# Lessons from Deploying a Diagnostic Game with Children in a Clinical Setting

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## Abstract
Medical settings such as hospitals or clinics can provide logistical challenges to researchers not familiar with those environments. In this paper we present the lessons that we learned from the hurdles that we faced when bringing a diagnostc video game for children to a clinical environment. We share a list of the problems that we encountered and the solutions that we implemented. We believe that our observations and approaches can help other researchers attempting to deploy data collection in medical environments.

## Author Keywords
Serious Games; Amblyoblia; Video Games; Hospital Environment; Clinical Environment; Games for Health.

## ACM Classification Keywords
H.5.m [INFORMATION INTERFACES AND PRESENTATION]; I.2.1 [APPLICATIONS AND EXPERT SYSTEMS]; J.3 [LIFE AND MEDICAL SCIENCES]; K.8.0 [PERSONAL COMPUTING]: GAMES

## Introduction
Hospitals and other clinical environments are ripe sites for research. They are spaces filled with systems and technology that fascinate researchers interested in solving complex problems that yield demonstrable human good.

However, they are not easy spaces to conduct research, especially for the uninitiated. In addition to regular considerations when performing research (e.g., interactions with gatekeepers and advocates), there are cultural and regulatory hurdles unique to the environment.

We present the problems that we encountered while deploying a diagnostic game with children in a clinical setting, distilling our solutions into a series of viable practices. Most of our lessons are related to researching in a clinical setting; however, we provide a few lessons that are more relevant to working with children in particular. While some of these lessons may be obvious to those who have familiarity with medical settings, we seek to provide a written record of the challenges that we faced. We believe that some of the lessons learned are generalizable and therefore may help researchers entering this space avoid common logistical pitfalls.

## A Game for Diagnosing Children with Amblyopia

Our work centered around deploying a serious game for health (e.g., [1], [2]) in order to study its utility for diagnosing children with amblyopia. Initially the project was developed by graduate students who had success with the game in various serious games competitions, motivating them to advance the project from a standalone prototype to a clinically validated instrument.

Amblyopia, also known as lazy eye, is one of the most common eye disorders found in children [7]; it is also the most common case of reduced monocular visual acuity in children [5]. Identifying amblyopia can be challenging as children are often not cooperative with the visual examination [5]. This can lead to misdiagnosis [4]. 2 to 3 out of 100 children will suffer from amblyopia at some point in their life. Screening is a valuable tool since early treatment is more effective—so much so that there is a higher willingness to pay for treatment earlier in a child's life [6].

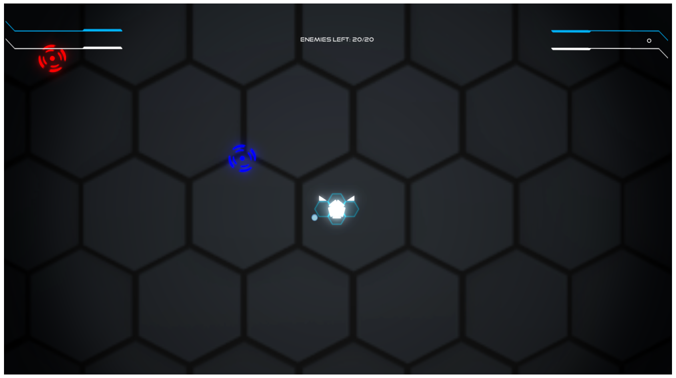


**Figure 1:** A screenshot of Healthx during gameplay. Targets (shown here in red and blue) appear on the screen and move towards the white circle in the middle of the screen. Targets are destroyed if the participant tracks them with their eyes for 3 seconds. Targets disappear once they reach the middle of the screen.

The premise of the study was around creating software—in the form of a video game—to generate an automatic diagnostic decision without any verbal communication with the children. Since some children are non-communicative, relying on communication between a clinician and a child is fraught with complications. Ideally, we can treat more children more effectively if we can automate the screening of the disorder.

The study was conducted at outpatient service clinic. Ages of the participants ranged from 4–11 years old. The study was conducted by playing a video game (Healthx) for 3–5 minutes.

Healthx is a 2D shooting game that uses an eye tracker such that the eye gaze of the player determines the shooting direction on the screen. The player has to acquire moving objects on the screen with their gaze as fast as possible before the objects reach the center of the screen. A screenshot of the game is provided in Figure 1.

## Lessons Learned: Logistics within a Clinical Environment

In this section we present some of the obstacles that we encountered when deploying our game in the clinical environment, along with the solutions we implemented. We recognize that other solutions may be possible and that some experiences may be unique to our clinical environment; however, we believe that many of the problems that we encountered should be given due consideration by researchers attempting to run research software in a clinical or hospital setting.

**Problem A:** *Communal space in a clinic environment has many distractions. Particularly with children these distractions can affect the research experience.*

**Solution A:** We ran our experiments in locked-down rooms that could only be accessed by patients and medical staff. Those rooms are hard to find in a hospital environment, as space is usually at a premium. Hospitals and clinical settings are judged on the efficient use of space. Empty rooms and empty beds cost clinical settings tens of thousands of dollars, which is why space is a rare commodity [3]. As a result, negotiating enough access to such spaces is part of the upfront challenge when arranging to deploy in a clinical environment.

**Problem B:** *Hospitals are not prepared to have extra empty rooms for running experiments; available rooms can vary from day to day and hour to hour.*

**Solution B:** We designed a portable workstation that we could move from one location to another in a very short period of time. After trying different portable configurations, we found that using a laptop as a base workstation was the best approach. Unfortunately screen size was as issue, particularly since we were working with children. We added a flat monitor which we hooked up to the laptop. An additional advantage of the extra monitor was that it allowed the experiment operator to simultaneously observe different information than the player without interfering with gameplay. A photo of the setup is given in Figure 2. Portability, reliability, and rapid deployability became the mantra of our kit.

**Problem C:** *Sending the recruitment materials and consent form to patients through email cut down our time in the clinic by an average of 2 minutes, but decreased the participation rate; participants expressed concerns and asked questions via email, which were not always answered in a timely manner.*

**Solution C:** We moved the recruitment and consent process to in-person at the appointments. This gave us the ability to more easily answer patient questions and alleviate concerns. Alternatively, we could have made sure that the recruitment materials gave our information as contact information instead of the contact information for medical staff; this would have given us control over responding to participant questions.

**Problem D:** *We needed six months of data and couldn't have an engineer placed at the hospital full-time.*

**Solution D:** We recruited medical staff to run the tests on our behalf. After talking with the medical staff and designing

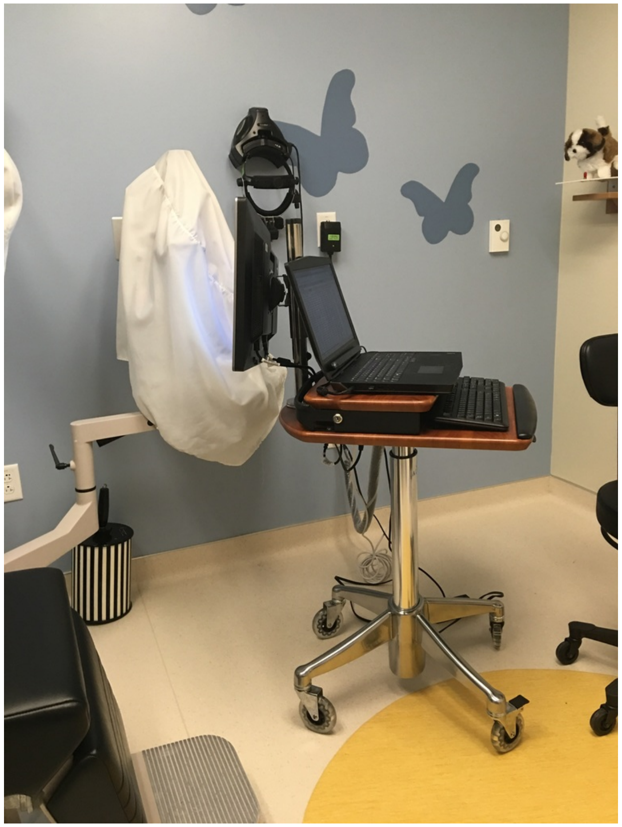

**Figure 2:** A photo of the Healthx mobile system. The table wheels can be locked down to prevent movement. The system has two screens: a laptop screen where the session operator can operate the playing session and the monitor where the player can interact with the game.

multiple systems, we settled on the following features/characteristics for the software:

- The program should be runnable in at most five steps. For us, the steps were: (1) run the app, (2) click start to begin the data collection, (3) automatically perform eye calibration, (4) enter the patient's name, and (5) choose the test type.
- The application should close automatically. Otherwise, medical staff were not always sure whether or not the game was still running (and continuing a previous run would resume the previous data collection).
- Choosing parameters such as the location where information is stored or which tests to run should be completely automated.
- Crash or bug reporting in the game should simply act as if the program has closed (instead of displaying error notifications).
- An icon should be supplied to close and restart the data collection. This allows medical staff control if they ever feel that something has gone wrong.

**Problem E:** *Medical staff already have a fulltime job. Additional research procedures can add to their workload (if they are administering), cause scheduling delays (if the experiments are run before appointments), or take up space (as previously mentioned). These factors create a lack of incentive to help out with the research.*

**Solution E:** We hired a medical staff researcher to run the data collection with the patients. Also, we streamlined the number of steps required to run the program (see Solution

D) in case the hired staff researcher wasn't available and other medical staff needed to run the data collection. We also worked to minimize the overall time required. On average, we added 10 minutes to the beginning of each appointment. While 3–5 minutes were for the experiment itself (playing the game), it took 5–7 minutes just to handle the consent process and explanations.

**Problem F:** *You may not be able to use clinical computers to run your experiments. In our case, the clinical computers' graphics hardware was insufficient for running the game. Additionally—and more broadly applicably—installing new software on clinical machines may require additional approval from the IT department.*

**Solution F:** Bring your own hardware.

**Problem G:** *Getting your computer Internet access. In order to get an Ethernet connection for our machine, we would have needed to go through several steps with hospital administration.*

**Solution G:** Use clinic's WiFi. While a cellular data connection would also work, it would not be considered a viable way to transfer any patient data unless further security measures are taken. Additionally, not all buildings may have good reception indoors.

**Problem H:** *Most of the hospital networks limit access in some way for security and privacy reasons. It is possible that you will be restricted in terms of the sites you can access (and the plugins that you can use). This situation is particularly problematic for data collection and sharing. (In fact, this was the largest deployment challenge that we faced.) Since we were collecting research information instead of medical data we were not able to take advantage of the hospital's existing systems and store that information in the patients' records. Furthermore, our experimental results included some patient data, meaning that we could not share the data via email or online sharing sites. We started out by storing information locally on the test machine. Once a week we (the engineers) transferred the experimental data onto USB drives.*[1] *After our analysis we shared data with the medical staff for review via USB. This added a lot of delay and was inconvenient for both the engineers and the medical staff.*

**Solution H:** We created a remote connection from our (the engineers') machine to the test station computer in the clinic. This connection was only established after 6pm, thereby ensuring that the machine was not running any experiments. We would remotely perform multiple analysis operations on the workstation and create output for the medical doctors. Hospital IT was able to set up a local connection between the test station computer in the clinic and our colleague's (the doctor's) computer, since both were inside the local network of the hospital. Once we were done with our analysis we stored the data on our clinic laptop. We then notified the medical staff through regular email about the availability of the information; they could then pull the research data onto their machine (using the connection the hospital IT set up). We provided medical staff with an offline analysis tool (a web browser visualization) with which to view the data.

## Lessons Learned: Logistics when Working with Children in a Clinical Environment

In this section we share some of the logistical lessons that we learned which were more particular to working with children in a clinical setting.

[1] This is potentially another reason to use your own hardware; some clinical or hospital settings will not allow the usage of USB drives.

**Problem I:** *When a child's parents stood behind them or in a different location the child would become distracted and look around to locate their guardians.*

**Solution I:** When dealing with participants under the age of 10, we made sure that parents stood in a location out of the way of the screen but still within the child's field of view.

**Problem J:** *We experimented with having children play the game before their exam, after their exam, and in the middle of their exam (between treatment steps). Children were less compliant and more distracted in the second two cases.*

**Solution J:** In order to have children be more compliant and less distracted during the data collection, it is advisable to fit the research process into the beginning of the appointment timeslot.

**Problem K:** *Young players are intolerant to bugs and failures in the system and express a lot of frustration.*

**Solution K:** We were extra careful to prepare research materials free of bugs.

**Problem L:** *Players were distracted by opportunities to move or fidget.*

**Solution L:** Given the playful nature of young children, chairs and research stations should not contain mobile components like rotating chairs.

## Conclusion

In this paper we share 12 of the challenges that we faced when deploying a diagnostic game for children in a clinical setting. We include the solutions that we employed to surmount these obstacles. We believe that our observations may help other researchers attempting to work in a fruitful and complex environment.

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