher sense of independence. However, traditional computer-based systems do not account for the special requirements of MVPs (that we explained earlier), their

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families, therapists, and educators. Using Mixed Reality (MR) technology unlocks the possibility of introducing holographic training opportunities tailored for the MVP community. In our research project, we have previously introduced HoloType; a Hololens 2 MR application designed to support independent holographic typing training for MVPs. The previous system prototype design accounts for many of the challenges MVPs face [10]. Early trials with autistic and neurotypical people in Canada and the USA suggest that the application can help MVP acquire pointing skills provided they receive proper training.

The previous version of HoloType uses the Microsoft Mixed Reality Toolkit (MRTK) 'hand coach' to provide the user with visual cues as they learn to point at virtual objects, including a keyboard. However, the hand coach is limited in that it cannot dynamically adjust the level of guidance it provides. For example, early in training on HoloType, some users may benefit from hand-over-hand motor modeling from their CRP. They might also find cues, e.g., CRP pointing their finger at an intended target, helpful. Additionally, as noted earlier, the presence of a CRP confers a number of regulatory benefits in the real world, and, we speculate, in the virtual one.

In this paper, we present the first attempt to involve a CRP within an MR-based typing training program. Specifically, we offer an updated version of HoloType that leverages cross reality. The use of cross reality allows an MVP and CRP to exist and interact in the same virtual space simultaneously. While the current integration focuses only on training in spelling and typing, the framework can enable future applications such as remote cross reality and inclusive educational experiences for MVPs.

2 Concept Development

We follow a user-centered design approach following five steps namely, investigate, ideate, prototype, evaluate, and reiterate, similar to the process presented in [1]. During the investigation phase we conducted a requirements elicitation study with a formal caregiver (occupational therapist) and informal caregivers (parents). The study findings emphasized the importance of providing customization for people with different motor skills and different sensory regulation needs [10]. Conventionally, a caregiver acting as a CRP would sit next to the MVP and use a hand-held letter board (depicted in Figure 3, Picture A). The CRP will sit besides the MVP as shown in Figure 3, Picture B and deliver an educational lesson. During the session, the CRP would direct questions on the lesson to the MVP. The MVP would then use their finger to point at letters in response to a question.

While our initial HoloType application could replace the physical letter board and supplement the services of a CRP, it is important to support the MVP during the training phase and beyond. Thus, in the ideation phase we explored various ways of integrating a shared user experience via cross reality technology. We integrate a cross reality component to the application in order to simulate the conventional training and regulation imparted by a CRP to an MVP. The component provides an MVP with a shared, assisted experience for navigating and interacting with holographic objects presented as part of a lesson. After reiterating the application design, we arrive at a work-in-progress prototype called HoloType-CR that supports two user modes, which we explore in the following section.

3 HoloType-CR

As it was mentioned earlier, we have previously developed a holographic typing application for MVPs called HoloType. In order to accommodate individuals with different motor skills and different sensory regulation needs, we integrated a cross reality feature to the previous prototype and we named it HoloType-CR. This integration allows the MVP and the CRP to exist in the same virtual or physical space simultaneously. The current version of the system supports two user modes; CRP and MVP mode.

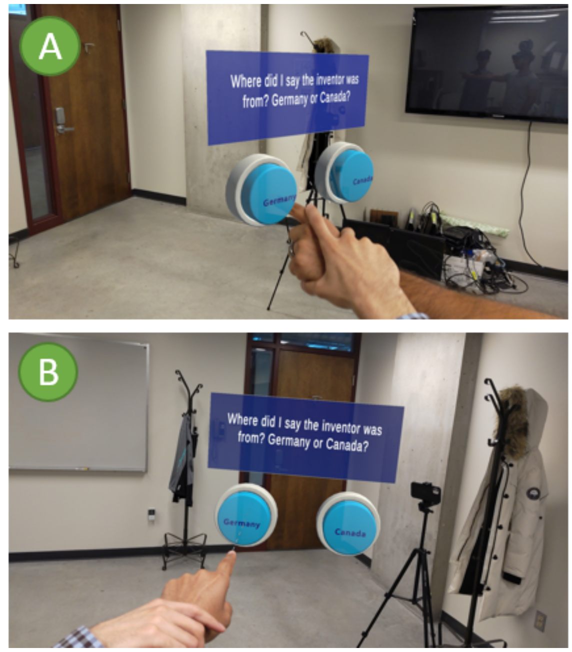

Figure 2: A) CRP using hand-over-hand training technique. B) Hand-over-hand as seen by the MVP.

3.1 CRP mode

The main purpose of the application is to help an MVP learn the skills required to communicate by spelling. This is done by providing age-appropriate educational content embedded in games that are meant to teach those skills. Furthermore, this platform offers three different levels of interactions for three different motor skills, which can be set by the CRP upon launching the application. In the 'beginner level', users are presented with simple multiple choice questions. These choices are implemented as large holographic buttons with generous spacing thereby making this mode ideal for MVP that have significant pointing skill challenges. After gaining practice with the beginner mode, an MVP can graduate to the 'intermediate level'. This level requires interactions with smaller buttons which together constitute sections of a keyboard. While the holographic buttons are smaller than the beginner mode, this mode avoids overwhelming the user with too many buttons by hierarchically presenting only the relevant sections of a keyboard for any given lesson interaction. Finally, after mastering the intermediate level, an MVP moves to the 'advanced level'. In this level, the MVP can interact with a lesson using a full keyboard built as small, closely spaced holographic buttons.

The CRP decides on the motor skills level appropriate for a given MVP. After the CRP selects the motor skill level, the application displays available lessons to choose from. If the CRP does not find a suitable lesson, they can visit an online lessons-loader web application to create customized lessons. These lessons get loaded automatically to the HoloType via a RESTful API (more on the system architecture in the next section). After selecting the lesson, the CRP would give a name to the session and push the 'done' button which will make the session available for the MVP. Figure 1 shows a screenshot of the UI during the session setup process. Once the student joins, the CRP can observe their interactions with the application. The CRP can then choose to intervene by either pointing or interacting with the UI directly or by hand-over-hand motor modeling as depicted in Figure 2. At this point, we have implemented the CRP mode for Hololens 2, and we tested it on iOS. This flexibility allows for full or partial CRP presence depending on the user's needs.

3.2 MVP mode

From a MVP perspective, the UI design is very simple. The entire UI will always self-orient facing the MVP. We made this design decision since many MVPs tend to move constantly as a coping mechanism for sensory issues. While this design doesn't fully utilize MR technology, we continue to work closely with different stakeholders to learn how to integrate other aspects of MR more effectively. Once the MVP joins the session, the first segment of the lesson will be delivered word by word with closed captioning narration to the user to foster better attention. The voice and speed of narration within HoloType is customized by a CRP based on the MVP's unique needs.

In the beginner level, answering the multiple choice questions is done via two large buttons with generous spacing between them. Virtual visual cues (MRTK hand coach) are available to help MVP with basic motor skills to choose the correct answers. As discussed previously, cross reality allows us to extends this by facilitating context-aware, adaptive cues from the CRP as well as hand-over-hand motor modeling, see Figure 2. For example, a CRP might move their own finger to the vicinity of the right button as a cue to the MVP. If the MVP chooses the correct answer, they will be directed to the next question or the next lesson segment and if not, they will be asked to answer the question one more time. The CRP has the choice to skip a question to mitigate MVP frustration.

In the intermediate level, the keyboard is divided into 5 segments, A-H, I-P, Q-Z, 0-9, and punctuation, see Figure 3, screenshot C and D. The MVP can switch between the segments based on their answer to the question. We made this design choice to reduce the possibility of overwhelming the user with too many, small-sized, buttons. The technique of splitting of the alphabets is similar to what occurs when training is taking place in the real world. In the advanced level, the keyboard is divided into two segments only. The first segment contains the letter board (similar to the physical letter board), and the second segment contains numbers and punctuation, see Figure 3, screenshot E. The keyboard buttons are smaller and closer to each other compared the intermediate level's keyboard. In all level, questions are always coupled with a related 3D model. Based on our interactions with occupational therapists, our implementation provides simultaneous visual, textual and audio cues to increase MVP engagement.

4 System Architecture

There are three main components of the system; the lesson loader web app which is used to create or modify lessons prior to the session, the Hololens client application and the RESTful API for online data exchange.

4.1 Lesson loader web app

The system is designed with the expectation that CRPs/teachers can create their own lessons using a simple and non-technical web tool. The app allows for creating and modifying lessons tailored to individual student interests and motor skill levels. The application is built using React and Bootstrap, and it uses a RESTful API to allow for seamless integration across the multiple platforms involved in the system .

4.2 RESTful API for communications

Lesson data is stored in a MongoDB instance hosted on Azure. Each lesson is a document containing metadata to identify the properties of the lesson, such as name, motor skill level and schema version, and a list of interactions. The schema defines several interaction types. For example, a narration type provides a Speech Synthesis Markup Language (SSML) formatted input of lesson narration that will be read and displayed to the MVP. Various quiz interaction types

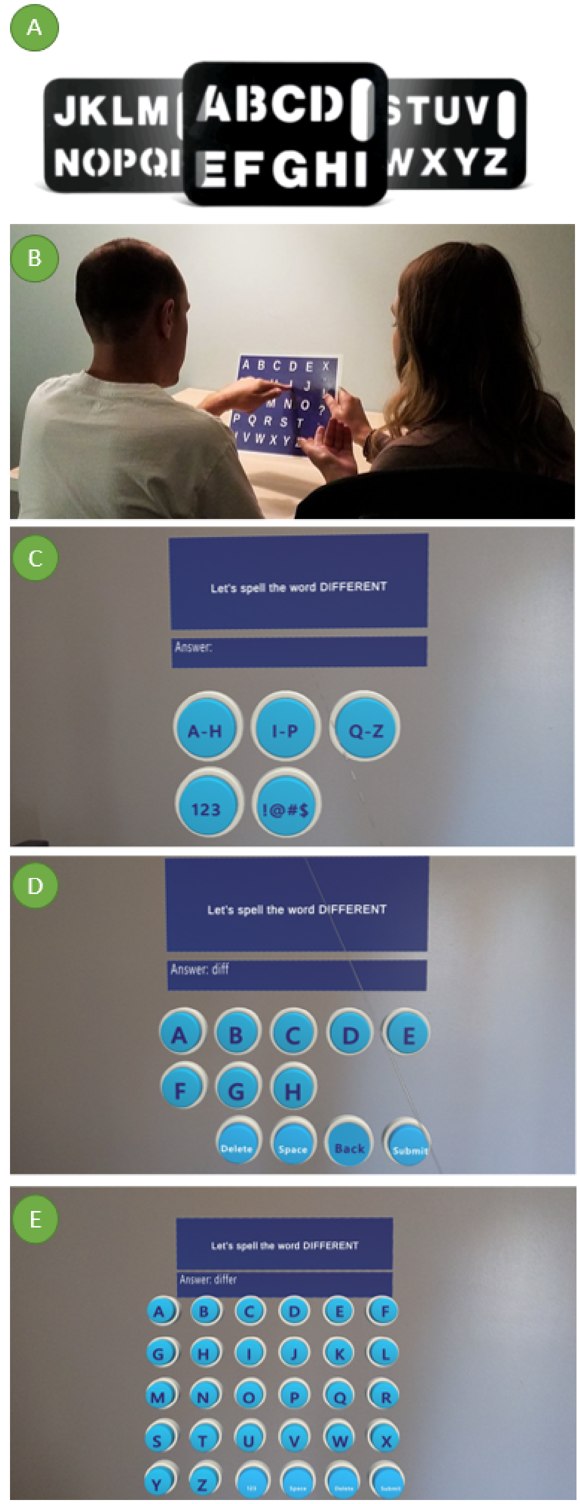

Figure 3: A) Partial physical letter board used in conventional pointing training source: www.i-asc.org. B) Full letter board used for MVPs at a later stage of training, source: www.aalive.org . C) Five-segments holographic keyboard for intermediate level users. D) Partial holographic keyboard as seen by the MVP user. E) Full keyboard for advanced MVPs

are currently implemented such as Multiple Choice, Letter Selection, and Keyboard Input. The app client uses the motor skill difficulty to modify the UX appropriately. For example, the app client uses the simplified keyboard input for intermediate lessons and the full keyboard for advanced lessons.

4.3 HoloLens app client (UNITY)

The Hololens client is developed in Unity using MRTK 2.7 and the Photon PUN 2 library for networking. Users are joined to a Photon networking room by either creating the room as the CRP (teacher) role, or join a room as the MVP (student) role. Syncing the state uses the Photon's scene management functions to switch scenes and event between clients. The cross reality shared experience requires each interaction to be individually networked. One of these cases is the button status (e.g., pressed, released) and the user interaction. This is accomplished by streaming the state of the button to the other client in real-time. The Unity application is built with scenes that represent the interactions in the lessons; for example, there is a lesson narration scene to narrate the lesson or a multiple choice quiz scene. These scenes are loaded by a singleton game manager that processes the selected lesson created in the web application.

4.4 Tablet / Other Hololens app client (UNITY)

Since the project is built in Unity with MRTK, the build platform can be updated, and the same application used on the Hololens can be ported to other XR supported devices such as VR headsets or tablets. Additionally, the open standard of the lesson schema allows other clients to build around the lesson plans.

5 Discussions and future plans

The HoloType application is the first of its kind to support holographic interactions for MVPs. The overall goal of this research is to supplement training with a physical letter board with training via HoloType. Integrating the cross reality component at this point is limited to setting up the session, observing the MVP, and intervening when needed. We are in the process of finishing the final details of the system prototype. Thereafter, we have a plan to evaluate the system with MVPs and their CRPs.

Our future plans involve more shared experiences via cross-reality technology. For instance, we plan to create a shared holographic teaching experience for multiple MVPs who attend school in-person where the teacher can work with multiple students simultaneously. For students who are unable to attend in person classrooms, we plan to integrate remote CRP interactions via VR headsets. Our vision of the final system design includes mixed reality, virtual reality, and augmented reality integration. With the advancement of new devices such as the Varjo, CRPs can switch between virtual and mixed reality environments seamlessly.

6 Conclusion

In this paper we presented our cross-reality based HoloType application for supporting holographic typing training for nonspeaking autistic people. The current system design simulates the conventional letter board pointing experience which allows for simplified transitioning to independent use of HoloType. The system supports two user modes; CRP mode and MVP mode. Accounting for people with different motor skills, the system provides three levels of difficulty and the ability of a CRP to offer motor modeling, context-based cues and emotional regulation strategies. In the next phase of this project, we plan to evaluate our prototype with MVPs and their CRPs. At a later stage, we interned to test the usability of our suggested system for remote pointing training.

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