Interactive and Intelligent Visual Communication Systems

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Abstract
Interventions to support children with cognitive and social developmental disabilities often include visual elements. Use of visual artifacts has been shown to increase the communication and understanding levels of children with disabilities. We describe a research agenda for expanding these capabilities using interactive, collaborative and intelligent systems.

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Introduction
Interventions to support children with cognitive and social developmental disabilities often include visual elements. Two important issues in the design and use of these interventions are communication and support for understanding time and activity sequences. Current tools for supporting these needs include a variety of analog visual artifacts, such as booklets of cards representing individual activities. These artifacts use words, images, and sometimes tangible objects to represent objects, activities, and people that are central to the child using them. Use of these tools has been shown to increase the communication and understanding levels of children with disabilities, in particular for children with autism spectrum disorder (ASD) (for overviews of some of these successes, see [7] and [9]). In this paper, we describe a research agenda for further expanding these capabilities using interactive, collaborative and intelligent systems.

Our research agenda includes a series of smart classroom technologies for augmenting communication

Figure 1: Visual schedules can be placed on the wall for use by the whole class, like this monthly calendar.

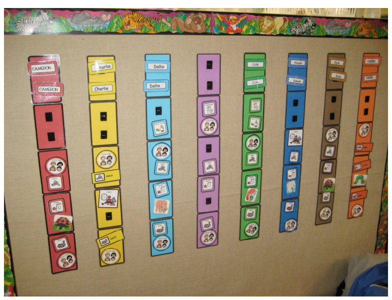

Figure 2: Visual schedules can be placed on the wall for use by the whole class, like this monthly calendar.

and understanding with visual tools. These systems provide easy and flexible mechanisms for child-caregiver communication. They also provide benefits such as mediated communication and collaboration between caregivers. For example, using these systems, caregivers can generate reports, share information with one another, and in some cases, and even update schedules at a distance as circumstances change. We are exploring large and small-scale digital visual communication and schedule systems, the sensing and interaction frameworks required to add intelligence to them, and the network infrastructure to tie them all together.

Background and Related Work

Children with autism spectrum disorder (ASD) can experience anxiety when trying to understand concepts of time and scheduled activities or to communicate with caregivers around their needs. The structure needed to reduce this anxiety and support better self-organization is often provided through visual schedules. Likewise, tools to support communication of needs with caregivers also often included visual elements [7].

"Visual schedules display planned activities in symbols (words, pictures, photograph, icons, actual objects) that are organized in the order in which they will occur" [5]. They present the abstract concepts of activities and time in concrete forms by using pictures, words, and other visual elements to describe what will happen, in what order, and where. Visual schedules have been used successfully in classrooms, homes, and private practices to address difficulties with sequential memory, organization of time, and language comprehension and to lessen anxiety [4, 6]. In schools, visual schedules can assist students with transitioning independently between activities and environments by telling them where to go and helping them to know what they will do when they get there. They can also support individuals with less severe disabilities in entering the workplace by providing external direction for common workplace phenomena.

The information in any visual schedule must be kept up to date—an extremely onerous task, often completed by caregivers in condensed timeframes. Furthermore, the communications tools themselves tend to be more effective if they can be made to be engaging to the individuals using them. Thus, the traditional pen and paper "low tech" assistive technology approach can be improved. These communications tools can be even more useful and successful with the addition of interactive and intelligent computing technologies.

Designing Augmented Tools for Visual Communication

In considering the needs of students and caregivers alike, we first made use of previous research, including a multi-year ethnographic study of caregivers of children with autism [3], focus groups centered on children with autism spectrum disorder and their caregivers [1], and an *in situ* study of the deployment of a new ubiquitous computing technology for classrooms behavior management of children with special needs [2]. We also leveraged previous work in understanding intelligent systems for home healthcare [8]. We then began collaborating with two schools: an Interagency Assessment Center for children from 18 months to three years old and a special education pre-school. At the same time, we began collaborating with researchers at the University of California, Irvine Medical School and the 4OCKids neurodevelopment center.

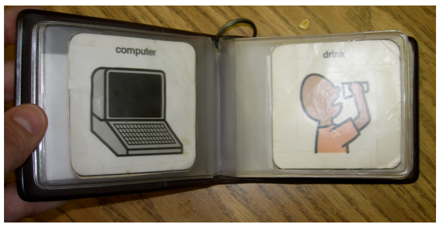

Figure 3: Communication tools are often created for individual use in a mobile format. The personal "wallet" shown above was developed as part of an integrated communication strategy, wherein the teacher would use verbal cues coupled with visual cues to remind the student of his tasks and ask him which reward he would choose. The one below is a commercial version of the same concept that we purchased from a school supplies company.

Our visual schedules and communications systems allow for easy and flexible adjustment of their content through both human-inputted information, such as that produced by caregivers and machine-generated input gathered automatically from sensors. These data will enable caregivers and individuals with ASD to organize activities, choices, and utterances, leveraging these varied inputs not only for dynamic real-time assistance but also in support of faster, easier, and richer communication between caregivers and more complete record keeping about activities and progress.

Our design explorations included sketching and prototyping simple interfaces with collaborators. They also included examining how the introduction of intelligence in the form of a combination of rules and simple machine learning algorithm might further remove the burden from the caregivers for using these systems.

Some elements can be pre-determined with rules. For example, a rule indicating lunch is always at a certain time regardless of what activities have been completed, would ensure that lunch choices are provided to the students in their communications devices at an appropriate time. Other practices, however, are hard for caregivers to identify explicitly and can be very difficult for individuals with disabilities in this area. For example, when a speech therapist is delayed in another classroom, students may interact with her at a later time and that interaction may be shorter. Similarly, sometimes the same activity that takes place each day is highly dependant on available materials.

Prototype Systems

Our initial prototype systems include both mobile and environmental platforms. Mobile Communications Tools (Mocotos) can support students in prompted or spontaneous speech and communication acts. Nomatic*VS focuses on larger scale tools, such as classroom sized intelligent visual schedules.

Our initial prototype Mocoto functions much like a choice board or communications wallet and includes a portable device not much larger than popular cell phones, the Nokia N800 (see figure 4). Both children and adults can use the touch screen on the device for interactions. Adult caregivers can also make use of desktop software to "program" the devices.

The current Nomatic*VS prototype mimics much of the functionality of a traditional visual schedule for a classroom but adds interactive elements. Groups of children with the same overall schedule of a classroom would use this system as a reference point throughout the day as well as a reinforcer when the activities are to begin or are completed. The Nomatic*VS design consists of a large, touchscreen-based, classroom-facing display, supported by software installed on a personal computer for use solely by the primary caregiver. Over time, the system will (a) learn appropriate times to prompt caregivers for update, (b) enable caregivers to make quick selections from a large database of activity icons, and (c) collect data about the use of the system for later reference, analysis, and reporting.

Continuing Work

We are currently exploring how other interface and applications features might be used to improve these systems further. For example, using a mobile or environmental screen coupled with tangible resources, such as physical items, might further integrate the modeled and real worlds. We are also examining how

Figure 4: The Mocoto for the n800 uses the interface metaphor of pictures on cards. By swiping a finger across the small icons, a larger version of the card can be viewed. Students can use this functionality to choose silently a visual communication cue or to activate an audio prompt based on that card.

to incorporate video modeling, in which video clips of a task being performed successfully are displayed alongside the instructions.

Another major challenge remaining is to ensure that these systems can connect to each other and to external systems through a network to support collaboration. These capabilities will allow for remote adjustment and review of schedules by other caregivers. Communication between the myriad of caregivers involved in caring for children with special needs is often a challenge. By automatically producing up to date schedules and dynamically presented communications choices and tracking their use, these tools work as assistive technologies supporting the users at the moment and as collaborative technologies providing richer communication among caregivers.

Conclusions

Interactive and intelligent systems for supporting communication and scheduling for children with ASD hold the potential to enhance quality of life and education. Our research agenda includes development of systems for augmentative, assistive, and visual communication and coordination in both small and large form factors. By designing these tools as part of collaborations with a variety of experts and potential users, we have begun to create a suite of tools and plan to continue this work by evaluating them *in situ.*

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