Activity-Based Interaction: Designing with Child Life Specialists in a Children's Hospital

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ABSTRACT
Child Life Specialists (CLS's) are medical professionals who use activities to educate, comfort, entertain and distract children in hospitals. Adapting to a shifting cast of children, context and mediating activities requires CLS's to be experts at a kind of articulation work. This expertise means CLS's are well equipped to help technologists introduce child-facing interventions to the hospital. We conducted participatory design activities with 9 CLS's to develop two mobile systems to explore how CLS-child interactions are shaped by activities. We observed 18 child-CLS pairs using these systems in a hospital setting. By analyzing these encounters, we describe a continuum for classifying activities as either *Co-Present* or *Collaborative*. We then introduce a framework, *Activity-Based Interaction*, to describe structural components of activities that impact their position on this continuum. These concepts suggest new approaches to designing mediating technologies for adults and children.

Author Keywords
Child life specialist; children; mobile computing; collaboration; participatory design; articulation work; hospital

ACM Classification Keywords
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General Terms
Design, Experimentation, Human Factors

INTRODUCTION
As the HCI community's general interest in healthcare has grown, hospitals have emerged as an especially popular topic. A large group of researchers have explored how healthcare professionals collaborate in the hospital, studying how doctors, nurses and others share information and coordinate (e.g. [2,3,9,21,22]). Others have emphasized a patient-centered approach, studying systems that empower patients at the hospital and during their encounters with health providers [8,12,17,23]. A particularly challenging patient has however received less attention: the hospitalized child.

Children are unique and challenging to design for, and are the subject of entire conferences and a wealth of literature [14,25]. The problem of creating an empowering, therapeutic, collaborative system for children is further complicated by the introduction of physical or psychological illness and hospitalization. Researchers have studied the effects of hospitalization on children for decades [16,20]. Developing a tool that can identify and adapt to seemingly endless potential traumas and opportunities across an equally endless array of unique, idiosyncratic children is daunting, to say the least.

To aid our efforts designing for hospitalized children we propose enlisting the aid of a unique type of healthcare provider; the Child Life Specialist (CLS, often referred to collectively as 'Child Life'). CLS's are healthcare professionals that use activities to help children and families adapt to the stresses of the hospital and illness. Bardram *et al.* have described the 'articulation work' that doctors and nurses undertake to coordinate and enable collaboration [2,3]. Articulation work is a useful lens for considering the work a system or researcher must do to adjust to an individual child's cognitive and physical needs. CLS's are experts at this novel type of 'articulation work', and thus are perfectly suited to inform the design of child-facing interventions in the hospital, and to mediate their use by a wide variety of patients.

In this paper, we offer a realistic look at a mobile computing intervention in a children's hospital, developed using a participatory design approach with Child Life. We provide an introduction to these understudied but crucially placed actors in children's hospitals. Two prototypes were developed through our work with Child Life. We evaluated these prototypes along with various control systems in authentic CLS-child encounters at Children's Healthcare of Atlanta's Egleston Hospital. By analyzing these evaluations, we introduce a framework for comparing and understanding activities that mediate between adults and children. We compare key components of activities in order to classify them along a continuum from highly interactive *Collaborative* examples to more passive *Co-present* types. We call this framework *Activity-Based Interaction*.

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This paper is structured as follows. We begin with a discussion of related work, covering relevant projects in and outside the hospital. Following is a brief introduction to Child Life Specialists and a consideration of their value as collaborators and mediators for technologists. We then describe our work developing and evaluating technologies with Child Life at Egleston Hospital. After studying evaluations by 18 CLS-child pairs, we introduce Activity-Based Interaction and employ this framework to analyze the activities we observed.

A Note on Terminology

"Activity" is a broad term. We use *activity* to denote the games or systems that CLS-child interaction is structured about (e.g. a card game, an art project, a mobile computing system), rather than to invoke a particular theory or context.

RELATED WORK

We draw inspiration from two different types of related work. The first explores technology that mediates children's communication, especially with adults. The second studies interventions in children's hospitals. This work often involves adult medical professionals, but rarely devotes much attention to understanding their role.

Mediating Interactions with Children

Yarosh *et al.*'s investigation of communication between separated parents and children, like our work, focuses on mediated adult-child interactions [24]. Yarosh *et al.* developed a telepresence system, ShareTable, through which remote parents and children interact as though sitting at the same tabletop. Discussion of turn taking at board games hints at how activity structure can affect collaboration. However, the bulk of analysis is focused on the particular difficulties of non-colocated collaboration as embodied and addressed by the ShareTable system.

Chipman *et al.* developed Tangible Flags [11], a mobile system in which children attach physical 'flags' to objects, and then attach notes to a flag via a tablet computer. Tangible Flags were evaluated in a nature-walk setting, with a park ranger supervising and adding prompts to each flag's attached notes. The idea of Tangible Flags is similar to and inspirational for our own tagging system, and one of our prototypes also involves creating a digital artifact. Chipman *et al.*'s brief discussion of flexibility and empowering children is also highly relevant, but considers only the particular design of Tangible Flags. We study a large assortment of activities, seeking to create a generalized framework for comparisons. We also emphasize interaction between adults and children, while adults take on a background, guiding role in Tangible Flags.

Mobile Stories, developed by Fails *et al.*, is a handheld system that allows children to work together to create a story as they explore their physical environment [13]. Our Scrapbook prototype is quite similar to Mobile Stories, and we likewise found participants to be particularly mobile during this creative activity. Mobile Stories is however a multi-device system, and the authors are largely concerned with how the effects of different UI modes for coordinating devices affect action within the same activity. Our work considers how choosing completely different activities may impact collaboration.

In The Hospital

Zora, a virtual world allowing users to chat and create an environment, has been the subject of numerous evaluations with hospitalized children [5,6]. By designing personal and public spaces, children were able to explore and share their values and identities, for example creating a world that avoided any mention of dialysis. Though CLS's and nurses have been involved in some of these evaluations, their participation is mentioned only in passing or consists of comments on children's use.

Benveniste *et al.* used Wiimotes to create a music therapy system for use at an intensive care center [4]. The system was effective at encouraging self-expression and identification. Comparisons to traditional music therapy are made, but not to other mediating activities. An interface allowing an adult therapist to control which instruments children control is mentioned. However, the role of the therapist in music therapy, and the interventions effects on that role, are left unexplored.

CHILD LIFE SPECIALISTS – HCI OPPORTUNITIES

When discussing our work, the authors generally must begin by explaining what exactly a CLS is. Most hospitals require specialists to be certified by the Child Life Council (thus a certified CLS or "CCLS") [26], a certification created in 1986. Child Life Specialists focus on psychological wellbeing, normalization, education and coping [19], and as such may be seen as complimentary to more clinically focused doctors and nurses. Hospitals have employed CLS's to help children manage pain and to reduce anxiety [1,10].

CLS's are experts at articulation work**:** work that orients and prepares actors and environments for collaboration. Bardram *et al.* have explored how physical and organizational articulation work, such as moving medical equipment or tracking surgeon schedules, allows the coordination and reconfiguration that drives the hospital [2,3]. The CLS job description emphasizes a smaller-scale, more intimate kind of articulation work: adapting to each individual child and family. A CLS must continually assess a child (and family's) developmental level, personality, and physical condition to identify and address problems. Specialists use this information to select appropriate activities, and to modify those activities on the fly. Introducing and participating in each activity requires further articulation work: describing activity goals, setting up equipment, and taking turns for example. CLS's are able to accomplish this work across the entire cast of children in the hospital. CLS expertise at performing this sort of articulation work means they are ideally suited to introduce new interventions to young patients. Further, thanks to their holistic approach to the child's experience at the hospital and with illness, specialists are likely to be in direct or indirect contact with almost any sort of intervention.

Finally, CLS reliance on activities means specialists offer an opportunity to explore mediating technologies for children and adults. An activity or system's design may be able to shape CLS-child interaction, perhaps by encouraging particular types of articulation work. This could lead to new systems that help CLS's counsel children. Studying how activities guide specialist encounters with children could also produce insights relevant to other environments where technology mediates between adult and child, such as the classroom and the home.

SYSTEM DESIGN – WORKING WITH CHILD LIFE

Early Work: The Interactive Storybook

Formative work in 2009 introduced the lead author to Child Life Specialists. Through interviews and focus groups with a diverse group of medical professionals, we created an interactive storybook built around a 'magic wand' metaphor. Children used a 'wand' to scan objects in their hospital environment, such as medical machinery or a doctor's nametag. Scanned objects were then incorporated into an ongoing story that was part journal, part educational text and part fantastical journey. While the magic wand metaphor had promise, the interactive storybook never made it past a Wizard of Oz implementation. Several lessons compelled us to reboot the magic wand project.

Our focus on CLS's as design partners and collaborators with children was born of the interactive storybook's struggles with complexity. Creating a custom, correct story for each child is a daunting task, even when scoping to a particular diagnosis. Aside from idiosyncratic medical treatments, children within even a narrow age range can have drastically different personalities and developmental levels. As previously mentioned, CLS's exist largely to address these differences, tailoring the services they provide to each child's 'story'. Instead of working with this existing expertise, the storybook attempted to reproduce and encapsulate it. Rather than competing with or replacing specialists, we resolved to create a tool to support them in their mission and leverage their articulation work expertise.

While we were still designing a system to comfort and educate hospitalized children, we now needed to unpack the CLS-child relationship. It quickly became clear that the storybook/journal design was overly complex for this purpose. However, specialists still favored the magic wand metaphor as a tool that would be easy to share, easy to clean, simple to understand and conducive to getting children out of bed. Thus, we set out to re-cloak the magic wand approach of scanning objects in a simpler system.

Target	Description
IV Pole	Holds bags of liquid for intravenous lines.
Monitor	Small screen, attaches to IV Poles and other equipment.
Blood Pressure Cuff	Typical inflatable cuff.
Nurse Whiteboard	Large board with nurse and doctor names, daily goals.
Bed Controls	Adjust position of bed, for use by child as well as adults.
Handwashing	Various foam and soap canisters, attached to walls.
PPD Box	Contains protection/isolation gowns, gloves and masks.
CLS Nametag	Badge with name and picture.

Table 1. Magic Wand Targets.

Spaceman and Scrapbook: Two Magic Wand Systems

We used an iterative, participatory design approach in our redesign. Researchers collaborated with Child Life through a walkthrough, two focus groups and informal emailing, eventually creating two distinct prototypes for evaluation.

To begin our redesign a CLS took the lead author on a walkthrough of a hospital floor, visiting the different types of rooms specialists interact with children in. Patient rooms and activity/play rooms were identified as the most likely places for extended CLS-child interaction. Triage rooms and treatment rooms are generally used for short periods, or when children are somehow incapacitated, and CLS's only intervene in special cases. One notable exception is dialysis treatment, where children must sit by a dialysis machine for several hours but are not generally sedated or distressed.

We also identified targets for the magic wand (see Table 1), particularly searching for targets that were present across rooms and floors, or that children frequently asked about. In total 7 targets were identified, including things like IV Poles and Disinfectant Foam, with CLS nametags added as an 8^{th} target. Child Life vetted target selections and descriptions over email, and at focus groups.

The first focus group, with 5 specialists, followed the walkthrough. Participants began by reviewing the selected target, and answering some priming questions on what children ask about these targets and the hospital in general. A sketching exercise followed, in which CLS's drew a picture of their ideal magic wand system and explained its function to the group. Some key design requirements arising from this focus group and our prior work with the interactive storybook are listed below.

- *Games* – According to our participants, games are critical to maintaining child interest beyond 5-10 minutes of novelty. One sketch depicted a scavenger-hunt, another a detective game where the wand took the form of a magnifying glass revealing secret clues.

- *Limited Information* – Scanning a tag should provide only a modest amount of information, allowing the CLS to elaborate as appropriate.
- *Cleanliness* – Every system component must withstand disinfecting after every use.
- *Synchronous Collaboration* –Due to issues with theft, mobile systems are not released/checked out without an accompanying CLS. Therefore, systems should be designed for synchronous rather than asynchronous use.
- *Privacy* – Materials are re-used and shared between different children and CLS's. No residual information or content should carry over.

From these requirements, the two designs described below were developed and refined in a second focus group. Both designs were implemented on Apple's iOS using an iPhone 4 with a water-resistant case that was easily disinfected. Tags for targets were laminated to allow disinfecting. For privacy, completely closing either prototype via iOS's multitasking menu erased all data and reset the application.

Spaceman

Our 'Spaceman' prototype (Figure 1) is built out of the first focus group's detective idea. As in the detective idea, the phone is used to view a 'hidden' graphic by hovering over a tag on an object. In this case, various space-themed objects such as planets and astronauts are displayed using ARToolworks' ARToolKit. A 'listen' button plays a short audio sound bite describing the target (e.g. IV Pole, Blood Pressure Cuff). Each target is attached to a unique graphic and message. By viewing a sufficient number of targets, users can unlock two reward games (one after 2 unique scans, the second after 4 scans). The first game is a Simon Says style memory game. The other is a simple tile puzzle.

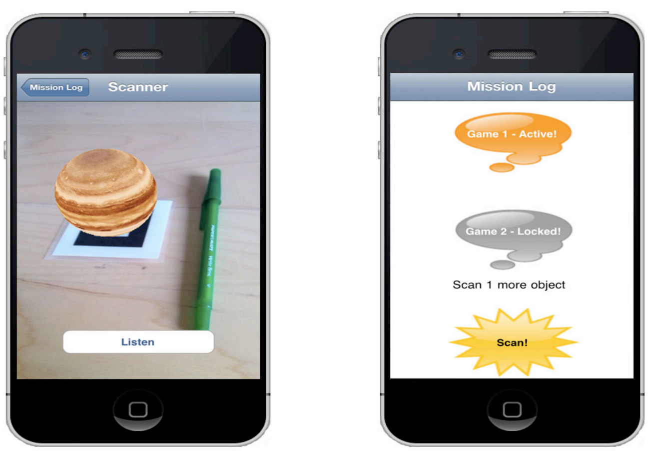

Figure 1. Spaceman prototype. The left image is viewing a tag and listen button. A pen is shown for scale. In the right image is a menu where users select from scanning tags or playing unlocked games.

Scrapbook

One focus group sketch described a sort of gift registry scan gun, allowing kids to scan targets and review them later. This thought loosely inspired the 'Scrapbook' prototype (Figure 2). During the second focus group, participants revealed that scrapbooking is already an activity employed by CLS's. With this prototype users construct a virtual scrapbook, adding new pages and selecting graphical themes for each page. Photos and audio can be recorded and added to a page, then graphically resized and rearranged. Scanning a target's tag adds a piece of audio describing that target to the current scrapbook page. This audio is identical to that used in the Spaceman prototype.

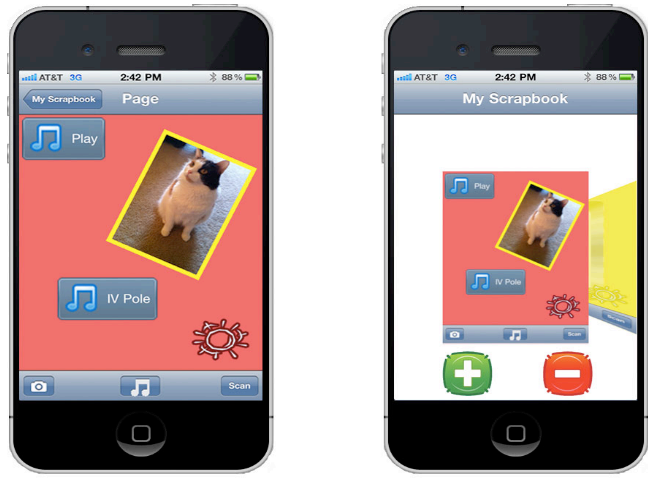

Figure 2. Scrapbook prototype. The left image shows a scrapbook page with a photo, audio, and audio from scanning a target (IV Pole). The image on the right displays the interface for moving between scrapbook pages or adding new pages.

Both prototypes met with acclaim from CLS's. The Spaceman prototype emphasized games, graphics and rewards, all highlighted by focus groups as important for engaging children. Meanwhile, the Scrapbook prototype preserved some of the most favored components of the old interactive storybook in a simpler package, such as content creation and an organic opportunity for reinforcement/review of information. Given the different characteristics of each prototype and our interest in studying CLS-child interaction as opposed to creating one 'best' system, we developed and evaluated both designs.

METHODS

By evaluating our prototypes and comparing against existing activities, we sought to explore the potential of mobile, ubiquitous systems to support CLS's working with children. Specifically, we wanted to compare the utility of each activity for rapport building, educating and empowering children, normalizing the hospital, and finally for having fun. We were also alert for unique interactions related to our prototypes.

We planned our evaluation in the spirit of a technology probe, with a few changes from a classic approach [15].

The stresses, interruptions and physical environment of a children's hospital would be impossible to reproduce in a lab. Thus, we emphasized realistic use, observing CLS's using our prototypes and traditional activities during their actual, everyday work with a wide range of children at the hospital. Researchers encouraged specialists to employ the prototype systems as they saw fit, rather than sticking to a set mode or order of use or aiming to exercise all functionality. Further, we focused our observations on the interpersonal events that activities engendered or affected, rather than on system usability. Our evaluation differs from traditional technology probes by eschewing logging; researcher observations and video were used instead.

Environment

Children's Healthcare of Atlanta's Egleston Hospital hosted all evaluations. Children and specialists organically determined the natural place for their interaction (and thus the evaluation) on a case-by-case basis. For the vast majority of our participants, this was in the patient's personal room. Patient rooms centered on an adjustable hospital bed along with a futon and several chairs, a bathroom with exterior sink, and varying medical equipment. Two participants chose public playrooms, while two others were confined to a semi-public dialysis area with curtains between patients. Several participants reached out through open doors to include the hallway in their evaluation, and one participant actually went on a short journey around their ward.

All CLS's at the hospital were eligible. Children at least 6 years old, prepared for an English-language interview and not incapacitated by treatment or illness was eligible.

Procedure

CLS's called researchers when they were ready to work with a child who met our simple criteria (6 years or older, not incapacitated). Prior to evaluations using a prototype, researchers gave specialists a brief refresher on functionality, and encouraged them to apply or not apply system components as seemed effective. CLS's and children both began their evaluation with an interview, built mostly around Likert-scale questions with 5 options. Questions dealt with children's familiarity with their specialist and the room, their comfort at home and at the hospital, and their computer use. Children also positioned pictures in order of their favorite activities.

After the interview, the CLS's and children used one of our prototypes or participated in a default activity. A researcher observed and filmed the activity in progress. For prototypes, a researcher quickly attached appropriate target tags throughout the room. Default activities represented ordinary CLS-child interactions, as if researchers were shadowing CLS's. In 2 of 6 cases, children were already playing a video game and the CLS joined in. In the other cases, CLS's offered children a choice between board, card and video games or artistic activities like painting or poetry. When either the CLS or child declared the activity over, researchers gave children an exit interview. This interview also relied on Likert-scale questions, and repeated several questions from the previous interview. Other questions focused on the children's experience with the activity. Finally, researchers gave the specialist an exit interview. This interview was Likert-scale based with a free-response section at the end, which was used to include emergent behavior from the evaluation. The interview asked CLS's to judge the efficacy of the activity along several dimensions, and to consider their relationship with the child.

RESULTS

18 children, 10 male and 6 female from 6 to 14 years old (average 9.9) participated in our study. A 19th participant felt too ill to complete their evaluation and is not included in our reporting. 9 CLS's, all female, participated. This was a highly varied group of children, both in and outpatients, with 10 different general diagnoses. These 18 pairs were split evenly into groups of 6 to evaluate either a prototype or to participate in a default activity. We refer to pairs by number and activity. For example 14-SM was the 14th pair, which used the Spaceman prototype, while 13-SB used the Scrapbook and 16-DA did a default activity.

Non-parametric statistical tests appropriate for ordinal data (e.g. Wilcoxon Signed-Ranks test, Mann-Whitney test) were employed to analyze repeated measures within the three groups (Spaceman prototype, Scrapbook prototype, Default) and compare across groups [18]. No statistically significant differences were found. Small sample sizes, particularly after splitting participants into groups, may have contributed to this result. The average and standard deviation for some selected questions are presented for descriptive purposes (see Tables 2 and 3). Taken as a whole, participating in any activity improved the CLS-child relationship as measured by a "how well do you know this child/CLS" question. Children and CLS's moved from an average of 2.89 to averages of 4 and 3.55 respectively, this result was significant ($p < 0.05$, Mann-Whitney test).

General Observations

Interruptions were extremely common (10 participants), ranging from quick adjustments to an IV to an hour-long conversation with a doctor (pair 9-SB). Interrupters included nurses, doctors, and family members. Some interrupters halted the activity, in these cases durable activity state like scrapbook pages was useful in re-starting the activity. Others allowed the activity to continue, or even participated in the activity themselves. The type of activity seemed to have some influence over how interruptions were handled; we cover this further in the discussion section.

In all groups, CLS's focused on offering choices to children. Default activities other than with children from pairs 11-DA and 7-DA (who were already involved with an activity when the CLS

Child Likert Scales - PRE	Average	SD
How often do you use videogames, computers and cell phones?	4.11	0.90
How comfortable are you at home?	4.29	0.67
How comfortable are you in this room?	3.56	0.78
How well do you know this CLS?	2.89	1.53
CLS Likert Scales - PRE	**Average**	**SD**
How well do you know this child?	2.89	1.49
How familiar is the child with this room?	3.89	1.11

Table 2. PRE-Activity Likert scales were from 1-5, with 5 corresponding to "Very Often, Very Well" etc.

entered the room) began with CLS's offering a selection of games and projects. Within an activity, CLS's worked to highlight opportunities for children to make choices. Different activities offered different choice opportunities or 'control outlets' as termed by CLS from pairs 8-SB and 17-SM. For example, during card and board games, CLS's would ask kids what rules they used. During art activities, CLS's offered different materials to children, and asked kids for suggestions on what to craft themselves. With both prototypes, CLS's continually asked children what to scan next.

Finally, children and CLS's showed a drive to complete activities. Default activities, with the exception of one crafting activity, ended only after a game or project was finished. Pairs using both prototypes were interested in complete scanning: all 12 pairs scanned every available target. Children in pairs 10-SM and 12-SM asked observing researchers for additional tags to scan. The CLS in 12-SB suggested children might be conditioned to complete activities at school and at the hospital, or to following mandatory directions from hospital staff. Researchers were careful to emphasize the voluntary nature of the study, but only a single child withdrew mid-evaluation.

Prototypes: Tags and Scanning

The mobile, tag-scanning element of the prototypes was very effective at getting kids out of bed and moving around. Out of 12 participants, 7 moved around the environment to scan tags. No children participating in default activities, all of which were table or screen-based, moved around their room, this difference was statistically significant ($p < 0.05$, Mann-Whitney test). Further, 4 of the mobile children began the activity in bed attached to IV's or other equipment, and did not initially choose to get up. Using the prototypes, CLS's were able to coax them to their feet.

When children were physically unable to move, such as when they were undergoing dialysis, or had not yet been drawn out of bed, CLS's employed a 'proxy scanning' technique. After asking children what to scan next, the specialist would take the phone and access a tag, and then return the phone to the child for viewing. CLS's in pairs 1-SM, 13-SB and 18-SM went one step further, detaching indicated tags from objects and bringing them to the child, keeping the child in control of the phone at all times.

CLS's were eager to give physical control of the phone to the child. For example, most patients kept the lights in their room off, making some tags difficult to scan with the limited sensitivity of the iPhone's camera. When a child needed assistance with one of these tags, CLS's preferred helping by positioning the phone by physically guiding the child, resorting back to 'proxy scanning' and taking the phone themselves only when necessary.

Spaceman Prototype

During the design process, two games were added to the Spaceman prototype as 'rewards' for scanning tags. However pairs 6-SM, 17-SM and 18-SM, fully half the participants who used this prototype, did not even bother to open the games, despite prompting from the CLS. It appears that the scanning activity and AR graphics, along with the previously mentioned drive for activity completion that was observed, were motivation enough.

Though evaluations were not explicitly timed, sessions with the Spaceman prototype were generally quite rapid. Only pairs 1-SM and 10-SM, where children fixated on completing the puzzle reward game, spent any significant time with the prototype after scanning was complete.

	Spaceman		Scrapbook		Default	
Child Likert Scales - POST	**Average**	**SD**	**Average**	**SD**	**Average**	**SD**
Was the activity fun? (Smileyometer)	3.50	1.05	4.33	0.82	4.17	0.75
Did you feel like you were part of the activity? Were you important?	3.67	0.82	3.5	1.52	3.50	0.84
Did you feel like you were in charge? Did you help lead the activity?	3.17	1.17	4.50	0.55	3.00	1.26
CLS Likert Scales - POST	**Average**	**SD**	**Average**	**SD**	**Average**	**SD**
How often did the child take the lead or initiate part of the activity?	3.50	1.05	3.83	1.17	3.50	1.05
How effective was the activity at strengthening your relationship?	3.33	0.82	3.83	0.75	4.33	0.82

Table 3. POST-Activity Likert scales were from 1-5, with 5 corresponding to "Very Often, Very Well" etc.

Scrapbook Prototype

Conversely, evaluations using the scrapbook tended to have a long duration, as children greatly enjoyed taking photos and audio recordings. CLS's were able to keep the activity moving by suggesting new people and objects to capture. We originally expected children to take pictures of tagged objects to match with the audio recording attached to the tag. Though one pair did exhibit this behavior, people were the most common recording target.

Recorded messages or photos were a catalyst for conversations. Generally, children wanted to share their photo or message with the recorded party immediately after recording. Children in half of the evaluations (8-SB, 13-SB and 19-SB) took secret 'spy' recordings of others, sharing them after recording as a surprise, or sharing them only with confederates (e.g., the CLS).

Default Activities

Significant periods of silence marked 4 of the 6 default activities, either children or CLS's and children both focused on an individual-centric project.

Two pairs played video games that the children were already involved with when the CLS and researcher arrived; a racing and a shooting game. Both were single-player games, and CLS-child interaction was very distracted even when the specialist took a turn at playing the shooter game. While children 'zoned-in' on the game, parents made small talk with the CLS and occasionally attempted to goad a response out of the child. In both cases, this revealed that the games were related to other interests of the children (outdoor activities and archery, respectively), but this did not lead to any further conversation with the child.

Two other pairs did artistic activities; painting and a craft with beads. CLS-child interaction in this case was slightly more active, but still marked by silences as each party worked on their own craft. No parent was present during the painting, but the parent during bead crafting took a similar approach to parents present during video games, talking directly to the CLS and occasionally prodding the child.

The last two pairs had more animated interactions. One pair played the chance-based board game Candyland, in which players compete to reach the finish first but do not directly affect each other. Turns in Candyland are only a few seconds long, meaning players are constantly reacting to new game states. The child and CLS were in near-constant conversation, commenting on the results of each turn, and a crowd of parents and relatives also chimed in. The second pair played Uno, a competitive card game. Turns were again rapid, and the specialist and child again had a constant conversation centered on the outcome of each turn. Playful negotiation of the game's rules was also part of the conversation, and an interrupting nurse once arbitrated.

DISCUSSION

The activity-based interactions we observed may be classified along a continuum from *Co-present* to *Collaborative*. We describe this means of characterizing activity-based interactions, and then highlight key structural components present across each type of activity.

Collaborative vs Co-Present

Collaborative activities are filled with interaction between participants. While engaged in a collaborative activity, such as the Scrapbook prototype, children and CLS's have continuous conversation. Interrupters are generally included in the activity in some way, for example shuffling cards for Uno or posing for a Scrapbook photo. Actions that affect the progress of the activity, such as playing a card in Uno or taking a photo for the Scrapbook, impact not only the actor but other participants as well. Uno, Candyland, and the Scrapbook prototype were collaborative.

Co-present activities on the other hand do not require working with a collaborator to proceed. In our evaluations they were marked by long periods of silence when participants focused in on performing the activity. Co-present activities seem to encourage interruptions that don't seek inclusion in the activity. Pairs 16-DA, 11-DA, 7-DA and 3-DA all participated in co-present activities. For each of 16, 11 and 7, an observing parent used a silent period to initiate a side conversation with the CLS (no parents were present during 3-DA's evaluation). Painting, crafting and single player videogames are all co-present activities.

The Spaceman prototype offers an example of an activity in the middle of the continuum, with both collaborative and co-present components. Brief interactions occurred after a tag was scanned. The speed with which tags were scanned and thus new collaborative interactions began meant few prolonged silences. Further, when interrupted (only 10-SM), the interrupter sought to participate, pointing out additional tags. However, participants never spent much time discussing a tag, and the feeling of an ongoing conversation never developed. The two pairs that spent much time with the unlockable reward games exhibited extremely co-present characteristics, with children focused on the game and CLS's watching from the sidelines.

Key Components of Activity-Based Interactions

Certain structural elements of activity-based interactions are key for determining whether the activity tends towards the collaborative or co-present end of the continuum.

Control Outlets – Inward and Outward Facing

CLS's continually offer children choices or 'control outlets', such as which activity to do or which arm to use for a shot, to promote feelings of control and security. Activities are filled with control outlets: which color to paint with, which tag to scan next, what to photograph. We categorize outlets as 'inward facing' or 'outward facing'.

Inward facing control outlets impact only the activity, not the external environment or other actors. Choosing a paint color or selecting a tag to scan are both inward-facing control outlets. Playing a video game is generally a long series of inward facing control outlets. These sorts of choices draw attention to the activity itself, and away from interactions with collaborators. Co-present activities tend to be dominated by inward facing control outlets.

Outward facing control outlets affect not only the activity, but impact the physical environment or other actors as well. Choosing the rules of a game or taking a photo of someone are outward facing control outlets. Making a move in a competitive card game is an outward facing control outlet. These sorts of choices draw attention towards the environment and collaborators, encouraging interaction and responses from affected parties. Collaborative activities tend to be dominated by outward facing control outlets.

Physical Totems of Control

Each evaluated system had some physical totem that allowed control over the activity. Collaborative activities generally shared these totems, which were catalysts for interaction. Examples include board game pieces and playing cards. With our prototypes, the phone was passed back and forth or over-the-shoulder collaboration was used. When proxy scanning with the Scrapbook prototype, CLS's would return the phone to the child after a scan, allowing them to interact with the added audio piece.

Co-present activities lacked these shared totems or had difficulty sharing them. The art activities provided each actor with his or her own totem (art supplies), removing any need to share. With single player video games, the lone totem (the controller) was not passed back and forth but exchanged for long periods of timed, clearly demarcating who was driving the activity and who no longer had input.

State

Activity-based interactions function as state for CLS's and children. All activities we evaluated had some obvious state, such as a board game's board, a video game's monitor or our prototype's tags. Activities rely on easily sharable state to orient the interactions of participants. Examples include sharing completed pages in the Scrapbook, reacting to a card in Uno or guiding a child to the next tag in either prototype.

Collaborative and co-present activities tend to rely on different types of state. Co-present activities often emphasize state that may be easily sharable, but is not easily modifiable by more than one person. Consider again a single-player video game with only one controller or personal art projects. One may easily comment on the game action or a partner's painting, but may not easily affect the game or painting directly. On the other hand, collaborative activities include state that multiple participants affect, such as a game board or a scrapbook audio recording.

Aside from physical state, each activity-based interaction is itself a kind of state that CLS's and children are able to reference and return to. This was evident in our evaluations of default activities, many of which had been performed previously by the CLS-child pair. For example, subject 3 had painted with their CLS previously and jumped right into painting, even though she was starting a completely new picture. By choosing a familiar activity, participants are signing up for familiar collaborators, context and actions. Repetition in this fashion can be useful for rapport building with children, creating a comfort zone.

Handling Interruptions

As mentioned, the majority of evaluations were interrupted at some point by either a parent or a medical professional. The frequency of interruptions in the hospital, and recovering from them via system state, are known (e.g. [7]).

A more fluid way thinking about interruptions is seeking to include the interrupter in the activity. Co-present activities tended to encourage superficial comments (e.g., "that's a nice painting"), or even led interrupters to completely ignore an activity. This was the case with pairs 16-DA, 11-DA and 7-DA, in which parents had side conversations with the CLS. Collaborative activities allowed more meaningful contributions, such as shuffling a deck of cards. Some of the most seamless interruption handling was observed with the Scrapbook prototype, via audio and video recording of interrupters and sharing of Scrapbook pages. This was the only activity that led to participants effectively seeking out interruptions, looking for others to involve in the activity.

Comparing Activities

Activities that seem very similar on the surface may have very different characteristics and capabilities. Contrasting our two prototypes, both of which are based on the same 'magic wand' metaphor, is illustrative of this and of the interrelations between characteristics.

Spaceman

The Spaceman prototype seemed reasonably accessible to children (refer back to Tables 2 and 3), but was less effective than other activities at promoting and sustaining CLS-child interaction. It seemed to be more *co-present*, though some *collaborative* elements are discernable.

- Spaceman had few *control outlets*: tags were already distributed throughout the room, and reward games were already set. Existing outlets, such as choosing targets and playing a reward game, were *inward facing*.
- Activity *state* was difficult to share via graphics on a small screen, which further required appropriate positioning with respect to a tag. Modifying state, that is playing a game or viewing a new tag, was only an option for the participant in control of the iPhone. However after each tag was scanned, CLS's and children generally engaged in a quick verbal interaction discussing the tag and selecting the next target.

- Simultaneous use of the *physical control totem*, the iPhone, was limited to semi-effective over-the-shoulder help. The actor without the phone was usually reduced to sitting and waiting, or commenting on audio bits.
- Only one *interruption* was observed: the interrupter (a hospital volunteer) suggested which tag the child should scan next. There seemed to be little capability to include an interrupter in the activity in a more significant way, given the previously described difficulty in sharing activity state or the iPhone itself.

Scrapbook
The Scrapbook prototype was quite effective at promoting and sustaining CLS-child interaction, with some sessions lasting as long as an hour. CLS's reported this was significantly longer than typical sessions with a child. A *collaborative* activity, Scrapbook sessions were generally quite lively.

- The Scrapbook had more *control outlets* present via creating, themeing and organizing pages. Scanned objects could now be positioned on a page or placed with a photograph, rather than simply viewed. Further, *outward-facing* control outlets were present through the Scrapbooks photo and audio capture capabilities. Most children took pictures of the CLS, parents and medical professionals, sometimes posing them. The child in 8-SB wanted everyone present, including researchers, to record messages. Pairs 8-SB, 9-SB and 13-SB took surreptitious 'spy' photo or audio recordings of staff or parents, with 13 actually stalking nurses through the hallway.
- Activity *state* was easy to share by passing the phone, since unlike the Spaceman prototype no positioning for AR trackers was required. Further, scanning a tag or taking a recording produced a persistent change for any participant to review. It was easy for participants to understand what was going on when photos or video were being recorded. By posing or making noises, recording subjects were able to affect system state.
- Sharing the *physical control totem*, the iPhone, was commonplace. Photo and audio recording always produced an interaction, usually sharing the iPhone for the record-ee to review and comment on the Scrapbook. The iPhone was rapidly passed back and forth or held by both participants in these cases, as opposed to being relinquished while an actor faded to the background.
- Participants actively sought out others to record for their scrapbook. Rather than acting as *interrupters*, these subjects became fellow participants.

Designing Activity-Based Interactions
Consideration of components like *control outlets, state, physical control totems* and resources for handling *interruptions* could help intervention designers tailor their activity to be more *co-present* or more *collaborative*. Existing activities could also be tuned.

The Spaceman prototype, for example, could be shifted towards the collaborative end of the spectrum. It was difficult for Spaceman participants to share the single control totem (the iPhone). A totem with a larger screen, such as a tablet, may be easier to share. More outward facing control outlets could also be added, perhaps by allowing users to place their own tags and attach messages. A more collaborative activity will tend to encourage a livelier, conversation-filled interaction.

Co-present activities may have their own uses. Pair 16-DA participated in a co-present arts and crafts activity. The CLS in this pair mentioned that this child was very shy, and relied on her mother for a sense of security and also to lead conversations. The co-present craft activity's silent periods led to conversations with the mother, who was able to reveal some of the child's interests and provoke some longer responses. A co-present activity may be useful for building rapport with a shy child or their parents, before attempting a more collaborative activity.

Our Scrapbook prototype could include more co-present elements to support these goals. Rather than revolving around a single shared physical totem, a second iPhone could be incorporated. A linked Scrapbook, shared across phones, could allow participants to work collaboratively on one page or co-presently on separate pages. More inward facing control outlets, such as static 'stickers' to add to pages, could also be added.

CONCLUSION
Our Activity-Based Interactions framework can be applied to design new mediating activities for CLS's. We showed how seemingly similar activities like our two prototypes could lead to quite different adult-child interactions, and used ABI to describe subtle differences in our prototypes. ABI can inform the design of new activities, creating systems that encourage co-presence or collaboration as necessary.

An extension of ABI to consider activities that shift between collaborative and co-present could prove interesting. Our Spaceman prototype already exhibited characteristics of both activity types. It may be possible to create an activity that participants can shift towards collaborative or co-present on a whim. CLS's could for example use such a 'dual' activity to move from collaborative to co-present if they needed to engage with a parent. Children could also have input on an activity, perhaps moving into a mode that encouraged collaboration once they reach a certain comfort level with their specialist.

ABI may also apply to contexts outside the hospital. Adult-child activities are present in the classroom, at home, in the museum and on the playground. This means ABI has the potential to offer insight on the design of a broad array of activities, from a tutor teaching a child sign language to a parent playing a musical instrument with their child. Future work could explore whether co-present and collaborative are sensible terms in these contexts, and study whether components like control outlets, physical control totems and state have the same influence as in CLS-child interactions. Observing larger numbers of interactions and refining questionnaires to more directly address ABI constructs will be key in validating ABI in other contexts.

Finally, this paper highlights the potential of working with Child Life Specialists. Because of their skill at performing articulation work to adjust to children and families, CLS's were able to successfully collaborate with a variety kids across many activities, including our prototypes. Researchers would be wise to consult with CLS's when designing any child-facing intervention in the hospital.

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