From the War Room to the Living Room: Decision Support for Home-based Therapy Teams

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ABSTRACT
Teams of therapists often provide targeted interventions for children with developmental disabilities. A common practice in these cases is one-on-one interaction between a therapist and the child together with occasional group meetings of the therapists to discuss progress and make informed decisions to modify the intervention plan. We designed a system called Abaris to support this form of collaborative decision-making for a particular intervention popular in the treatment of children with autism. Our system allows for the simultaneous use of trending data across therapy sessions and detailed session data that is automatically integrated with highly indexed video. We discuss the impact this system had on the team dynamics, the amount of collaboration, and the effect it had on the team using evidence and videos to make decisions about the care of the child.

Categories and Subject Descriptors
H.5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces – Computer-supported cooperative work, Evaluation/methodology

General Terms
Design, Human Factors

Keywords
Capture and access, collocated collaboration, data-based decision-making, autism, computer-supported cooperative care

1. INTRODUCTION AND MOTIVATION
In the care of individuals with chronic conditions, treatments often span multiple caregivers across extended periods. Caregivers ideally will collect large amounts of data, both qualitative and quantitative, to help determine the effectiveness of various treatments and review these data regularly to adjust the care as needed. Because care is often administered individually, collaboration efforts are important in ensuring that care is administered correctly and consistently. Using recorded data as evidence to support decisions can be crucial for effective treatment.

Although data-based decision-making is an important component of chronic care management, it is not a trivial task. Many times, the task of collecting data is so burdensome that caregivers do not have time to collect it properly. Improper data collection may include missing data points, such as events that happen when no one was expecting them, or unreliable data due to being reported from a caregiver's retrospective memory, perhaps minutes, hours, or days after a moment of interest occurs. Even when data is collected, it might not be presented in a way that is amenable to synthesis and understanding, or it might not be consulted regularly enough to impact the trajectory of treatment in a timely fashion. Additionally, much of the data collected in these settings is paper-based, so it is difficult to make changes, share with others for discussion, make connections between different views of data, and review richer data such as videos or images.

Computing technologies can alleviate some of the burden of data collection and facilitate the automatic integration across different levels of detail, resulting in collaboration tools that can enhance the group decision process [10, 11]. We developed a system, which we call Abaris,[1] to support data-based decision-making for teams of caregivers providing Discrete Trial Training therapy (a form of Applied Behavior Analysis or ABA) to children with autism. Autism is a life-long developmental disability first appearing in young children and is characterized by deficiencies in communication, social skills, and creative and imaginative play. The care of children with autism can especially benefit from support in data-based decision-making, because it is often the case that individuals receiving the care cannot speak for themselves. Additionally, the behaviorists who are central to the treatment of these children are particularly interested in numerical data, especially that which show trends over time. We used video with automatically generated indices to important moments within care sessions and provided an interface for easily accessing these videos with digitally graphed trend data from care sessions. The team of therapists for one child used Abaris for four months to capture individual therapy sessions with the child and to review sessions, either collaboratively or individually, to understand the progress of the child over time. We then conducted an in-depth analysis of the effects of Abaris on the team dynamics.

CSCW'06, November 4-8, 2006, Banff, Alberta, Canada.

[1] Abaris was a legendary Greek priest and healer. It is also a play on the acronym ABA (Applied Behavior Analysis).

In this paper, we describe the nature of these types of care teams and how our system affected their work practices. We begin with related work, followed by an overview of the domain problem, including the nature of the teams and the artifacts used in decision-making. We then give an overview of the Abaris system and the details of the study. Next, we will go into detail about how our system changed the nature of the team dynamics and the artifacts used in making decisions. We end the paper with a discussion of the implications for technology supporting data-based decision-making and general conclusions.

2. RELATED WORK

Caring for and educating another person is often an inherently collaborative effort, including everyone from highly trained professionals to family members with varying experiences. Researchers in CSCW have broadened the term "work" in the last few decades to include such things as education, learning, medical care, and a wide variety of other in-home activities. The history of examining these collaborative activities is long and broad. As such, this section highlights those efforts to which this work most directly relates and from which this work most directly draws.

2.1 Meeting Together

A wide variety of technologies exists in both research and commercial products to support teams of people meeting together, in person or at a distance, synchronously or not, for large and small groups. An exhaustive list would be impossible to maintain within the scope of this discussion. Of particular relevance to our work, however, is the strand of research, initiated in the ubiquitous computing research community, concerning the automated capture of team meetings for perusal later by an individual or the group. The Tivoli [14] and TeamSpace systems [17] both relied on the artifacts created as part of the team meeting to provide cues to the user to access that information later. Furthermore, the eClass project [3], and many other subsequent efforts, provided these capture and access services for a classroom setting. Significantly, in this work, the collaborative system was not used to document the meetings themselves as much as to provide input to the discussions at the meetings. There has been relatively little research into automated capture and access systems in which access is predominantly a synchronous, collaborative effort [21].

There have been numerous computing systems designed to support collaborative, synchronous meetings, similar to the type of interaction our system was designed to support. For instance, Teasley *et al*. examined how people in "war rooms" can effectively use technology to support collaboration [20]. Wang & Blevis have investigated what technical design concepts can support a team of industrial designers [22]. Other individual technological design factors have also been explored. For example, shared displays can impact the collaboration of teams who are synchronously located [7], including large, shared displays [18] and tabletop interaction [6].

2.2 From the War Room to the Emergency Room to the Living Room

Similar to the early studies of war rooms and air traffic control towers [9, 12, 19, 20], the CSCW community has had a long tradition of interest in fast-paced group decision-making phenomena. Despite the movement of healthcare from specialized clinics into our own homes, the majority of healthcare-related collaborative technologies have not had a focus in the home. Collaboration in emergency rooms and among emergency service workers has garnered particular attention as a unique set of situations in which workers must take advantage of the tools around them, technological and otherwise, to support cooperative activities for the good of the patients in need. Whalen [23] describes the coordination that can and must take place between callers and the emergency support staff through the lens of Computer Aided Dispatch (CAD). Similarly, Bowers and Martin [2] focused on the collaborative work of dispatching ambulances for emergency paramedic care. Finally, the SOS project sought to uncover ways in which collaboration differed across emergency care situations based on the organization providing the care [15].

Care teams studied as part of this project also use a variety of tools available to them to communicate among the team members, maintain mutual awareness of information, and distill ambiguities in directions and diagnosis. The pace of these decisions and this communication among the group is much slower, however, than in emergency care. Decisions are made with respect to the direction and specifications of the care only two to four times per month during discussions that can range anywhere from a few minutes to half an hour. Additionally, the work we conducted takes place in a home setting, which does not have many of the resources available to offices and medical settings, and is a fairly new topic in coordinated care. Pinelle and Gutwin are a notable exception in their work in supporting home-based care teams [16].

Individual decisions are also very different, in part due to the pace of the care, but primarily due to a different understanding of what is at stake for the individual receiving the care. In the case of emergency work, a patient's life may well be at stake, and decisions must be made quickly and with respect for the severity of the potential consequences of a mistake. In the care of a child with special needs, an individual's decision about the child's performance on a task or understanding of how to ask the child to perform a task could have significant repercussions in terms of the child's ability to learn from that request. The child's life, however, is never in physical danger. Indeed, even the errors in learning can usually be corrected if caught by the team within a relatively short (weeks rather than years) period of time.

2.3 Getting Help in Making a Choice: The Advent of Decision Support Systems

One of the first sets of applications to evolve with the advent of distributed and personal computing was the concept of Decision Support Systems (DSS). These systems have evolved over the last 35 years from simple attempts to quantify and record information about ideas, people, and organizations into complex applications that may provide a variety of features, including collaborative discussion tools and complex preference algorithms for individuals and for groups [16]. The long history of these applications has included their use in analysis of complex problems by managers in corporations as well as in engineering and scientific pursuits.

Interestingly, DSS technologies often use information gathered from a large number of people and a large number of resources to generate models that are then used by a single person to make a decision. Furthermore, they typically distill rich information (such as preferences or measures of quality) into numeric

representations, again to abstract the data for clearer decision support. In this paper, we focus on an application designed to support a group of individuals making complex decisions about the teaching and care of a child with special needs.

2.4 A Broad View of Cooperative Care

Consolvo *et al.* [5] coined the term Computer Supported Cooperative Care (CSCC) to describe the broad range of caregiving activities that a group does using technology. Although that initial work focused on the in-home care of elderly individuals with a variety of health and cognition difficulties by a network of adult caregivers [4, 13], many of the challenges in helping an older person to maintain independence also exist when helping young children with disabilities to gain independence [1].

We define cooperative care as the broad set of activities involved when two or more people assist in the care or teaching of another individual. Often, this individual may have physical, cognitive, or emotional disabilities that limit independence and self-care or self-instruction. The caregivers in question thus may be healthcare professionals, but they may also be family members, educators, neighbors, specialists in rehabilitation, *etc*. The activities surrounding the traditional definitions of care and of teaching are also significant, and thus we include them as part of the CSCC challenge. The team meetings, which may use a number of tools including decision support systems and capture of significant data, in addition to the therapeutic interventions themselves are indeed a significant part of the care process. We describe here how a system supported the collaborative work of a team (even when the child was not present), not only when they were together, but also when each individual used the system alone.

3. DOMAIN PROBLEM AND THE ABARIS SYSTEM

This section provides an overview of discrete trial therapy, a best practice therapeutic intervention for children with autism and provides details of two main areas we studied: the use of artifacts and the level of participation. We then describe how we designed and developed the Abaris system to support a therapy team.

3.1 Overview of Discrete Trial Training

Discrete Trial Training therapy is currently a best practice method for teaching academic and life skills to children with autism and other developmental disabilities. In DTT, a team of therapists works individually with a child in a controlled setting. In individual sessions, a therapist instructs the child in a variety of skills in a highly structured, repetitive manner, helping the child master correct behavior through errorless teaching and positive reinforcement. These skills, grouped as programs, often include academic skills such as word pronunciation, object identification, or counting, but can also include more practical skills, such as toileting or getting dressed. Throughout a session, the therapist records grades on paper for each trial of all of the skills on which the child is working. After each session, she calculates percentages of trials completed successfully and independently and plots each program's results on hand-drawn paper graphs. Finally, if a skill has been "mastered" and thus no longer needs to be actively targeted, she will add new skills to the program. Therapists also write several paragraphs of general notes about the therapy session. These bookkeeping activities usually require 20 to 30 minutes of the therapist's time at the end of each session. The next therapist reads the collective notes before the next session, an activity that generally takes five or ten minutes.

DTT therapy is used in both home and school settings to teach skills which can later be generalized outside of therapy. Many young children actively engage in anywhere from 10 to 40 hours of therapy per week spread out over one to two hour sessions. The individual therapists working with a child typically participate in weekly or semi-weekly meetings to discuss the child's progress. In these meetings, therapists use several artifacts in their discussion of progress on the collection of active skills. Therapists may analyze these artifacts as a group during the meeting or use them as evidence at a particular point in the discussion. We describe these artifacts in Section 3.3 in more detail.

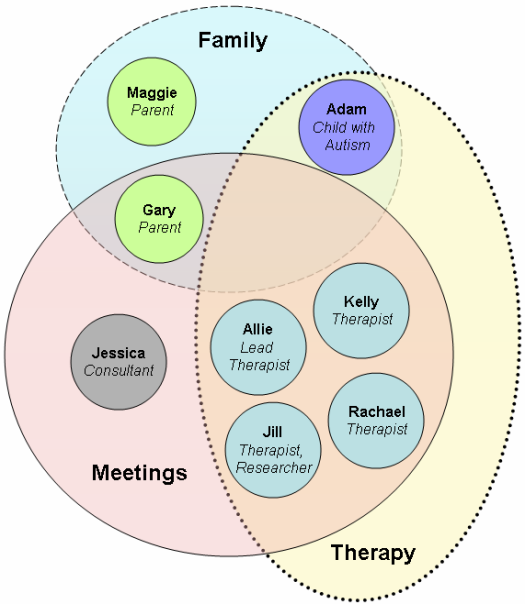

Figure 1: Diagram of interaction amongst people involved in therapy and meetings. Large ovals indicate relationships involving family, therapy, and meetings.

3.2 Traditional Practices of DTT Team

Traditionally, team meetings, with participation from everyone working with a child and people who have a vested interest in the child, are an integral part of any DTT intervention. In the team we observed, the therapists typically met twice a month to discuss the progress of the child in learning various skills. During these meetings, a consultant who specializes in behavioral analysis and DTT attended. She often examined the data collected throughout the week and made recommendations about the intervention plan. The consultant had little direct interaction with the child, only seeing him while testing out a skill during the team meetings. She regularly asked the therapists to help clarify the data they collected. Based on the numeric data (often visualized as graphs) and input from the therapists, the consultant determined if the child is progressing well with the current path, or whether changes to the program of therapy would be necessary. Typically, one or both parents were present to inform the therapists of any significant behavioral and/or academic issues outside of therapy that may affect the sessions themselves. These issues often included the start of a new treatment, drug, or diet plan as well as reports from school.

The makeup of people in attendance at the team meetings was relatively diverse. They varied not only in their relationships to each other but also in their relationships with Adam,[2] the child for which the therapy was being administered (see Figure 1). In the team we studied during the deployment, the parents, Gary and Maggie, hired the consultant, Jessica, and the lead therapist, Allie, who work together at a behavioral consulting firm. Adam's parents hired two additional therapists, Kelly and Rachael. Jill was a researcher and a trained therapist who joined in therapy and meetings as an observing participant during deployment.

3.3 Artifacts Used in Decision-Making

During team meetings and individual therapy sessions, participants often took advantage of a wide variety of artifacts available to them to enable or enhance their work. Some artifacts were products of the therapy itself, such as samples of the child's handwriting. Others could be presented as a prop for discussion during team meetings, used as key information for individual or group decision-making, or provided a conduit for communication among team members. Team members used these artifacts in therapy sessions to make decisions about the work at hand, directing them to try new skills or change the way they were testing old skills. They also used these artifacts to make determinations about the direction of therapy as a whole outside of individual sessions. These artifacts support decision-making processes surrounding the child's ability to learn a skill at an appropriate rate, the potential additions of new skills to learn, and the determination of success with the current course of action. Below is a description of each of these artifacts and the varied ways in which they were used before the introduction of Abaris, as well as the advantages and disadvantages observed for each.

Graphs showing child's performance over time

- *Description*: Therapists graph data points for each skill which shows the percentage of correct trials for a cumulative set of grades
- *Use*: Therapists use this to show trends in progress over time
- *Advantages:* Shows trends over time, quick to access
- *Disadvantages:* Does not provide details on specific grades or context, hand drawn, only exists on paper

Videos of therapy sessions

- *Description:* Therapists use web camera in a fixed location to record 1-2 hour therapy sessions on a nearby computer
- *Use:* Shows events that cannot easily be described in words or remembered by the therapist
- *Advantages:* Very detailed, reliable account of events during therapy, shows others exactly what happened
- *Disadvantages*: Without indexing, extremely difficult to find moment of interest and thus time-consuming to review

Data sheets from individual sessions

- *Description:* Individual grades for trials from each therapy session written by the therapist directly after the trial
- *Use:* Shows which grades therapists give for different skills
- *Advantages:* More detailed information about how a child did on a particular skill than the graph for that skill, may also show notes from therapist written at time of trial
- *Disadvantages:* More difficult to find data of interest than with graphs because there are more of them and they are located in varying places

Therapy samples from sessions

- *Description:* Physical artifacts from actual therapy sessions, such as handwriting samples or artwork
- *Use:* Shows examples of what the child is capable of
- *Advantages:* Provides actual proof of what child is capable of, reasonably quick to access, does not decay with time
- *Disadvantages:* Limited in scope since it is only applicable to certain skills with tangible samples, some context of therapy lost if therapists cannot remember it

Reenactments of child performing a skill

- *Description:* During meetings, the therapists may have the child try to perform some of the skills from therapy to see if they can repeat incidents from therapy
- *Use:* Used when therapists want to see if a child is capable of doing certain skills before adding them to the therapy program, used to train therapists to conduct trials consistently
- *Advantages:* Realistic, multi-observer reenactments of what the child is capable of and good therapist training technique
- *Disadvantages:* The child might not be able to perform under pressure, may not explain why some therapists have better results than others

Memory of those present at a team meeting

- *Description:* Recount of events during weekly sessions
- *Use:* Used to explain graphs, help clarify differences in grades, make hypotheses about progress
- *Advantages:* Very quick to access
- *Disadvantages:* Can often be very unreliable, includes no details, decays over time, absent therapists cannot contribute

Observations from External Sources

- *Description:* The parent at the meeting may bring in outside knowledge from the child's school or other therapies, such as if the child had a bad day at school or is not making progress in other areas
- *Use:* Used to bring in outside knowledge about what may or may not affect the child's progress in therapy
- *Advantages:* Very quick to access
- *Disadvantages:* Relies on other people's accurate descriptions, thus can be unreliable or even misleading

Notes written by therapists after sessions and meetings

- *Description:* After each therapy session, therapists write general notes about session experiences and any problems they had, also includes minutes from previous meetings
- *Use:* Session notes are typically used when one therapist is absent from the meeting and to convey information from session to session between meetings, previous meeting notes are used to refer to decisions made in past meetings
- *Advantages:* Thoughts of therapist written within minutes of completion of therapy session
- *Disadvantages:* Largely qualitative, cannot easily show trends over time, lacks specific details, harder to access

[2] All names have been changed to preserve anonymity.

One design goal was to provide access to those artifacts that are most likely to provide reliable and repeatable forms of evidence. Because analysis of the most reliable data available is an integral part of behavior analysis as a science, our system served its users best by providing relatively easy access to salient points within the most reliable data source available, typically video.

3.4 The Experimental System

While working together with a team of Discrete Trail Training therapists, we iteratively designed and built Abaris, a system to support the practices of the team. This section serves as an overview of the system design. For a complete discussion of the design and implementation of Abaris, we refer to a previous publication [11]. Our main goals for this system were to increase the accuracy of data collection during therapy sessions and enable therapists to easily access more reliable artifacts during meetings. We devised a way to capture and index videos of therapy sessions, automatically generate graphs of the child's progress, and provide an interface for quickly accessing these artifacts during their meetings. To minimize changes to the regular practice of the therapy, we leveraged natural components of the therapy protocol by replacing regular data sheets with Anoto® digital pen and paper technology and using Nexidia™ speech recognition on the therapists' spoken commands to the child. After sessions, therapists entered the grades using a regular desktop PC and the Abaris system (see Figure 2). Using these grades, Abaris automatically calculates percentages and creates graphs of the data. We used timing information from Anoto and Nexidia to approximate timestamps corresponding to the trial time in a video stream. This timing information created a highly indexed video that could facilitate navigation on a per-trial basis.

We designed the access interface to support individuals or groups in reviewing specific interactions during the therapy sessions. Our system provides access to data by displaying graphs for each of the skills on which the child is currently working, either one at a time or overlaid for comparison. As the user hovers over the data point for any particular day during which that skill was tested, a tool tip displays detailed data from the data sheet about that day (see Figure 3). When the user selects one or more data points, a new window appears with the relevant video and the ability to jump easily between the occurrences of tests of the skill of interest. Users can also switch between videos of multiple therapists testing the same skill (see Figure 4).

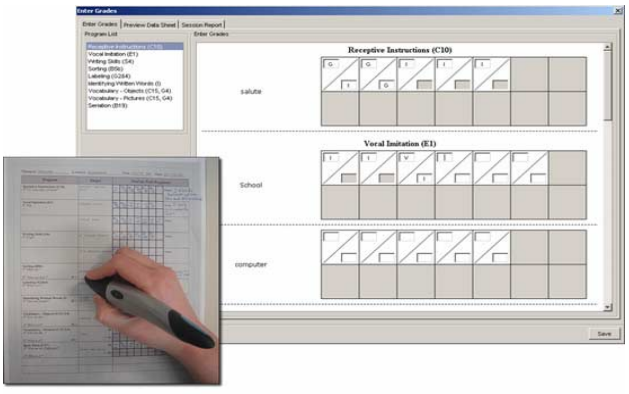

Figure 2: The lower left shows a therapist writing on a data sheet with a digital pen. The right shows the data entry portion of the capture interface.

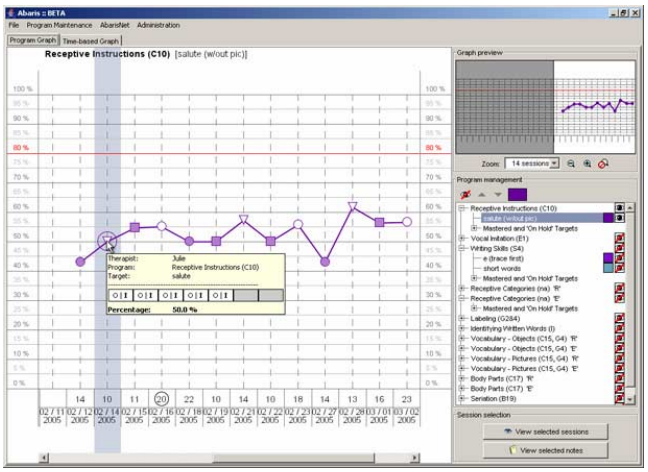

Figure 3: The graphing portion of the access interface. When the user hovers over a data point, a tool tip appears with more information for that day.

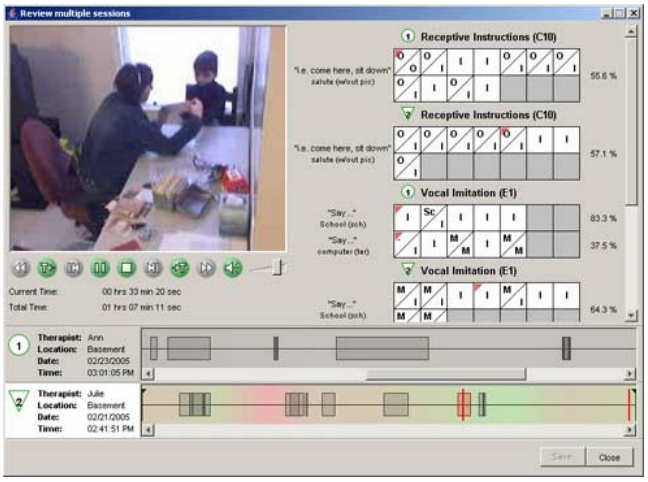

Figure 4: The video display window. Bottom shows timelines for two sessions, right shows grades similar to the data sheet. Clicking on both the timeline and the grades will jump the video to the moment that the skill took place in the session.

4. STUDY DESIGN AND RESULTS

To evaluate the impact of our system on the team of therapists, we conducted a long-term deployment and studied its use over four months. Two key goals of Abaris were to support the decision-making abilities and discussions of therapists in team meetings and to increase use of reliable artifacts in the decision-making process, while reducing the reliance on less reliable, unverifiable ones. In this section, we discuss our study design and the results in affecting the team dynamics and the use of artifacts.

4.1 Study Design

Before building Abaris, we studied extensively the practice of discrete trial training by being trained as therapists ourselves and conducting therapy and participating regularly in team meetings. There are two main reasons for this. First, by understanding what it is like to perform the therapy, we gain a better understanding of how to design the application, which is consistent with the findings from other participatory design projects. Secondly, since we were deploying this with a real child and a real team of

therapists, we needed to be sure that researchers were nearby to answer questions and solve any problems so that there would be no loss of data. We were concerned about how playing the dual role of being a researcher and a member of the therapy team affected the adoption of the system, so we had researchers who were not on the therapy team help with observation and analysis portions. Additionally, we triangulated our observations with more objective data such as usage logs and videos. In the end, we found that it had a positive influence on the team dynamics.

Thus, in the 18 months prior to deployment and throughout the design process, several members of the research team conducted regular therapy (at least one session per week) as participating observers. During this time, we observed and participated in bi-weekly team meetings and collected artifacts from therapy, videos of a subset of meetings, and notes from observations. For the deployment, the therapy team used our system in the home of one child for a four-month period between February and June of 2005, with one member of the research team continuing during deployment. This therapy team consisted of a lead therapist and three other therapists, with a fourth starting at the end of the third month (see Figure 1). The parents of the child also occasionally used the system and the father regularly participated in team meetings. Overall, the team used our system to record 52 therapy sessions, for a total of 45.1 hours of video.

The therapy team conducted six meetings using Abaris. The team, which normally met once every two weeks, succumbed to scheduling difficulties during the study resulting in gaps of one to four weeks between meetings. Two members of the research team observed and participated in meetings before the system, with one researcher continuing during and after deployment. In the meetings, our interface was projected onto a wall from a desktop computer (see Figure 5).

We videotaped meetings and instrumented Abaris to log important interactions during the meetings. We also collected minutes produced from all six meetings, notes written by therapists after each session, work samples from the child's therapy sessions, and field notes from the researchers with observations of both therapy and meeting sessions. We conducted interviews with each member of the therapy team toward the end of the deployment period and in the months after the system was removed. This type of long-term, mixed method study provided an opportunity to uncover the best results of actual use without biasing the results by being a member of the therapy team.

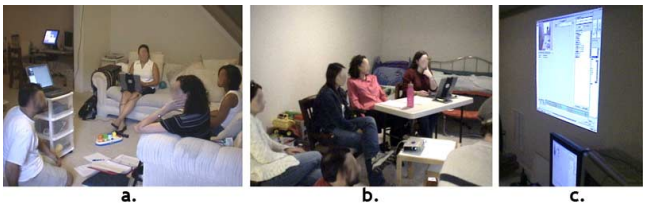

Figure 5: a) Team meetings without Abaris. b) Team meetings with Abaris. c) Abaris projected on a wall during meeting.

4.2 Results

4.2.1 Impact on Meeting Control

Prior to the deployment, the consultant ran the meetings and asked for feedback from the therapists or the parents when questions arose. She was the only one with easy visual access to the graphed data and data sheets, which were typically placed in a binder that she held throughout the meetings. Only when others present requested to see a graph or a data sheet were they shared amongst the group. When Abaris was used, however, everyone could see the graphs projected on the wall at all times. Therapists reported that because they could see the data, they felt more engaged in the meetings and participated more. When we asked the consultant, Jessica, about this change, she reported that the quality and the number of the comments were better than before and that the meetings were "much more efficient." When asked, she also reported that she did not feel like her control was lost during meetings, and in fact, appreciated more input from the other members of the team.

> **Jessica (Consultant):** *"I didn't feel that any authority or dominance that I wanted was taken away from me in any way shape or form... I loved being able to have a more engaged team."*

We designed the access interface for use by one person at a time, mostly for the sake of simplicity. Thus, one person volunteered to "drive" the meeting each time. At the first meeting, a member of the research team drove the interface under the direction of the therapists, to demonstrate its use. During this first meeting, the consultant and others would make requests about what to show on screen. After the first meeting, the lead therapist, Allie, was comfortable enough with the interface that she often became the driver. She also adopted the habit of reviewing data and videos before the meeting to have things in mind that she wanted to discuss during the meeting. Sometimes, at the start of the meetings, Allie would already have videos loaded and ready to play. As decisions were made in the meeting, she would use Abaris to immediately make changes to the therapy program. These changes then became available to the next therapist printing her data sheet - a significant change over the manual production of data sheets that needed to be made by the individual therapists directly before therapy. Because the system was controlled by a single user, other team members made requests when they wanted her to change what was currently being shown. Interestingly, even though the lead therapist felt that she lost a bit of control over the overall therapy (due to the system handling many of the managerial duties), she gained more control during the meetings due to taking on the role of driving the interface.

In this type of team, each of the members has varying degrees of expertise in the therapy. Therapists who are less knowledgeable or experienced about therapy might be reluctant to question decisions made by team members with more experience. However, during the time Abaris was used, there were a few instances in which the less experienced therapists used the video as evidence to question a decision being suggested by more experienced therapists. During these discussions, they noted something they believed they had seen in the video that others did not. The conversation below illustrates one such example, during which the entire group challenged the lead therapist about what she was accepting as a correct response for the child.

> *[New graph is displayed, showing a very high upward trend, then a sharp drop in progress for Allie's session. If Allie had continued the trend, the skill would have been considered "mastered" or completed.]*
>
> **Jessica (consultant and Allie's boss):** *"nooooooo….."*
>
> **Allie (lead, extremely experienced therapist):** *"I want to talk about this one…"*

Jessica: *"Allie, what did you do? I don't think I want to hear this story."*

[Allie explains what happened and demonstrates what occurred during her session]

Jessica: *"I want to see… sorry …"*

[Group plays video of Allie performing the skill]

Kelly (newer therapist): *"See, now I was accepting that" [referring to child's response while watching Allie's video]*

Jessica: *"let's clearly talk about what we're accepting and what we're not accepting"*

[Conversation continues amongst all *therapists in which they each demonstrate what they were accepting and note how the video showed Adam doing the same thing in Allie's videos that she was not accepting]*

Jessica: *"Change your data…. She's an outlier, we just won't count [that one]."*

[Jessica then ensures that Allie is comfortable with changing the data so that the child masters the skill, and Allie agrees, so the data is changed and the skill is mastered]

In another instance, Kelly challenged a hypothesis by Jessica (the consultant) on the objects to which the child is attending during a particular task. Jessica was explaining one possible hypothesis, and Kelly countered with another while referring to the video as evidence. They then continued the conversation based on Kelly's observations as opposed to Jessica's hypothesis, which typically would have been taken as the most likely explanation.

4.2.2 Changes in the Level of Collaboration

To estimate the impact of Abaris on team collaboration, we rated the level of participation of each therapist during the meetings and compared this participation when our system was in use against when it was not in use. For this evaluation, two researchers watched videos of three meetings with our system and three meetings without (one prior to deployment and two several months after the end of the deployment). We chose these videos based on what was available and which ones had the most team members in common, since regular therapists changed frequently or certain team members were absent. For each video, we looked at each of the decisions that were made, based on the meeting minutes from that meeting. For each decision, we rated the level of engagement in the conversation for each member of the care team on a scale from 1 to 3, where 1 is little or no input into the decision, and 3 is significant participation in the decision. We reviewed a total of 39 decision points made in meetings without Abaris and 42 decisions made in meetings with our system. In meetings with Abaris, we determined that the average participation level was 2.44 for all team members across all the decision points across all three meetings, with a standard deviation of 0.44. Without Abaris, the average participation level was 1.98 with a standard deviation of 0.69. Figure 6 shows a graph of these figures. It should be noted that these averages are an estimate of the participation level.

While these figures are an estimate, they are consistent with the reported observations of team members about their participation levels in the meetings. In her post deployment interview, the consultant reported that she believed the discussion was better in the meetings with Abaris.

Jessica (Consultant): "*I do feel like with the system we certainly did a lot of discussion around things, around programs, because everyone's able to look at that data and make hypotheses and talk about that…. And people were able to visually see that, and I think make better comments. The quality of comments maybe went up and maybe the number too."*

In the meetings without Abaris, the discussion mainly centered around the lead therapist, the consultant, and the parent of the child. With Abaris, we saw higher participation levels among the regular therapists. The lower standard deviation during the deployment condition may indicate that the discussion was more distributed amongst members of the team.

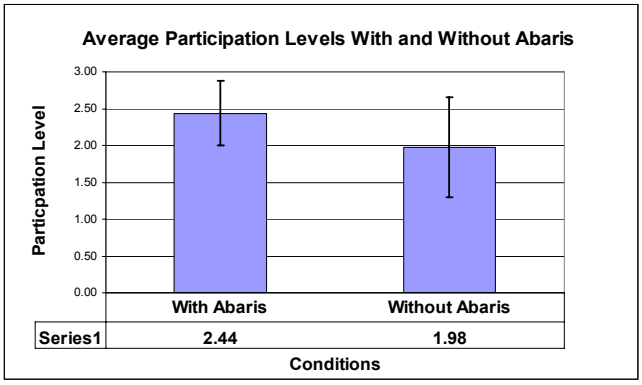

Figure 6: Meeting participation levels with and without the use of Abaris.

4.2.3 Changes in the Use of Artifacts

During the deployment, we observed a significant change in the artifacts therapists used in the decision-making process. In the same six meetings analyzed above, we also kept track of which artifacts at least one person consulted in the discussion for each decision point (39 decisions without Abaris, 42 decisions with). Table 1 lists the artifacts described above and the percentage of time they were consulted in the decision points we tracked during the meetings with and without Abaris.

Table 1: Percentage of time an artifact was used for each of the decision points we tracked in meetings, both with and without the use of Abaris.

	%With Abaris	%Without Abaris
Video	45.2	0.0
Graphs	81.9	56.0
Data sheets	45.2	20.5
Therapy samples	19.0	0.0
Reenactment	4.8	0.0
Memory	83.3	92.3
Ext. Observations	21.4	25.6
Therapist Notes	19.0	5.1

These percentages are meant to serve as an estimate in the changes that our system had on the use of artifacts. The

significant differences to point out are that videos were used in 45.2% of the decision points with the meetings with Abaris, and they were never used in the meetings without the system that we analyzed, although the videos of sessions were available. The videos were likely never used before because it was so difficult to find interesting moments, but the therapists reported that with Abaris, it was much easier to find the moment of interest. Therapists reported the video was useful because they had never seen each other perform therapy before, so now they could see how others do it and make sure they were all consistent. It also gave them the opportunity to reflect upon themselves and their own techniques. Without the video, they would not have had the same opportunity.

> **Allie (Lead Therapist):** *"I think the typical use of the video was to compare the responses for the different therapists ... [Video of me] helps me to do a little self-analysis."*
>
> **Kelly (Therapist):** *[while watching video of herself] "I just realized he was doing the exact same thing I was doing, and I didn't even catch that [while I was doing therapy]*.

Graphs were still the most frequently referenced artifact during the discussions at meetings, and with Abaris, their use increased even more. Notably, the graphs were also the default display for the system. The use of datasheet information also increased. In this case, datasheet information was available by hovering over a particular data point in the graph as well as in the video viewing window, compared to being placed in a separate area of the paper notebook from the graphs in the traditional method. While therapists still frequently references their memories, memory was no longer the only artifact used in the decision-making process. The therapists were referring to other kinds of artifacts to supplement their memories and make the decisions.

The team members reported in interviews afterwards that viewing the video allowed them to see subtleties about the way they were doing therapy that they did not notice while they were conducting it. One therapist in particular noted that she did not realize how small differences could affect how the child reacts.

> **Kelly (Therapist):** *"even though we all have the same training, there's a lot of little differences… we're just realizing which of those actually impact [child's name] and which ones don't."*

Although there was no notable change in the amount that other artifacts were used, there were some noticeable differences in the way they were used. In the therapy notes, for example, therapists using our system would add directions to the team to watch the video from their sessions for a further explanation of their notes. Even though therapy sessions had been video recorded prior to use of the system, these comments were a completely new phenomenon.

> **Examples of therapy notes for sessions with our system:**
>
> *"I am not sure if I did the seriation [a skill they were working on] correctly, so watch the video to check it out."*
>
> *"Counting at the table today was great, refer to video."*

4.2.4 Using Video as a Substitute for Being There

Team members often used video as a substitute for other activities. For example, video of team members absent from the meetings might replace those members' inputs to the discussions. One of the regular therapists, Rachael, had a regular conflict with meeting times and thus was only present in one of the six meetings at which the therapists used Abaris. In three of these team meetings, there were nine instances of viewing Rachael's session videos. These instances all occurred directly after questions about her techniques. Previously, when a therapist could not make meetings, the input from the missing therapist was non-existent, and afterwards the lead therapist would call that person, explain the results of the discussion, and ask him or her to change the practice to suit what the group had discussed. With Abaris, the other therapists and consultant in the meeting specifically requested to see the videos of the non-present team member in the discussion during which other present team members were adding their own explanations for how the child was progressing. Thus, the video served as a substitute for Rachael being present at the meeting, though the effectiveness of video as a substitute is an open question. In this case, the video allowed them to learn things they would not have learned had the therapist simply been absent. What they learned, however, was that she conducted her sessions significantly differently from other team members and thus a new requirement of presence at future team meetings was imposed on all of the therapists.

The consistently absent team member reported appreciating having the videos represent her during the team meetings that she could not attend. Rachel also stated in her follow-up interview that she appreciated the specific feedback she received.

> **Rachael (Therapist):** "*it [feedback] only helps [child's name]. I needed to know if I was doing it wrong.*"

Rachel used the video as a substitute for her being at the meeting in her own way. Before each session, she would view the videos of the lead therapist to see how to perform therapy for skills she in which she was less confident.

> **Rachael (Therapist):** *"I looked at the video to see how to do the bears… I always messed that up." [referring to a skill where the child must count a row of small, plastic bears]*

The lead therapist also began to use meeting minutes in a different way. After watching an individual's videos that could not be present at team meetings, she would write notes to that therapist with specific directions based on observations from the video.

> **Example of minutes for a meeting with our system:**
>
> *"Rachael, you are saying "do the trucks" or "do in order" and he is still doing it right, but please give the "do small to big" command so we can focus on generalization"*

Previously, the meeting minutes did not have this level of detail and were never directed toward a specific person.

5. DISCUSSION

The results of our study have uncovered several interesting results, especially regarding the use of videos influencing team dynamics and how technology can influence the use of artifacts in decision-making. We believe some of our findings can help others in designing similar technology for related domains.

5.1 Team Dynamics

By being a part of the therapy team, we were able provide the "champion" of the system to encourage its initial use, something Grudin argues is critical for groupware adoption [8]. In the post deployment interviews, we queried the therapists on how they felt our enthusiasm affected their adoption of the system, and all of

them said they were glad we were there and were comfortable enough with us to give us honest feedback. They also reported that since we were there to help them, they were more comfortable with taking risks and exploring the use of the system.

Analysis of the use of a capture and access application to support data-based decision-making for a team of caregivers has some implications for other collaborative systems.

1. *Collect data from all caregivers.* Individual therapists can be empowered to see critique as part of a group effort towards improvement only when all team members are being scrutinized equally. The reciprocity inherent to sharing videos of everyone's sessions also enables team members to better empathize and trust one another with common concerns and fears.

2. *Use floor control to empower an individual or share control amongst the group.* Previously, the consultant led meetings and was the only one who could view most the data. Therapists interjected when appropriate, but rarely if ever asked to see the artifacts. Thus, floor control in the initial design of the system always defaulted to a single individual. This individual wielded an enormous amount of control in what to show on screen and whether to yield to requests from the group.

3. *Provide a way of opting out of data collection.* Therapists reported in post deployment interviews that they would like the option of stopping video recording. Therapists commented that there might be times when they did not want their videos viewed by others, such as if anything happened that the therapist would be embarrassed to share with others. Sometimes, these moments can only be detected after the fact. Thus, designers should a way for therapists to remove a subset of the video without deleting the entire record. Our findings indicate that video is extremely useful, however, and thus therapists should only be encouraged to "opt out" in rare circumstances.

4. *In collaborative care settings, design for the needs of the individual receiving care first and the individual concerns of the caregivers second.* Surprisingly, no therapist reported feeling uncomfortable with sharing videos of their sessions with others within the same care team. Video capture is a relatively common work practice in this domain. However, anecdotal evidence from the consultant and lead therapist suggests no other team has ever reviewed these videos to near the extent of our team using Abaris. All of this team's therapists commented that they were willing to put aside some of their own reservations to help the child.

5.2 Use of Artifacts

The use of shared artifacts is essential to any collaboration effort. The ways certain artifacts were used did change with our system. In this section, we highlight several key insights into changes in the use of artifacts for collaborative care teams.

1. *The context of the individual activities captured in videos can be as meaningful as the activities themselves.* When our system was used, discussions were sometimes initiated as a result of something observed in the video that was not the primary focus of the video segment chosen. Events happening before or after a moment of interest were often useful in understanding the child's ability to perform a particular skill. Thus, individual clips of the skill tests are not as useful as approximate indexing into moments of interest within the entire video. In fact, errors in our indexing scheme sometimes were beneficial because they forced the team to view more of the context of therapy.

2. *Multiple levels of detail are important.* Our system provides access to artifacts with three distinct levels of detail. The graphs show a summary of progress over time. The individual daily data sheets show the subjective assessment of the therapist at the time of therapy for individual tasks. Finally, the video of a session provides very low-level details of a session. Different levels of detail were necessary in the problem-solving process for different discussions. Sometimes, a quick view of the datasheet might clarify a question, but other times, viewing the video of actual trial during the session was necessary. Caregivers should be able to transition between different levels of detail easily and as necessary. With Abaris, the default view was to see an overview of the graph, see data sheet details about a particular data point using the hover tool, and then view the video if even more detail was needed.

3. *Providing easy access to richer artifacts may lengthen the meeting time, but increase the richness of the discussion.* Meetings in which the team used Abaris tended to take longer, despite the commonly reported perception by team members that they were "more efficient" than meetings without. Furthermore, therapists universally reported being more engaged in the meetings. The consultant reported that having everyone see the data helped the other therapists see the importance of collecting the data. We also observed that regular therapists participated in the discussions more, and there was less downtime in waiting for the consultant to ask the therapists a question. Therapists mentioned that the discussion was worth the extra time spent in the meeting, but this may not be the case for every team.

4. *Speed of access to artifacts is important.* Even though access to some artifacts was much faster than it had been previously, towards the end of the meeting, participants sometimes expressed reluctance to access more detailed data. Therapists referenced the datasheets using our system much more frequently than they had done previously when the individual data sheets were stored in a different part of the notebook from the graph overviews.

6. CONCLUSIONS AND FUTURE WORK

In this paper, we presented results of an extended case study of a collaborative information system designed to support a specific data-intensive therapy for children with autism and other related developmental disorders. Our system, Abaris, was unique in that it automated the collection and presentation of data across three levels of detail, from long-term trends to individual grades for a given therapy session that served as an index into recorded video of the actual therapy session. Our hypothesis was that this integrated information system would positively influence the quality of collaboration at team meetings. We discovered changes in control amongst team members and in the use of artifacts in the decision-making process. In the case of the team we studied, therapists reported that Abaris was a valuable tool in helping the team use more reliable artifacts in their decision-making with minimal disruption to the structure of the therapy sessions.

Although this application was targeted at a very specific type of data-based decision-making, this type of collaboration is common in chronic care management. Capture and access systems can be used to support collaborative discussion and the concepts of expanding artifacts available in this type of discussion easily extend to other conditions, such as diabetes, cancer management, or the elderly. We believe that this type of capture and access

technology will be useful in helping other teams who stress the importance of evidence when making crucial decisions about the care of an individual with a chronic condition.

We are further investigating how we can apply variations of our capture and access system in other settings and for other purposes, such as for use in classrooms, for training of therapists, for supporting therapy meetings at a distance, and for providing a means for a longitudinal assessment of the child's progress in learning various skills. Other uses in the Discrete Trial Training domain are to provide a corpus of appropriately indexed videos of real therapy sessions to domain experts who can use it to evaluate the impact of the actual therapy on the child. Additionally, we are looking at how this type of collaborative capture and access system can be used in other domains, such families using home videos to facilitate discussion of an aging parent's health.

7. ACKNOWLEDGEMENTS

First and foremost, we wish to thank the therapy team for being so open to this collaboration. We acknowledge Sebastian Boring for his development efforts and assistance during the deployment of Abaris. Thanks to Shwetak Patel, Khai Truong, Jay Summet, Giovanni Iachello, and other members of the Georgia Tech Ubiquitous Computing Group for their helpful comments on the writing of this paper. This work was funded in part by the National Science Foundation Graduate Fellowship and the Cure Autism Now foundation. It is covered under Georgia Tech IRB protocol #H03220.

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