Mobile Capture and Access for Assessing Language and Social Development in Children with Autism

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ABSTRACT

We present a mobile device that supports expert practices for assessing the development of language and social skills in children with autism (CWAs). Our Tablet PC–based system combines aspects of existing paper- and video-based data-recording activities at a preschool for CWAs. We created in Macromedia Director a prototype that supported automated capture and access of multiple data streams, addressing the information needs of researchers, teachers, and parents. Video of natural classroom behaviors is synchronized with researchers' assessments of behavioral variables. We obtained user feedback on our prototype and on the resulting Java-based system, which we will deploy and evaluate.

Keywords

Ubiquitous and mobile computing, computer-supported cooperative work, ethnography, capture and access, autism

INTRODUCTION

Early behavioral intervention — begun when children with autism (CWAs) are approximately ages 2 to 5 — is reported to improve the language and social skills of "virtually all children, and in some cases it leads to complete eradication of any sign of the disorder" [4]. At the Walden Early Childhood Center at Emory University, early intervention is administered in the context of typical preschool education activities. Treatment plans are individualized for each child, because CWAs "are often characterized by idiosyncratic learning styles" [5]. Assessments of CWAs' ongoing, naturally occurring social behaviors in the classroom help determine both the effectiveness of interventions and the appropriate goals to be targeted. Observers must be both "very sensitive to the child's needs and reactions, and scrupulously *objective* in the measurement and analysis of those reactions" [5].

Treatment plans are developed collaboratively by members of three stakeholder groups: researchers, teachers, and parents. Data must be collected, analyzed, and reported to meet the needs of all these groups. It is crucial that proposed technological innovations support established practices. Mackay et al. suggest that designers who follow this guideline, taking "evolutionary path[s] to … new methods," may encounter less resistance to technological change [3]. Our goal is to understand better these practices from the perspectives of the stakeholders, and to meet their needs by developing technological solutions based on automated capture and access. We studied the environment and designed a prototype, then obtained user reactions that influenced the development of a system that we will deploy and evaluate.

CASE STUDY

Walden is the early-childhood model demonstration program of the Emory Autism Center, which is a component of the Department of Psychiatry and Behavioral Sciences at the Emory University School of Medicine. Walden has three classes — toddler (ages two and three), preschool (ages three and four), and pre-kindergarten (ages four and five) — of approximately eighteen children each. One-third of the students in each class are CWAs, and two-thirds are typically developing children who serve as role models for CWAs as they develop language and social skills.

For ten weeks, we spent six hours a week observing classrooms and interviewing stakeholders (two teachers, two researchers, and three sets of parents). We interviewed many more researchers and teachers as they worked.

Treatment plans for CWAs are written at the beginning of each child's tenure at Walden. The plans are reviewed quarterly and updated annually to meet each child's changing needs. Plans are divided into goals — such as improved language development, social interactions and engagement, and independent-living and school-readiness skills — which are then broken into measurable objectives set progressively over the school year. Data on these objectives are collected daily, in quantitative experiments incorporated into classroom routines. Research assistants also observe CWAs unobtrusively and capture data on video or on a paper spreadsheet known as a Pla-Chek (pronounced "PLAY-check"; Figure 1(a)), on which these variables are recorded:

- proximity to adult (within three feet)
- adult interacting with CWA
- proximity to typical child
- typical child interacting with CWA
- proximity to another CWA
- other CWA interacting with target CWA
- verbalization (words listed in dictionary)
- engagement
- focus on an adult (if the child is engaged)
- focus on another child (if the child is engaged)
- focus on a toy (if the child is engaged)
- autistic behaviors

Video data are coded later but for the same variables, except proximity to other CWAs, interactions with other CWAs, and autistic behaviors. This difference exists because research assistants may not know which children in videos are CWAs. Because of this similarity, we chose the Pla-Chek for our prototype.

Pla-Cheks place cognitive burdens on research assistants. They observe children for intervals of ten seconds, which are counted mentally, then record values in a line of cells. Each line is followed by ten more seconds of observation. The next line is filled and the process repeated until twenty intervals are done. Counting time complicates the recording, which requires strict objectivity.

Pla-Cheks for each CWA are recorded on ten consecutive days each calendar quarter. Classroom coordinators tabulate the data quarterly. Because sessions are not videotaped, they cannot be reviewed for accuracy, or be used for demonstrating visually to parents that progress is being made. The assistant director uses the tabulated data to prepare reports that indicate progress on each objective and can easily be fifteen pages long.

Parents receive these reports quarterly, and discuss them with classroom coordinators. However, parents can obtain visual evidence of their children's progress only by observing classroom activities through one-way mirrors or by watching videotapes. There is no artifact that combines visual evidence with expert assessment. We believe our system will do this effectively.

RELATED WORK

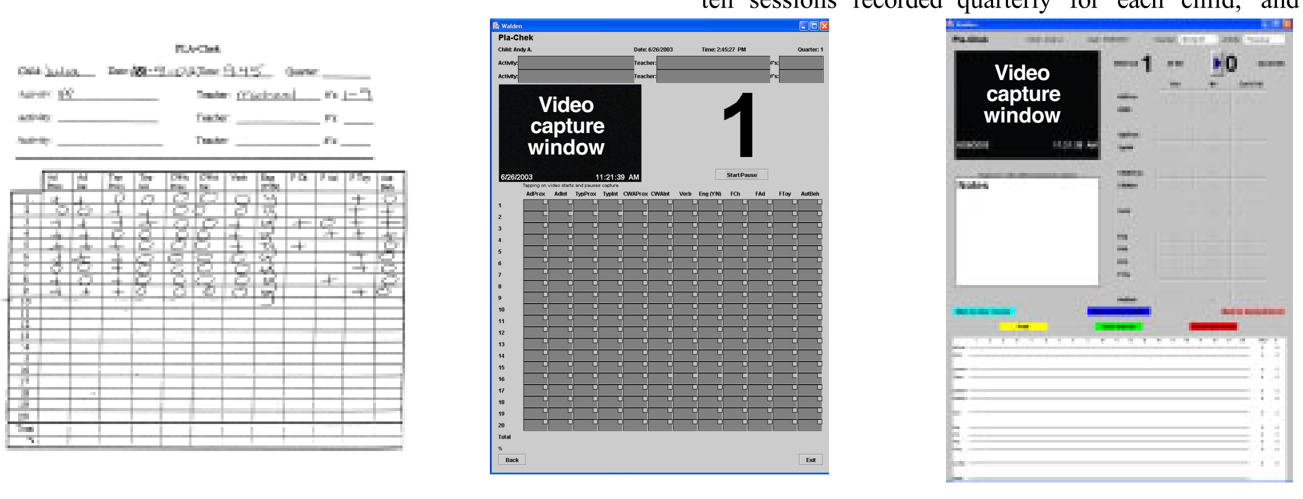
Our prototype follows the principle of "voluntary, explicit, task-appropriate interaction" that Arnstein et al. support in the second version of Labscape [1]. The cell-biology lab for which Labscape was designed is similar to Walden in that data must be recorded with scientific rigor. The first version of Labscape relied on sensors that could not "provide the detail, completeness, and reliability sufficient to the task."

Steurer et al. have chosen a sensor-based approach for another education environment, the Smart Kindergarten [6]. The authors suggest that data collected by sensors in a classroom can help teachers identify and address the learning problems of individual children.

DESIGN OF PROTOTYPE

With our prototype — designed in Macromedia Director and later implemented in Java — we transferred the Pla-Chek to a Tablet PC (Figure 1(b)). The prototype captured handwritten data as well as video from a webcam worn at the research assistant's beltline. The system tabulated the data as they are collected rather than requiring a teacher to do so later. The interface reduced the research assistants' cognitive load by providing a timer that counted two ten-second intervals for each line of data: an observation interval, then a handwriting interval.

The access interface (Figure 2(a)) contained the video and two visualizations of the data: a "macro" timeline of the ten sessions recorded quarterly for each child, and a



(a) (b) (c)

Figure 1: The paper Pla-Chek (a) was the template for our initial capture interface (b), in which we maintained, as much as possible, the look and feel of the original. User feedback led to the second iteration of the interface (c).

"micro" timeline of the session being viewed. Data were represented on these timelines by dots. Variable names were displayed on the Y-axis and grouped by dot colors: red for proximity to and interaction from adults, gray for proximity to and interaction from typical children, green for proximity to and interaction from other CWAs, black for verbalization, blue for engagement and focus, and pink for autistic behaviors. Graphed on the X-axis of the macro timeline were the ten quarterly sessions; on the X-axis of the micro timeline, numbers indicated the progression of time, measured in minutes, through the video.

Dots in the micro timeline were uniform in size, and represented single positive recorded occurrences of variables; dot sizes in the macro timeline varied to indicate the percentage of positive results recorded in each session. There were five sizes of dots, representing values in 20-percent increments. We considered using more sizes for finer granularity, but we believed that constraints of screen real estate would prevent clear distinctions in sizes.

When the user rolled over a dot in the macro timeline, the interface displayed the percentage represented. In both timelines, the percentages and number of occurrences of each variable were displayed at the end of the line. The user selected a session for review by clicking on its column in the macro timeline. That session's micro timeline and video then appeared. A vertical line moved along the micro timeline to help viewers relate variables to the actions displayed in the video. The access interface does not necessarily have to be viewed on the Tablet PC, although doing so would allow access in many settings.

SYSTEM IMPLEMENTATION

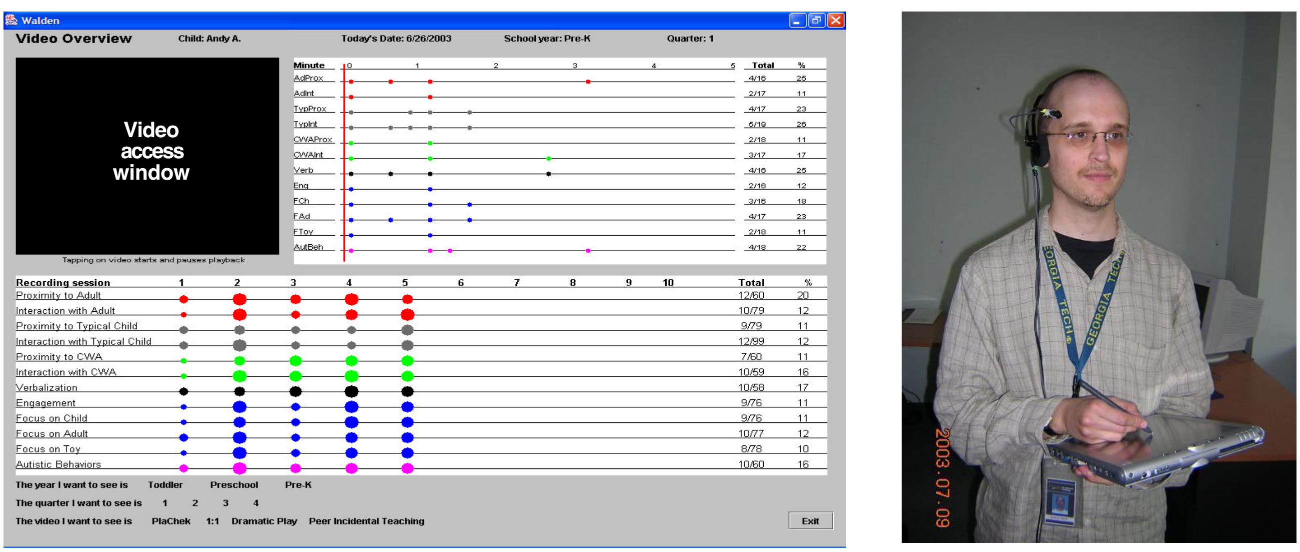
The Walden system was developed on top of the INfrastructure for Capture and Access Applications (INCA) toolkit [7]. INCA provides abstractions and reusable components that address capture-and-access concerns and facilitate application development.

The system has three INCA modules: a capture module to record annotations and video; a storage module to hold that information for later access; and an access module to provide synchronous access to multiple integrated streams of information gathered from context-based queries.

The capture interface is built on INCA's capture module, which supports the recording of video data and behavioral variables (Figure 3(a)). The video and handwritten annotations captured — with metadata describing when, what, and for which child information is being captured — are stored in a relational database using the storage module (Figure 3(b)). The access module draws on this database to compose the access interface (Figure 3(c)). In this interface, each marked behavior is an index into the video (Figure 3(d)).

The first capture interface used the Quill toolkit as a gesture recognizer, with a few changes that allowed for automatic interpretation and tabulation of the observers' data [2]. While this design supported a familiar method of data input, its deployment on a Tablet PC failed. Writing on a tablet was different from writing on paper in two important ways: calibration and resolution. Annotating boxes in the electronic form that were the same size as those on a paper version proved to be noticeably difficult, and the imperfect handwriting recognition resulted in a significant amount of time and effort being spent correcting the data. The research manager also found it difficult to keep children in the video frame while observing and annotating behaviors.

We redesigned the prototype to simplify capture. We used screen real estate more economically by replacing the spreadsheet with click boxes for "yes," "no," and "can't tell" (Figure 1(c)). The same set of boxes is used for each recording interval, with the number of the interval noted at the top. We replaced the cells for writing the names of teachers and classroom activities with drop-down menus from which the names can be selected. We added buttons



(a) (b)

Figure 2: The access interface (a) has at the bottom a "macro" timeline that shows an overview of a child's ten quarterly Pla-Chek sessions. The micro timeline at the top right shows the results of the selected session, and the video for that session appears at the top left. A researcher performs capture during naturally occurring classroom activities, using a Tablet PC with a head-mounted camera attached (b).

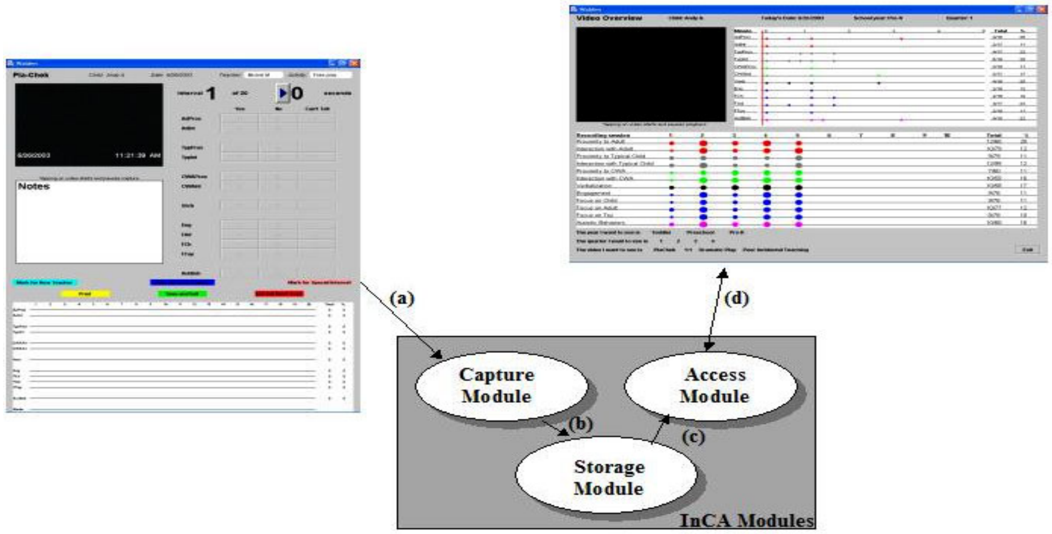


Figure 3 : The capture interface (a) is built on the capture module of INCA, which supports the recording of video data and behavioral variables. The storage module (b) saves the data for use by the access module (c) in composing the access interface (d).

that can be used to place marks in the timeline when teachers or activities change; these marks remind the research assistants to make the changes using the drop-down menus after the session, avoiding interruptions.

Handwriting and gesture recognition are no longer issues. Each ten-second interval is added to a canvas that renders a quick review of the CWA's behavior throughout the session. A head-mounted bullet camera — which ensures all data are recorded during the heads-up observation interval — replaced the beltline webcam (Figure 2(b)). A notepad was also added, allowing the research assistants to associate handwritten notes with each recorded interval.

FUTURE WORK

We will add a harness to support the weight of the Tablet PC, as well as a belt-worn pack to hold the battery and controller for the bullet camera. We will develop a plan for deploying the capture and access modules, recording and reviewing quarterly data for several children, and evaluating the usefulness and usability of the system.

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