Robot Characters for Innovative Medical Eye Exams in Kids

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Figure 1. Robot OCT Character named "Cory" 1/1 scale prototype assembled on KUKA Arm Robot.

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ABSTRACT

We contribute to new design directions towards robots that can socially engage with pediatric patients while imaging their eyes reliably. Eye imaging is essential to diagnose and manage ocular diseases, but practically impossible to conduct due to children's fear and aversion during the exam. Pediatric patients frequently require an exam under anesthesia, adding significant medical risk, stress, delay, and cost of care. We explored the design space of character design for an eye-imaging robot system to make eye exams more fun for children. Using contextual inquiry, we collected needs from stakeholders around eye exams, leading to the understanding of pain points. We then conducted design explorations of robot characters that could mitigate negative effects while amplifying moments of fun for pediatric patients. We built two low-fidelity robot characters and showed them to stakeholders. Our research highlights the need for these approachable characters to realize eye exams in pediatric patients with engagement.

Authors Keywords

Human-robot interaction; medical robotics; pediatric patients; design research

CSS Concepts
Human-centered computing~Interaction devices

INTRODUCTION

Eye imaging in pediatric patients is notoriously difficult and, for quantitative high-resolution modalities like optical coherence tomography (OCT), practically impossible. High-quality eye imaging with OCT is essential for screening, diagnosis, and management of pediatric ocular diseases. Patient participation and cooperation are necessary for successful imaging since the patient must gaze into the imaging instrument, follow a fixation target, and hold still for several minutes for a high-quality OCT exam. During an OCT exam, even the smallest misalignments or movements of the eye produce signal loss or corrupt images with motion artifact. For pediatric patients, age-appropriate fear and aversion responses limit cooperation, and thus participation, in clinical imaging. Consequently, such patients frequently require an exam under anesthesia in the operating room, which adds significant systemic medical risk, stress, delay, and cost to care.

In this work, we explored the design space for a child-friendly OCT system, much needed for pediatric ophthalmologists and their young patients to capture in-clinic eye images. By conducting design research with stakeholders (medical doctors, technical clinic staff, and parents of pediatric patients), we derived design explorations for a character to be implemented in a robot OCT system (Figure 1).

RELATED WORK

Relevance of OCT Exams

In ophthalmology clinics, OCT exams are especially helpful in diagnosing and identifying ocular diseases (Figure 2). OCT has revolutionized eye care in the last two decades and is now routinely obtained in many ophthalmology clinics. It can identify pathology in the retina that may not be detectable by other procedures and therefore provides valuable information in the diagnosis and management of many retinal diseases.

OCT has provided valuable insight on several key pediatric retinal diseases, including retinopathy of prematurity (ROP) [13]. In another study, cystoid spaces in patients with ROP during infancy were found to be predictive of visual and neurodevelopmental outcomes [21]. Through OCT, we have a greater understanding of anomalies, such as the delay in photoreceptor inner and outer segment growth in preterm infants from 23 to 31 weeks of gestational age [12]. In the potentially life-threatening disease of retinoblastoma, OCT has been important in detecting small lesions otherwise missed on clinical examination and the ability to follow macular lesions longitudinally to assess response to treatment [13], [14]. OCT data can also be valuable in providing normative data in children which is often lacking compared to the adult population [18].

There is a need to develop a cost-effective and reliable OCT tool with excellent diagnostic capabilities that can promote patient cooperation. Such a device can improve access to care allowing screening of more pediatric patients to identify and treat pediatric eye diseases, helping to reduce childhood visual impairment and blindness.

Figure 2. Adult patient during an OCT scanning. Hand belongs to the technician.

Figure 3. Tabletop OCT.

Barriers to OCT Exams

Tabletop OCT, which is the most widely used type of OCT system, requires positioning at the device height and maintaining fixation on a target (Figures 2 and 3). This can be very challenging or near impossible in young children and infants. Handheld OCT was developed for its use in children [19]. However, these may require contact with the eye. In patients with ROP, infants still demonstrated a stress response with OCT exam although less than during binocular ophthalmoscopy [1]. Another limitation is that these devices require a trained operator and since the COVID pandemic, staffing shortages have been a challenge in many clinics and hospitals. Furthermore, to obtain good-quality OCT images, an exam under anesthesia may be required, leading to systemic risks discussed earlier.

Pediatric eye diseases can lead to permanent blindness if they are not detected and managed promptly. There are significant challenges in screening children. First, some children cannot verbally express vision changes due to their young age or other conditions that delay evaluation if there are no outward ocular abnormalities [10]. Second, children are usually screened for eye diseases by their pediatrician or school using tools that can miss pathology [19]. Third, patient cooperation during eye exams is challenging in children for several reasons including fear, lack of understanding, and photosensitivity [1]. This can make it difficult for ophthalmologists to obtain good views of the eye to accurately diagnose and treat the patient's condition. In this work, we provide design exploration of physical prototypes that address patient cooperation.

Figure 4. Child-friendly tools to encourage pediatric patient cooperation. Pictures taken at W. K. Kellogg Eye Center, Michigan Medicine by the research team. **(A)** mutlicolored lights, **(B)** small animal toys that you can place on the finger, **(C)** popsicle sticks with animals, **(D)** fixation target of a green star placed on the walls of the clinic room.

Child-Friendly Tools for Patient Cooperation During OCT Exams

During an eye examination, ophthalmologists may need the child to fixate on a distant or near target or assess extraocular movements. There are several child-friendly tools to try to encourage patient cooperation (examples on Figure 4). These techniques are only partially successful. Some children will resist the eye exam, tightly squeezing their eyes closed and sometimes even kicking or punching the examiners. In cases where OCT exams are unable to be performed, the child may need an exam under anesthesia in which they will be subject to systemic risks of general anesthesia. Alternatively, if parents do not consent to an exam under anesthesia, pediatric patients go undiagnosed, worsening the condition.

Robotic OCT

The robotic OCT system we introduce here was developed by this team [27], [28] for ophthalmic imaging. It is a unique instrument that offers easy transportation in clinical environments, automated alignment and imaging, and minimal patient adjustment. It consists of a robotic arm with an OCT scanner attached to the end effector, a motorized vertical lift connected to the base, and a cart housing all necessary components for system operation (Figure 5). The robotic arm is mounted on a motorized vertical lift for anoptimized imaging workspace and easy adjustment to reach over furniture such as bedrails. Despite the innovation of a robotic OCT, this system is still problematic to use with pediatric patients as its large dimensions and "cold medical appearance" cause fear and reduce cooperation. In this work, we focus on the design of characters for the robotic OCT system that can promote patient cooperation by applying interaction strategies that are friendly to children.

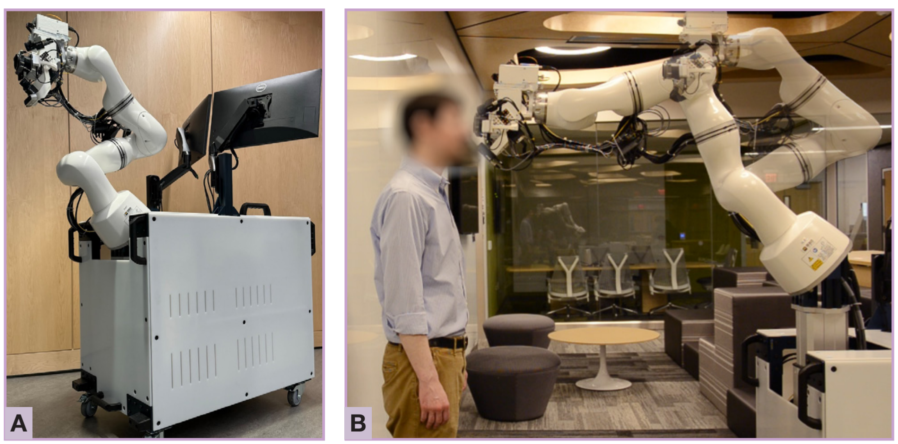


Figure 5. (A) Robot OCT System composed of a KUKA arm with an OCT scanner attached to the end effector, a motorized vertical lift connected to the base, and a cart housing all necessary components for system operation. **(B)** Adult patient during Robotic OCT scanning.

Robot Characters in Hospitals

For many children, visiting the hospital and engaging in tasks such as performing an OCT exam can lead to a state of increased anxiety [3], [7]. Interactive robot characters have been introduced as a possible tool in hospital and clinic settings to reduce negative emotions [9]. Robot characters are created to have an artificial personality that enables them to intelligently and socially sense and respond to humans, communicating with them through movement, sound, and natural language, while having an approachable embodiment [4], [6], [15], [17]. This multifactorial sensory experience is known to be an effective form of intervention for distracting children from stressful and anxiety-driven situations, thus decreasing negative experiences in healthcare settings [2], [8]. A few ways in which robot characters have previously engaged with children in healthcare settings are through music, games, and conversations [15]. Child-friendly robotic features that reduce negative emotions are distributed on three axes: (i) robot embodiment: how the robot looks and feels to children. Ideal features enable safe contact with robots such as soft material coverings [4], [5], [17] and robots shaped like animals, or creatures that are visually appealing to children [20]; (ii) robot behavior: how a robot character is designed to engage with children. Ideal behaviors include the expression of emotions using sounds, lights, and movements [16]; and (iii) activities: activities that the robot performs with children. Increased engagement tends to happen in storytelling [11] and gamification [15]. In this work, we explore the design of robot characters as a new tool for OCT screening of pediatric patients.

PROBLEM SPACE

What character design principles for a robot OCT system can promote pediatric cooperation and stakeholders acceptance?

AUTHORS' POSITIONALITY

This is an interdisciplinary study whose authors come from the fields of Medicine, Robotics, Information, and Architecture. They have domain expertise with ophthalmology, pediatric patients, and with the design of interactive technologies. This familiarity informs their reflections of the observations collected during this work and the insights derived.

STUDY 1: NEED FINDING WITH CAREGIVERS, DOCTORS, AND TECHNICIANS

Sample

Participants included one ophthalmologist, one OCT technician, and four caregivers of pediatric patients. Participants were recruited through random sampling at a pediatric ophthalmology clinic, representing key stakeholders in the pediatric OCT process. This study was approved by the University of Michigan IRB #HUM00264759. [Link for the protocol of Study 1.]

Procedure

Interview with Ophthalmologist

Ophthalmologist who has experience performing OCT eye exams was asked to complete an open ended interview to hear their perspective on OCT exams. Interview questions highlight aspects that work well in the current process, uncover pain points and frustrations, and unveil the impact of current strategies. Responses were recorded for descriptive analyses.

Contextual Inquiry and Observation with Doctors and Technicians

Contextual inquiry and observation was conducted on-site to witness the OCT exam process firsthand [22]. The observation involved interacting with a technician responsible for running the exams, allowing for an in-depth understanding of the strategies employed to ensure successful completion of the OCT exam by patients. This contextual inquiry provided insight into operational challenges and the practical approaches used in the exam room environment. Learnings were recorded for descriptive analyses.

Interview with Caregivers

Adult caregivers whose child had experienced an OCT eye exam in the past were asked to complete an open ended interview to elicit their perspectives on their experience with pediatric OCT exams. Interview questions were categorized by pre-exam, during exam, post-exam, and overall experience. Responses were recorded for descriptive analyses.

Analysis

Data from interviews and observations were thematically analyzed to identify patterns and challenges [23]. Themes such as engagement, environmental stressors, and communication gaps informed the creation of user personas and journey maps, guiding character-driven design decisions.

Results

The results show stakeholders' pain points during OCT exams, see Figure 6.

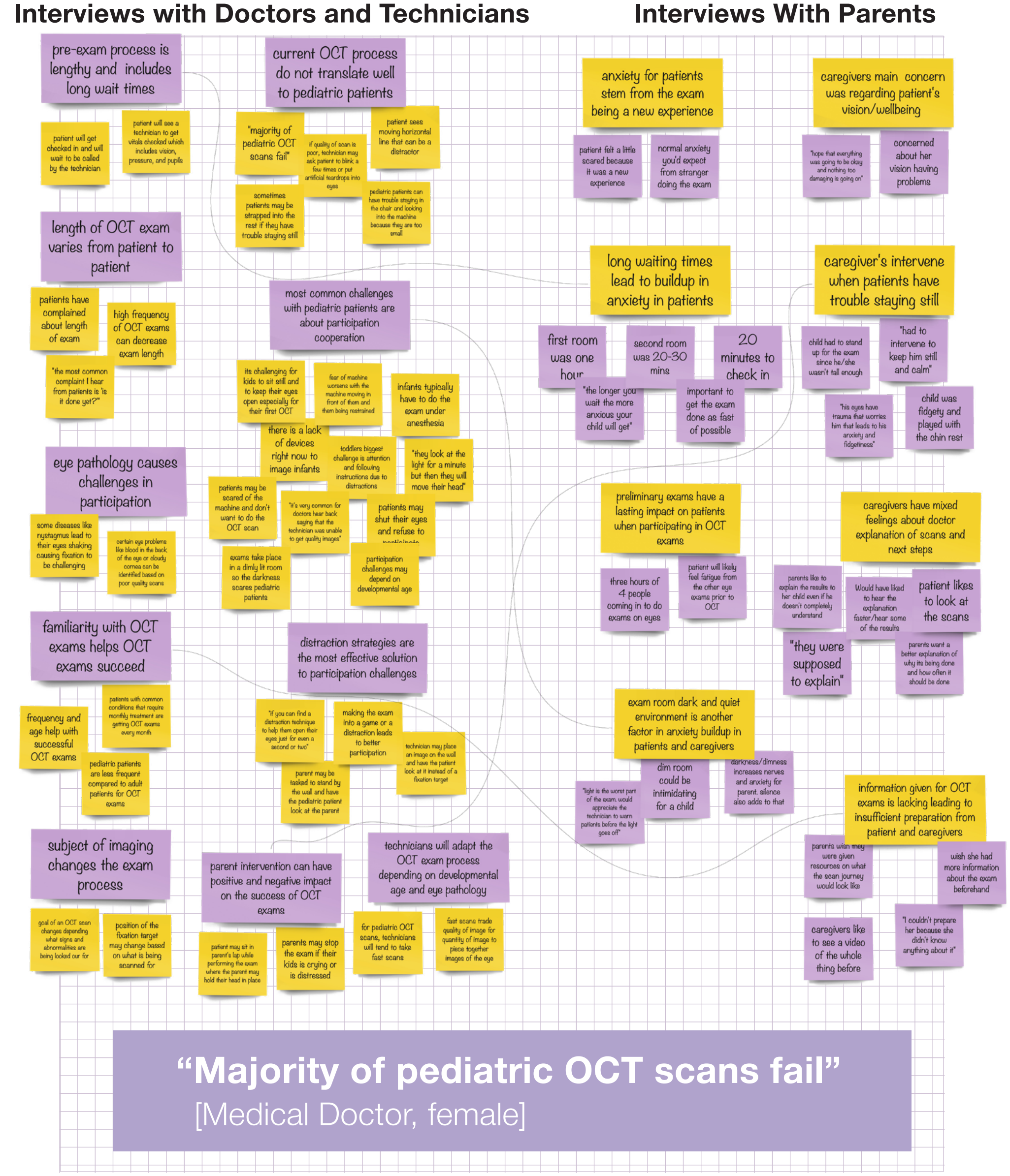
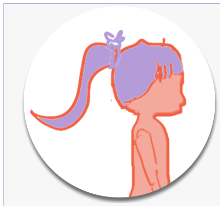


Figure 6. Thematic analysis of the pain points during pediatric OCT scanning adressed in Study 1 with technicians, doctors and caregivers.

PEDIATRIC PATIENT PERSONAS

We created two personas [24], Jackson and Abby, to represent two common cooperation problems in pediatric patients during a traditional OCT exam. The personas were derived from the interviews with stakeholders in Study 1.

ABBY



"Mom, I'm scared"

DEVELOPMENTAL AGE 6
FREQUENCY First Visit
VISUAL IMPAIRMENT None
PURPOSE OF VISIT Diagnosis

TIMID · STRESSED · WORRIED · ANXIOUS

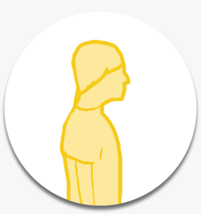
GOALS
- Leave the doctor's office and finish exam quickly
- Keep a comfortable distance from scary machines or tools
- Feel safe even in an unfamiliar environment

PAIN POINTS
- Difficulty staying still from restlessness or discomfort especially when the robot approaches
- Confused and overwhelmed by the instructions given by the robot
- Easily upset or startled by mechanical noises or sudden movements from the robot

NEEDS
- Reassurance and comfort from a trusted individual like parents.
- Familiarity with the robot to make future visits easier.
- Rewards and recognition for her bravery while interacting with the robot.

ADDITIONAL RELEVANT NOTES
- Afraid of robots/machines especially when they are moving towards her

JACKSON



"This is so boring"

DEVELOPMENTAL AGE 10
FREQUENCY Monthly
VISUAL IMPAIRMENT Neuropathy
PURPOSE OF VISIT Follow-Up

EXPLORATIVE · IMAGINATIVE · CURIOUS · ENERGETIC

GOALS
- Get through the exam quickly and easily
- Avoid boredom or frustration
- Experience encouragement and recognition for following instructions

PAIN POINTS
- The need to remain still or hold a position for several seconds can feel overwhelming
- Long exams or repeated attempts may cause loss in focus and induce restlessness
- Difficulty seeing fixation targets and focusing on tasks

NEEDS
- Flexible structure and small breaks to prevent restlessness
- Engagement through interactive and playful tasks
- Sensitivity to visual limitations that come with optic neuropathy

ADDITIONAL RELEVANT NOTES
- Diagnosed with ADHD - symptoms of hyperactivity and inattention

STORYBOARD: TRADITIONAL SCANNING

This storyboard showcases a traditional OCT scanning eye exam on Jackson, a pediatric patient. One of the major pain points in traditional OCT is the low cooperation of kids while performing the exam. This frequently leads to exams under anesthesia with increased health risks or undiagnosed eye conditions.

Speech bubble · Thought bubble · Jackson · The technician · Pain point · Solution moment · Jackson's caregiver

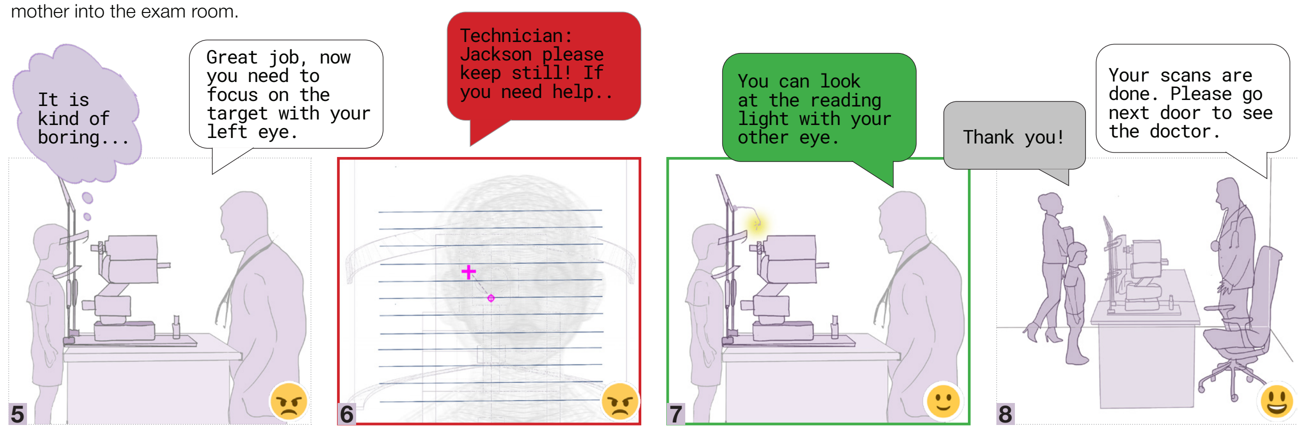
Glad · Bored · Neutral

1 *waiting room*
Jackson has an OCT exam. He took preliminary exams before this OCT, and he has been in the waiting area with his mother for an hour. The technician calls Jackson and his mother into the exam room.

2 *exam room*
The technician introduces himself and explains how the exam will run.

3 *exam room*
The technician instructs Jackson to place his forehead and chin on the rests and to state his name and date of birth for verification.

4 *exam room*
The technician instructs Jackson to focus his right eye on the fixation target and hold that position for 5-10 seconds.



5 *exam room*
Jackson succesfully completes the exam on his right eye. The technician instructs Jackson to follow the same steps for his left eye.

6 *exam room*
Jackson has difficulty maintaining his focus on the fixation target.

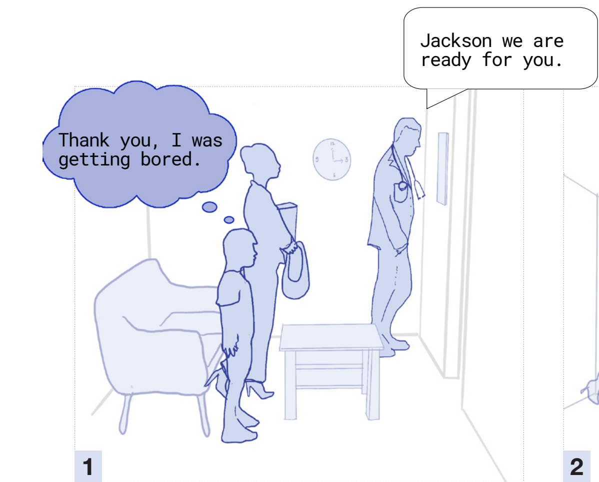
7 *exam room*
The technician instructs Jackson to focus on the fixation target with his opposite eye.

8 *exam room*
Jackson completes the OCT exam and the technician guides them to another exam room where a doctor comes in, introduces themselves, and begins looking at the scans.

STORYBOARD: ROBOT OCT

This storyboard showcases a robot performing an OCT scanning eye exam on Jackson. While robotics PCT enables tracking the patient's eye and having them stand in a more posture than in a traditional OCT, kids' cooperation during the scanning is still low due to fear of a "big robot".

Speech bubble | Thought bubble | Jackson | The technician | Pain point | Solution moment | Jackson's caregiver

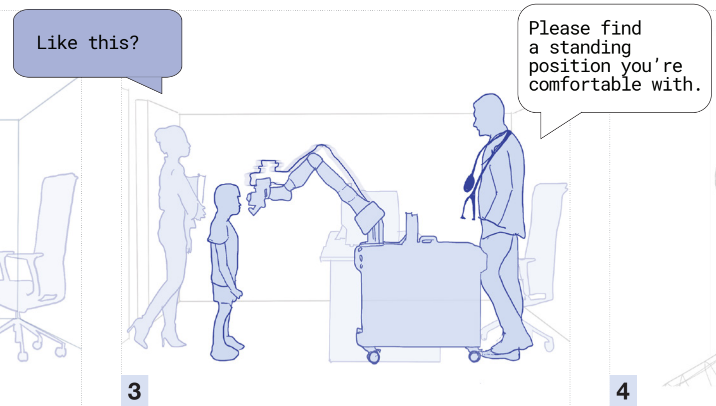


waiting room

Jackson has an OCT exam. He took preliminary exams before his OCT, and he has been in the waiting area with his mother for an hour. The technician calls Jackson and his mother into the exam room.

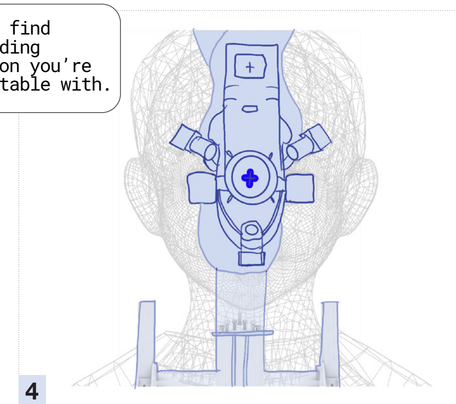
exam room

The technician introduces himself and explains how the exam will run with the Robot OCT.



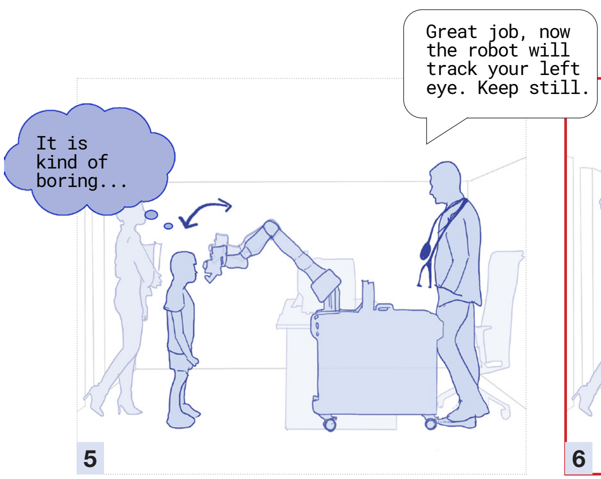
exam room

The technician instructs Jackson to stand still and find a comfortable position for the exam to begin.



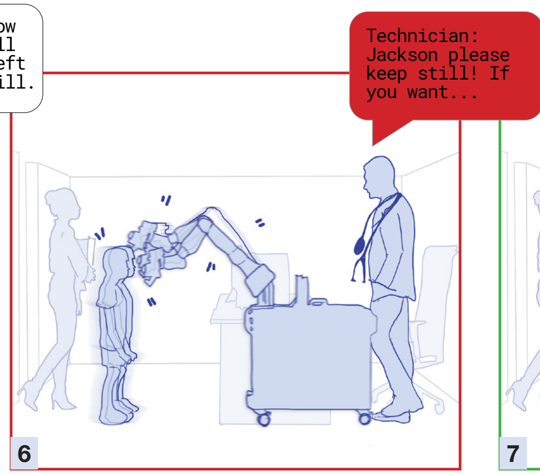
exam room

The technician instructs Jackson to focus his right eye to the middle point of the Robot lens placed at the end of the arm target and hold that position for 15 seconds.



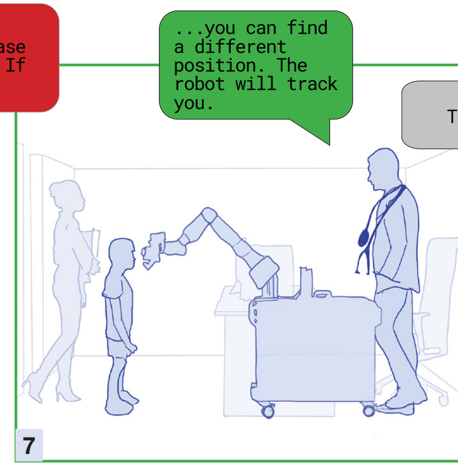
exam room

Jackson succesfully completes the exam on his right eye. The technician instructs Jackson to follow the same steps for his left eye.



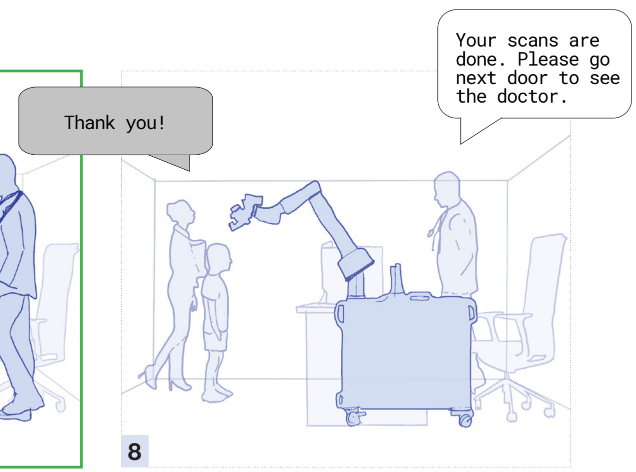
exam room

Jackson has difficulty maintaining his posture and focus on the robot lens. He starts moving, making the OCT scan fail.



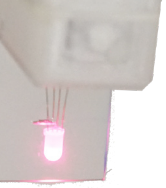
exam room

The technician instructs Jackson to be patient as the robot will target where his eye is and move according to him.



exam room

Jackson completes the OCT exam and technican guides them to another exam room where a doctor comes in, introduces themselves, and begins looking at the scans.



IDEATION AND EARLY CONCEPTS

The initial ideation process generated a wide range of narrative and interaction concepts aimed at improving the OCT experience for pediatric patients (see Figure 7). Through clustering and **thematic analysis** as well as our **findings from stakeholder interviews,** we identified several recurring design directions that ultimately informed the development of our two core characters: Pixel and Cory (more details in the following “Character Design” section).

One major theme was **familiarizing the exam environment**—reimagining the OCT scanner and its associated procedures through metaphors drawn from animals, nature, and child-friendly storytelling. Ideas under this theme sought to **transform intimidating medical equipment into familiar, approachable entities** (Figure 7. A).

A second theme, **embracing the coolness of technology,** reflected children’s enthusiasm for robots, secret agents, gadgets, and sci-fi aesthetics. Concepts around this theme highlighted opportunities to **make the exam feel like an exciting adventure, full of discovery** (Figure 7. B).

A third theme centered on **interaction and activating imagination,** providing task or goal-based activities that leverage **narrative-driven interaction** and encourage **active participation in the exam process** (Figure 7. C).

Together, these themes helped us move from abstract interaction goals to two differentiated character concepts, Pixel and Cory. Pixel emerged from concepts that emphasized **excitement, fun,** and **high-tech interaction,** offering a playful and motivating experience for children who struggle with focus. Cory, by contrast, evolved from ideas centered on **comfort, familiarity,** and **immersive escape,** supporting children who feel anxious or overwhelmed. These characters reflect a deliberate response to our early ideation insights, shaping design decisions that prioritize emotional engagement, sensory diversity, and child-centered care throughout the OCT exam process.

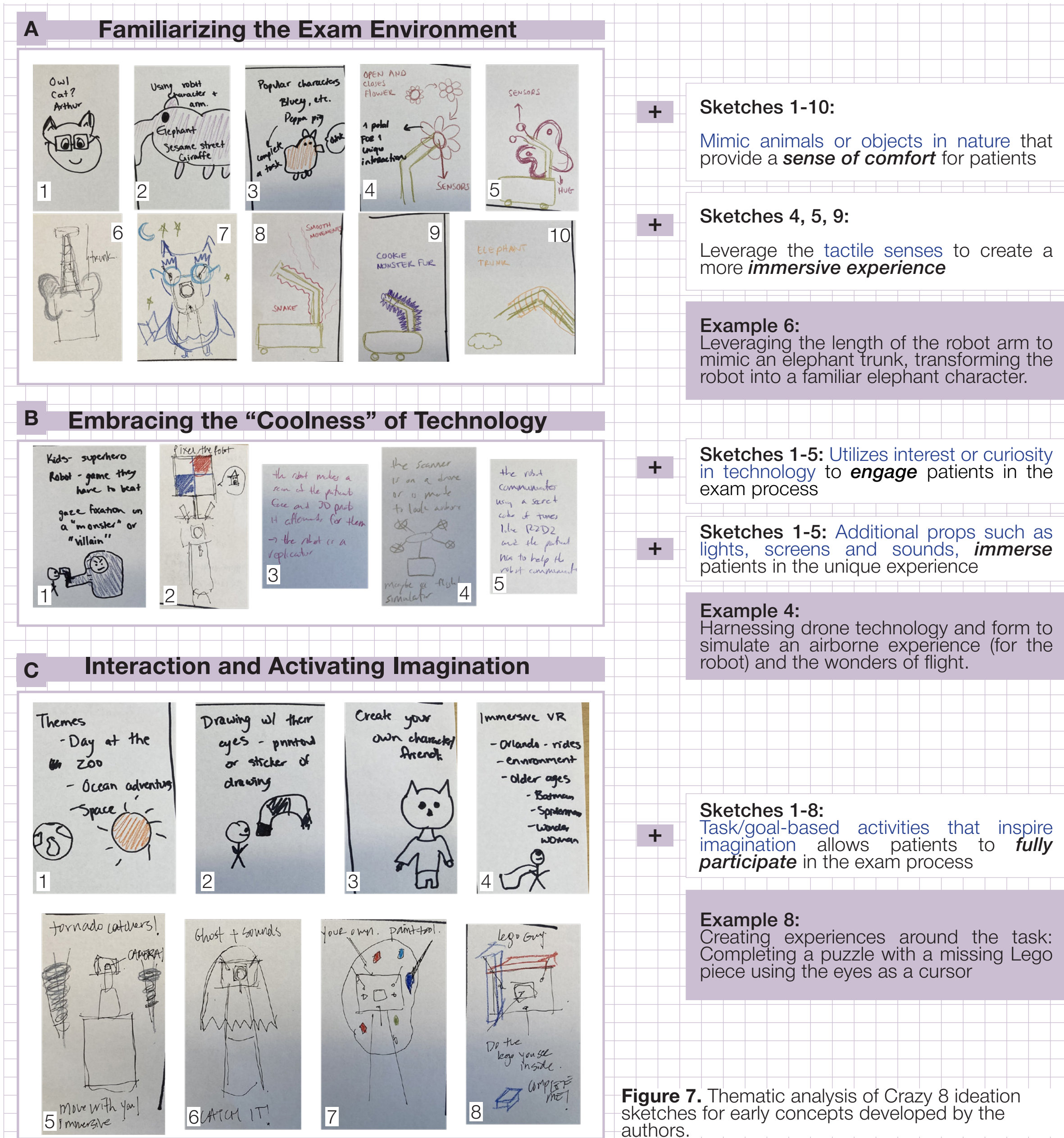
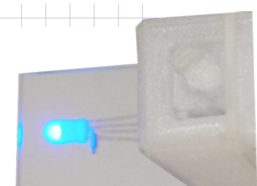


Figure 7. Thematic analysis of Crazy 8 ideation sketches for early concepts developed by the authors.



CHARACTER DESIGN

To address the unique needs of pediatric patients during OCT exams, two distinct characters were developed: Pixel, a secret agent robot, and Cory, a friendly sea anemone robot. These characters were designed to engage patients in playful and comforting ways, tailored to their individual challenges and emotions (Figure 10).

Pixel: The Secret Agent Robot

Pixel is a high-tech approachable secret agent robot for children like Jackson, who struggle with maintaining focus (Figure 8). To engage Jackson, Pixel sets up a mission in the form of a gamified interaction: Jackson, as a fellow secret agent, must deliver a gadget to Pixel and complete an identification scan.

Design Features:

Interactive Guidance: Pixel uses scanning lights to direct Jackson's focus, detecting when his attention wavers and gently guiding.

Encouraging Feedback: Pixel provides positive reinforcement and updates on mission progress to maintain motivation and excitement.

Tactile Interaction Components:

"Tech Archive": Pixel's tangible design consists of a transparent scanning device archive consisting of lighted boxes fabricated with clear plexiglass placed on a metal rack. The robotic arm underneath is exposed, revealing the advancements of the high-tech nature for the OCT scan.

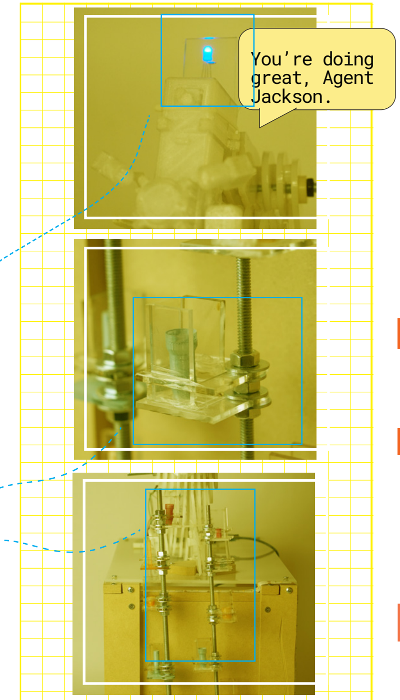


Figure 8. Detail images from smaller scale Pixel prototype.

Cory: The Friendly Sea Anemone Robot

Cory is a soft, colorful sea anemone with a passion for deep-sea photography, designed to comfort and calm children like Abby, who feel scared or nervous about the exam (Figure 9). Cory invites Abby to be the photographer for a new fish friend, framing the scan as a photoshoot in two underwater environments.

Design Features:

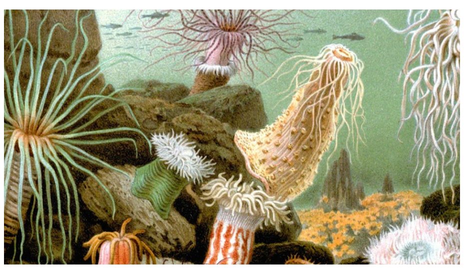
Stress Relief Interaction: Cory's gentle tentacles double as stress-relief tools, allowing Abby to squeeze them when she feels startled or scared.

Creative Engagement: By framing the scan as a photoshoot for an underwater friend, Cory transforms the procedure into a collaborative and imaginative activity.

Tactile Interaction Components:

Inflatable Tentacles: Cory's tangible design consist of colorful knitted protrusions in the form of tentacles that inflate with the sense of touch to respond to the physicality of the patient's movement.

Figure 9. Detail images from smaller scale Cory prototype.



A Inspiration: Sea anemones in deep sea *A selection of sea anemones, painted by Giacomo Merculiano, 1893*

B Initial sketches by the research team: a robot friend hiding between the anemones

C Fabrication: Tubular machine knitting in polyester & wool yarn mix used by the research team to assemble the robot arm in Figure 11.

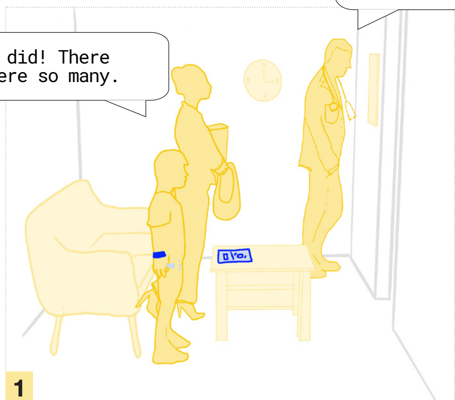
D Assembly: Assembling knitted textiles with embedded inflatable components

Figure 10. Concept design and fabrication stages for Robotic OCT character Cory. Including images A, B, and C.

STORYBOARD: PIXEL

This storyboard showcases Pixel, a robot character, performing an OCT scanning eye exam on Jackson. While Jackson still exhibits hyperactivity during the OCT exam, Pixel can engage him in the gamified eye exam, gently his attention while cooperating.

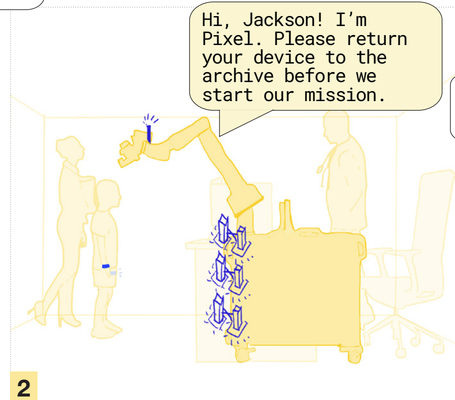
Speech bubble | Thought bubble | Jackson | Pixel | The technician | Pain point | Solution moment | Jackson's caregiver



1

waiting room

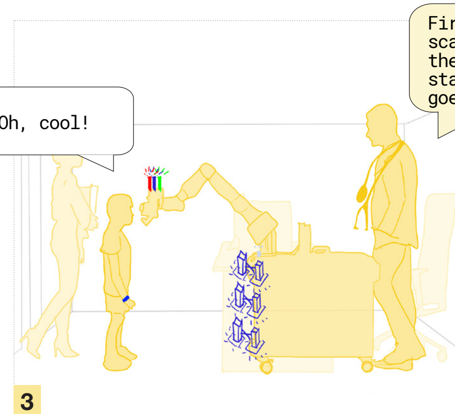
Jackson has an OCT exam. He took preliminary exams before his OCT, and he has been in the waiting area with his mother for an hour. In the waiting room, Jackson saw some camera lenses and scanning device parts.Technician calls Jackson and his mother into the exam room and asks Jackson to pick a gadget from the table for his secret mission to begin.



2

exam room

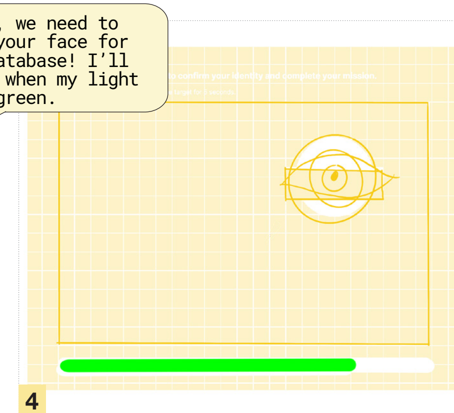
In the exam room, Jackson encounters Pixel. Pixel greets Jackson, introduces himself, and asks Jackson to deliver his scanning gadget to the tech archive on his cart.



3

exam room

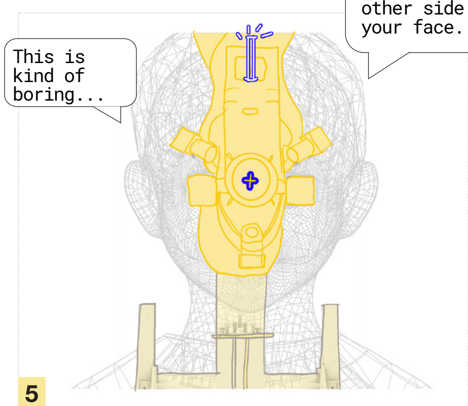
Pixel informs Jackson that he needs to get a face scan done for the secret mission to begin and asks Jackson to pick a position he is comfortable in to begin the scan.



4

exam room

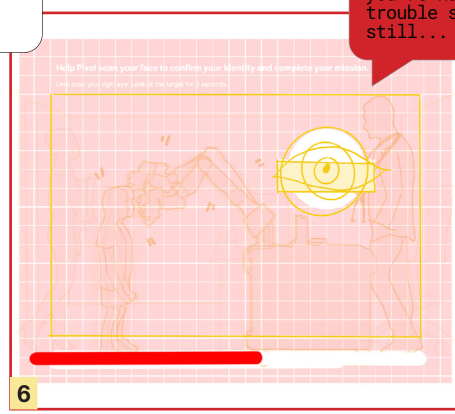
Pixel asks Jackson to focus his right eye on the screen inside the lens for the face scan and hold that position for 5-10 seconds. Inside the lens, Jackson is able to track the progress of the face scan.



5

exam room

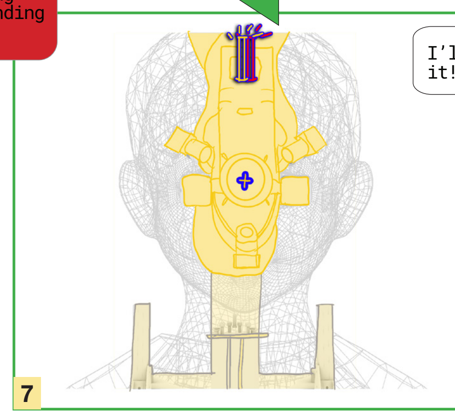
Jackson succesfully completes the exam on his right eye. Pixel instructs Jackson to follow the same steps for his left eye.



6

exam room

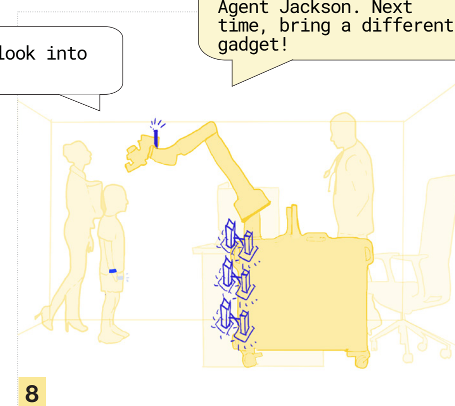
Jackson has difficulty maintaining his position and he is unable to look inside the lens without moving.



7

exam room

Pixel tries to coordinate with Jackson on his position, asking him to keep tracking the lights and the progress scan inside the lens.



8

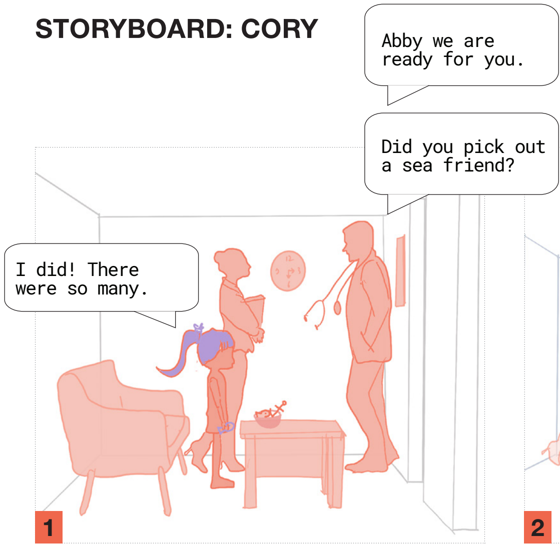
exam room

Jackson completes his face scan (the OCT exam) and Pixel guides them to another exam room where a doctor comes in, introduces themselves, and begins looking at the scans.

STORYBOARD: CORY

This storyboard showcases Cory, a robot character, performing an OCT scanning eye exam on Abby, a pediatric patient. While Abby is still scared of the robot device and the overall exam context, Cory provides her with a stress relieve and smoothing interaction when it asks Abby to touch is soft body and “hold on to it” when afraid.

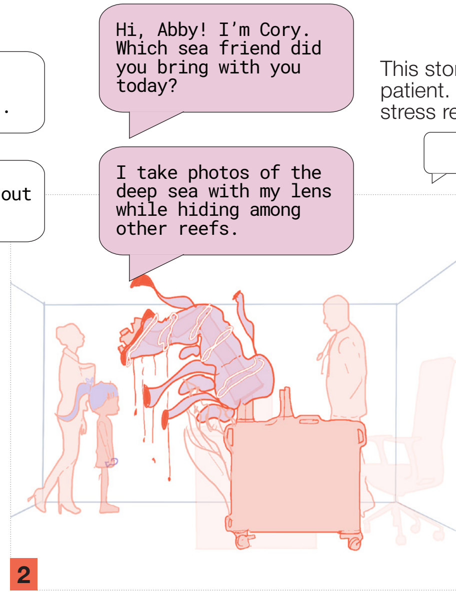
Speech bubble | Thought bubble | Abby | Cory | The technician | Pain point | Solution moment



1

waiting room

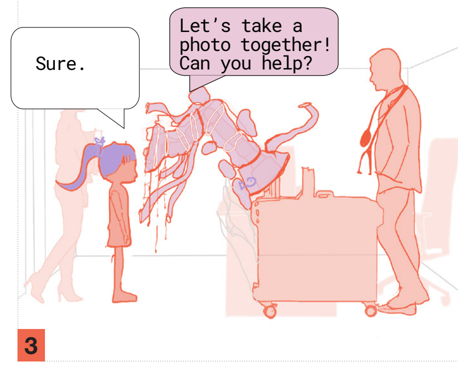
Abby has an OCT exam. She took preliminary exams before this OCT, and she has been in the waiting area with her mother for an hour. In the waiting room, Abby saw some toy sea creatures. The technician calls Abby and her mother into the exam room and asks Abby to pick a creature from the table.



2

exam room

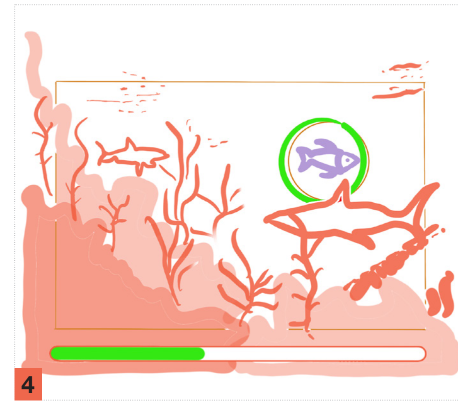
In the exam room, Abby encounters Cory. Cory greets Abby, introduces herself, and asks Abby to deliver the sea creature she picked out.



3

exam room

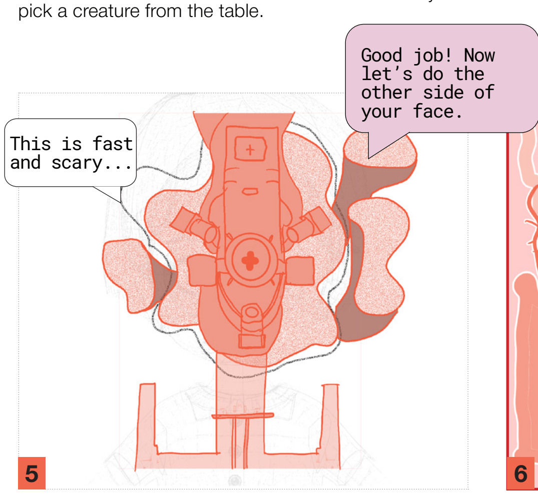
Cory informs Abby that she needs help taking photographs of the deep sea and asks Abby to pick a position she is comfortable in to begin the photography process.



4

exam room

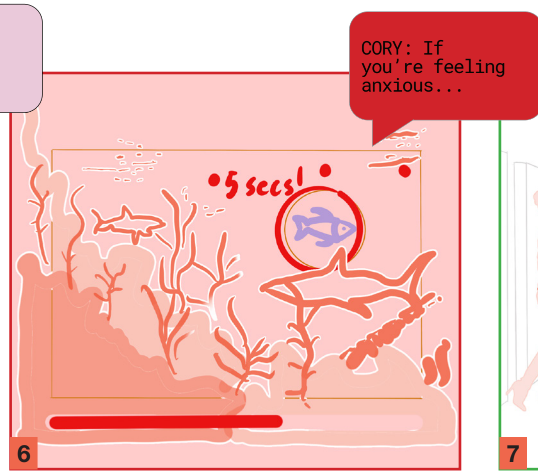
Cory asks Abby to focus her right eye on the screen inside the lens for the photograph and hold that position for 5-10 seconds. Inside the lens, Abby is able to track the progress of the photograph.



5

exam room

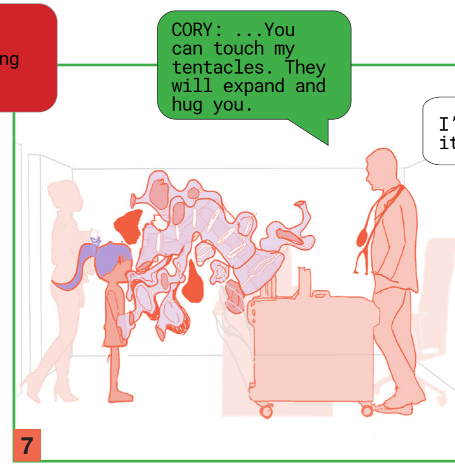
Abby succesfully completes the exam on her right eye. Cory instructs Abby to follow the same steps for her left eye.



6

exam room

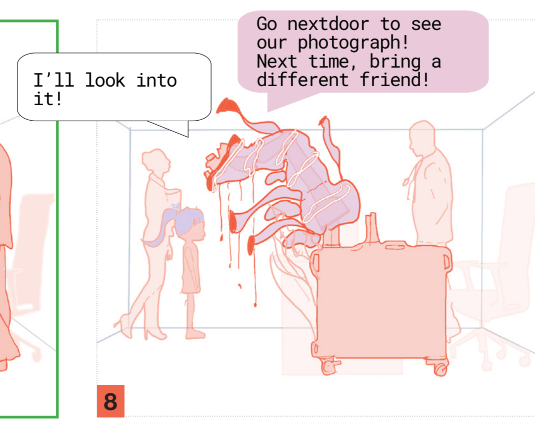
Abby has difficulty maintaining her focus on the fixation target, she gets nervous by the sudden movement.



7

exam room

Cory tries to coordinate with Abby on her position, asking her to hold her tentacles providing tangible support.



8

exam room

Abby completes her photographs (the OCT exam) and Cory guides them to another exam room where a doctor comes in, introduces themselves, and begins looking at the scans.

STUDY 2: PROTOTYPE INTERVIEWS WITH CAREGIVERS

Sample

Participants included 5 caregivers of pediatric patients who had undergone OCT exams. Participants were recruited through random sampling at a pediatric ophthalmology clinic, representing key stakeholders in the pediatric OCT process. Their insights were critical in evaluating the effectiveness of robot OCT character prototypes. Participants received 20 USD gift card. This study was approved by the University of Michigan IRB #HUM00264759.

Procedure

Stop-Motion Videos of Robotic OCT Characters

Adult caregivers were asked to view two videos showcasing different character prototypes designed for robot OCT (Figure 11). The first video featured Pixel, a secret agent robot, while the second introduced Cory, a friendly sea anemone robot. After watching each video, participants completed a survey to evaluate the characters based on their engagement, effectiveness, and alignment with the needs of pediatric patients. Link for both videos used during the study.

Survey Design

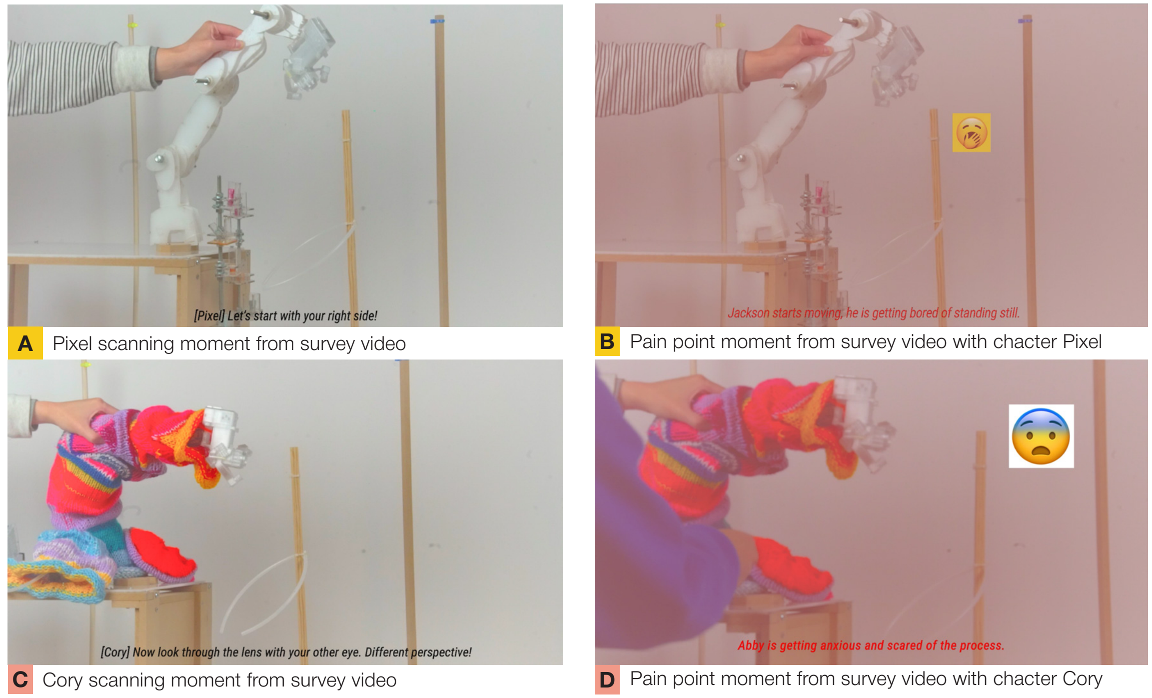
The survey aimed to assess: how each character addressed common challenges identified in pediatric OCT exams; the perceived benefits and trade-offs of each character; additional concerns or suggestions for character-driven interventions. Link for the protocol of Study 2.

Analysis

Survey responses were analyzed quantitatively and qualitatively to identify trends in character preferences and feedback on design elements. Open-ended responses were thematically analyzed to uncover suggestions for improvement and areas where the characters could better address patient needs. Insights from this analysis were used to refine the character designs and inform future iterations.

Results

Caregivers acknowledged the importance of robot characters during OCT exams. Figure 12 shows their insights on this.



A Pixel scanning moment from survey video
B Pain point moment from survey video with chacter Pixel
C Cory scanning moment from survey video
D Pain point moment from survey video with chacter Cory

Figure 11. Screenshots from videos shown to caregivers during Study 2.

Insights on Pixel

This character effectively addresses challenges related to patients' difficulties in target fixation and boredom. Participants found Pixel to be fun and/or interesting. Participants expressed concerns with the appearance of Pixel being too plain, boring, and almost scary and suggested incorporating a more cartoon, childish, and colorful embodiment design. They suggested incorporating a goal-oriented activity such as a scoring system to improve patient participation and motivation.

Insights on Cory

Similar to Pixel, this character was perceived to be very effective in addressing patients' difficulties in target fixation and redirection. However, it was not as effective in addressing fear of the OCT robot as only of participants found Cory to be calming and/or kind. Participants expressed concerns with the fabric as a sanitation concern or as a distraction for the patient from participating. They recommended adding more dynamic targets to sustain interest and incorporating calming sounds or music matching the ocean theme to assist in soothing and creating a comfortable environment.

Figure 12. Main insights from thematic analysis about caregivers' perceptions of Robotic OCT characters, Pixel and Cory.

DESIGN PRINCIPLES

Our design principles were derived from parent interviews and feedback from on our character evaluation study, which highlighted emotional, cognitive, and sensory challenges children face during OCT exams.

Robot-Powered Engagement: when the child disengages from the OCT scanning, the robot perceives this and re-engages them with gamified activities and prompts. Robot-Powered Engagement emerged from concerns about disengagement during scans, prompting the use of interactive elements to re-capture attention.

Tactile Comfort: Offering tactile comfort by expanding tangible protrusions to calm the pediatric patient during the eye exam to overcome anxiety or discomfort. Caregivers' observations about anxiety and discomfort informed Tactile Comfort, encouraging calming, tangible interactions.

Augmented Empathy: Using technology not only to succeed in the physicality of the exam but also to provide an empathetic experience for the eye exams. Requests for more emotionally attuned experiences led to Augmented Empathy, emphasizing a character that responds with care.

Multisensory Diversity: Incorporating multimedia character interactions that engage multiple senses can better accommodate the diverse preferences, abilities, and needs of children. Feedback from Caregivers recommended several features that leveraged Multisensory Diversity, promoting interactions across sight, sound, and touch that increase immersion.

Holistic Process Support: Intervening in multiple stages helps to reduce patient fatigue and sustain patient participation during the lengthy eye exam process. The need for support beyond the scan itself highlighted from our interviews with caregivers shaped Holistic Process Support, extending engagement across the entire exam journey.

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CONCLUSION AND FUTURE WORK

This study explored **how interactive storytelling can enhance pediatric OCT exams** by engaging young patients through character-driven robotic interfaces (Figures 13). Our findings reveal that character-driven designs, such as Pixel and Cory, can address challenges like **target fixation** and **engagement**, but further refinements are needed to better **alleviate fear** and **improve aesthetic appeal.**

Future directions include **developing a functional prototype** and **testing it with pediatric patients.** Pediatric patients were not tested on in the current iteration of the study since obtaining Institutional Review Board (IRB) approval for research involving children introduces additional ethical considerations and procedural complexity. Preparing these materials and securing the necessary approvals would have required a timeline and level of institutional support beyond the scope of this initial exploratory study. However, as the next step, we intend to include pediatric patients in the design and testing of the robot OCT characters.

In addition to further testing, we aim to **develop characters tailored to different developmental stages** and creating a customizable "Panel of Characters" that allows patients and caregivers to select their preferred companion for the exam. By integrating these findings into design iterations, we aim to enhance the pediatric OCT experience, paving the way for more **empathetic** and **effective healthcare technologies.**

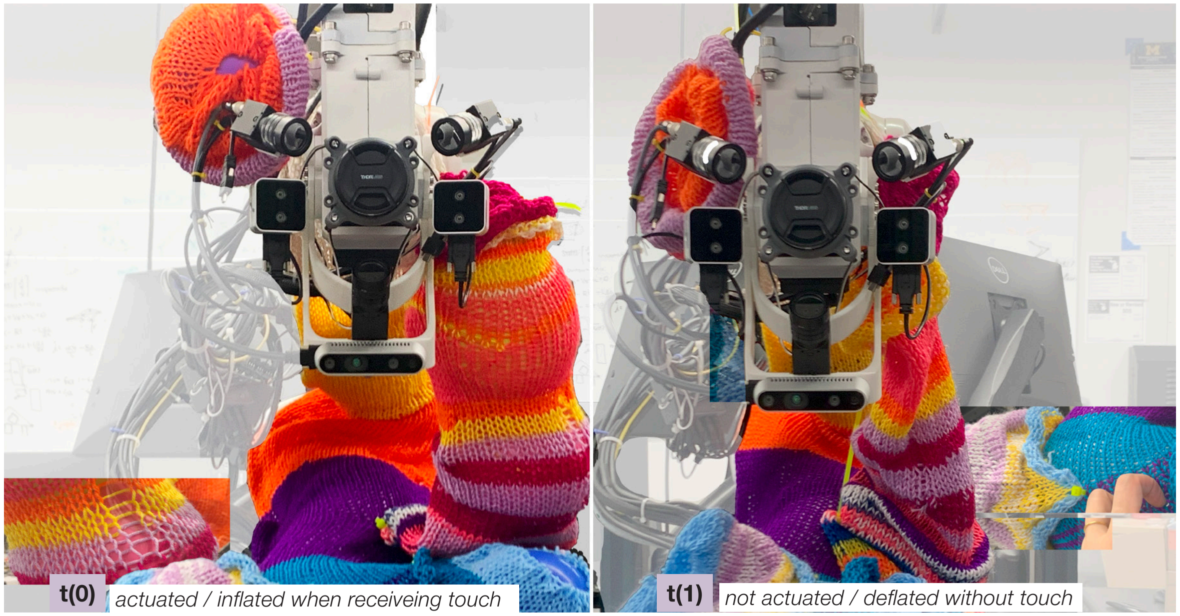

Figure 13. 1/1 scale prototype of Cory. Knitwork assembled on KUKA robotic arm. (overall dimensions of the system with the cart corresponds to, width: 2061.28081 mm, length: 296.68878, height: 467.33.498.) The design, fabrication and the assembly of the knitwork were performed by the research team.

REFERENCES

[1] V. Cassetti, T. Sanders, and A. Bruce. Challenges of eye health care in children and strategies to improve treatment uptake: a qualitative study from the perspective of eye care professionals in the uk. The British and Irish Orthoptic Journal, 15(1):96, 2019.

[2] C. S. Gonz´alez-Gonz´alez, V. Violant-Holz, and R. M. Gil-Iranzo. Social robots in hospitals: a systematic review. Applied Sciences, 11(13):5976, 2021.

[3] J. Hart. Reducing anxiety in pediatric patients. Radiology Management, 35(5):46–8, 2013.

[4] S. Jeong, C. Breazeal, D. Logan, and P. Weinstock. Huggable: Impact of embodiment on promoting verbal and physical engagement for young pediatric inpatients. In 2017 26th IEEE international symposium on robot and human interactive communication (ROMAN), pages 121–126. IEEE, 2017.

[5] S. Jeong, D. E. Logan, M. S. Goodwin, S. Graca, B. O'Connell, H. Goodenough, L. Anderson, N. Stenquist, K. Fitzpatrick, M. Zisook, et al. A social robot to mitigate stress, anxiety, and pain in hospital pediatric care. In Proceedings of the tenth annual ACM/IEEE international conference on human-robot interaction extended abstracts, pages 103–104, 2015.

[6] S. Jeong, K. D. Santos, S. Graca, B. O'Connell, L. Anderson, N. Stenquist, K. Fitzpatrick, H. Goodenough, D. Logan, P. Weinstock, et al. Designing a socially assistive robot for pediatric care. In Proceedings of the 14th international conference on interaction design and children, pages 387–390, 2015.

[7] A. J. Johnson, J. Steele, G. B. Russell, R. Moran, K. P. Fredericks, and S. G. Jennings. Decreasing pediatric patient anxiety about radiology imaging tests: prospective evaluation of an educational intervention. Journal of Child Health Care, 13(4):370–382, 2009. PMID: 19833667.

[8] B. K. M. Littler, T. Alessa, P. Dimitri, C. Smith, and L. de Witte. Reducing negative emotions in children using social robots: systematic review. Archives of Disease in Childhood, 106(11):1095–1101, 2021.

[9] D. E. Logan, C. Breazeal, M. S. Goodwin, S. Jeong, B. O'Connell, D. Smith-Freedman, J. Heathers, and P. Weinstock. Social robots for hospitalized children. Pediatrics, 144(1), 2019.

[10] A. R. Loh and M. F. Chiang. Pediatric vision screening. Pediatrics in review, 39(5):225, 2018.

[11] R. Looije, M. A. Neerincx, J. K. Peters, and O. A. B. Henkemans. Integrating robot support functions into varied activities at returning hospital visits: supporting child's self-management of diabetes. International Journal of Social Robotics, 8:483–497, 2016.

[12] R. S. Maldonado, J. A. Izatt, N. Sarin, D. K. Wallace, S. Freedman, C. M. Cotten, and C. A. Toth. Optimizing Hand-held Spectral Domain Optical Coherence Tomography Imaging for Neonates, Infants, and Children. Investigative Ophthalmology & Visual Science, 51(5):2678–2685, 05 2010.

[13] S. Mangalesh, B. McGeehan, V. Tai, X. Chen, D. Tran-Viet, L. Vajzovic, C. Viehland, J. A. Izatt, C. M. Cotten, S. F. Freedman, et al. Macular oct characteristics at 36 weeks' postmenstrual age in infants examined for retinopathy of prematurity. Ophthalmology Retina, 5(6):580–592, 2021.

[14] S. Mangalesh, N. Sarin, B. McGeehan, S. G. Prakalapakorn, D. Tran-Viet, C. M. Cotten, S. F. Freedman, M. G. Maguire, C. A. Toth, and B. Group. Preterm Infant Stress During Handheld Optical Coherence Tomography vs Binocular Indirect Ophthalmoscopy Examination for Retinopathy of Prematurity. JAMA Ophthalmology, 139(5):567–574,05 2021.

[15] A. Meghdari, A. Shariati, M. Alemi, G. R. Vossoughi, A. Eydi, E. Ahmadi, B. Mozafari, A. Amoozandeh Nobaveh, and R. Tahami. Arash: A social robot buddy to support children with cancer in a hospital environment. Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine, 232(6):605–618, 2018.

[16] C. J. Moerman and R. M. Jansens. Using social robot pleo to enhance the well-being of hospitalised children. Journal of Child Health Care, 25(3):412–426, 2021.

[17] C. O'Brien, M. O'Mara, J. Issartel, and C. McGinn. Exploring the design space of therapeutic robot companions for children. In Proceedings of the 2021 ACM/IEEE International Conference on Human-Robot Interaction, pages 243–251, 2021.

[18] A. L. Rothman, D. Tran-Viet, L. Vajzovic, V. Tai, N. Sarin, S. Holgado, K. E. Gustafson, C. M. Cotten, S. F. Freedman, and C. A. Toth. Functional outcomes of young infants with and without macular edema. Retina, 35(10):2018–2027, 2015.

[19] Y. Subhi, D. C. Schmidt, M. Al-Bakri, D. Bach-Holm, and L. Kessel. Diagnostic test accuracy of the red reflex test for ocular pathology in infants: a meta-analysis. JAMA ophthalmology, 139(1):33–40, 2021.

[20] K. Tanaka, H. Makino, K. Nakamura, A. Nakamura, M. Hayakawa, H. Uchida, M. Kasahara, H. Kato, and T. Igarashi. The pilot study of group robot intervention on pediatric inpatients and their caregivers, using ˙new aibo'. European Journal of Pediatrics, pages 1–7, 2021.

[21] C. A. Toth. Optical coherence tomography and eye care. New England Journal of Medicine, 389(16):1526–1529, 2023.

[22] S. Duda, C. Warburton, and N. Black. Contextual research: Why we need to research in context to deliver great products. In Human-Computer Interaction. Design and User Experience: Thematic Area, HCI 2020, Held as Part of the 22nd International Conference, HCII 2020, Copenhagen, Denmark, July 19–24, 2020, Proceedings, Part I 22, pages 33–49. Springer, 2020.

[23] M. Kuniavsky. Observing the user experience: a practitioner's guide to user research. Elsevier, 2003.

[24] T. Miaskiewicz and K. A. Kozar. Personas and user-centered design: How can personas benefit product design processes? Design studies, 32(5):417–430, 2011.

[25] S. McCarthy, P. O'Raghallaigh, S. Woodworth, Y. L. Lim, L. C.Kenny, and F. Adam. An integrated patient journey mapping tool for embedding quality in healthcare service reform. Journal of Decision Systems, 25(sup1):354–368, 2016.

[26] G. Gorisse, O. Christmann, E. A. Amato, and S. Richir. First-and third-person perspectives in immersive virtual environments: presence and performance analysis of embodied users. Frontiers in Robotics and AI, 4:33, 2017.

[27] M. Draelos, P. Ortiz, R. Qian, C. Viehland, R. McNabb, K. Hauser, A. N. Kuo, and J. A. Izatt, "Contactless optical coherence tomography of the eyes of freestanding individuals with a robotic scanner," Nature Biomedical Engineering, vol. 5, no. 7, pp. 726–736, July 2021

[28] G. Zhou, H. Pan, S. Staudinger, Y. Wang, J. Liu, S. Fleifil, C. Jin, N. Valikodath, and M. Draelos, "Mobile robotic optical coherence tomography system for ophthalmic imaging in clinical environments," in IEEE International Symposium on Medical Robotics (ISMR), 2025, accepted.