The Design of a Tangible Interaction Device to Alleviate Anxiety and Pain in Paediatric Burns Patients

Abstract
This paper presents a case study on the design of a unique tangible media device to alleviate anxiety and pain in paediatric burns patients. The multidisciplinary interaction design approach used throughout the study is presented together with the hardware and content design solution. Results of an initial study are presented which qualify the use of the device within a clinical trial. The paper concludes with a reflection on the process undertaken leading to suggestions for undertaking successful collaborative projects which span medical science, computer science and design disciplines.

Keywords
Interaction Design, Augmented Reality, Diversionary Therapy, Child, Burns Treatment, Pain and Anxiety Management

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Project Context
Dressing changes in paediatric burns patients is a painful but necessary procedure which requires the child to see a physician on a 3 to 7 day cycle (potentially over a 3 month period) where dressings need to be removed and examined and then reapplied. This particularly painful experience generally causes anxiety in both children and parents. Current pain and anxiety management relies heavily on drug intervention, often requiring the child to become completely sedentary. An alternative approach is the use of diversionary therapy for children. This typically involves the child’s attention being diverted during the removal of a dressing or examination of a burn. Techniques such as colour murals, book reading/video’s, interactive toys or music therapy are often used. Such techniques have remained unchanged for the past 10 years.

An alternative to these approaches is the use of digital media and emerging technology as diversionary therapy. Hoffman [1, 2 and 3] has identified the use of Virtual Reality (VR) as effective tool in the management of burns patients. However a limitation of VR is the space requirement in order to generate an immersive virtual experience. This can be overcome with the use of Head Mounted Displays, however, in burns patients this can be problematic as the type of burn may prevent such a device being worn. This is further compounded as such a device may raise the anxiety levels of some children.

When considering the use of digital media and technology in the treatment of burns in paediatrics, physical space, environmental contextual issues and a child’s anxiety level are critical factors and potential design constraints. Often examination rooms are small and crowded (Figure 1). In certain circumstances the child requires bathing in order to remove a bandage. Finally the technology can often be the source of anxiety, as the technology may be considered part of the procedure.

Figure 1. Clinical Setting - Stuart Pegg Paediatric Burns Centre

Augmented Reality (AR) is a technology which may overcome the limitations of VR and be suitable as a diversionary therapy technique in the treatment of burns and in other procedures in paediatrics. In AR, a virtual experience is created by overlaying a virtual image within the actual environment, whereas in VR an immersive experience is created by blocking out the actual environment [4]. Although such an approach offers benefits to Virtual Reality, the technology is still cumbersome and has not been contextualised for a child and further to a hospital environment.
Collaborative Study
A collaborative study between the Stuart Pegg Paediatric Burns Centre located at the Queensland’s Royal Children’s Hospital and the Australasian CRC for Interaction Design (ACID) was undertaken to investigate the use of Augmented Reality within the constrains of the clinical setting and required medical procedure. ACID was approached to investigate the development of an appropriate solution. It was felt that ACID could value add technology approaches as it is focused on understanding how to engineer better, more valuable and more appropriate technologies to the contexts of peoples lives. ACID provides a capacity to analyse unique situations – such as this hospital context – and then design and develop interactive devices and media appliances to suit people’s real needs.

The multidisciplinary research team consisted of medical physicians, industrial designers, content developers and computer scientists. A human centered design process unified the team, with all members of the group being involved at each critical stage of the project. It was expected that the outcome of the research would result in a combined hardware and content solution which could then be evaluated within a clinical environment to quantify the benefits the management of pain as a diversionary therapy approach for paediatric burns patients.

An overview of the six month design and development process, the final design solution and the results from initial clinical evaluation studies follows.

Design Development - Research
Interaction design is about finding better ways for people to interact with each other through communication technologies. Interaction design involves understanding how people, learn, work and play so that we can engineer better, more valuable technologies that are more appropriate to the contexts of their lives. As an academic discipline, interaction design is about the people-research that underpins these technologies. Therefore the starting point for this research was a grounded understanding of the cultural contexts which surrounded the treatment of burns patients and existing diversionary therapy approaches being used by the hospital. Researchers were able to observe clinical studies on multiple occasions to quickly determine the physician – patient – carer interaction within the intended clinical setting for the new device and determine limits of current approaches.

Research related to existing technology approaches was also required. As the design research team was not completely familiar with Augmented Reality, access to existing devices was provided to the team to use and trial in varying contexts. An understanding of the limits of Augmented Reality technology within the actual clinical setting was also required. As a constraint of the project was to utilise this technology and value add to it through the research undertaken – the deployment of the existing devices as a form of a technology probe was critical in determining the limits of such devices within this particular context.

Major findings from this research relate to existing AR devices which need a level of control over external lighting conditions which within the clinical environment, is impossible. The second point related
to the need to create compelling digital content which ensured that the child interacted with the device and immersed the child beyond visual stimulation, thereby creating a greater distraction from the clinical procedure.

**Design Development – Concept Studies**

These two primary observations from the research were applied through a number of concept design workshops. Through the use of visual thinking, physical mockups and Computer Aided Design renderings, three design approaches (Figure 2) were developed and presented as design narratives which demonstrated the content / hardware solution and the intended interaction between the physician – patient – carer.

![Initial Design Sketches](image)

**Figure 2. Initial Design Sketches**

The creation of content storyboards to promote greater engagement between the child and device was closely aligned to the device design development, to ensure the constraints of the technology were considered.

A central character, 'Hospital Harry' was developed and integrated into the intended interaction paradigm for the device. These concepts and the character were presented to the hospital staff and feedback resulted in a single concept direction to allow prototype development to begin.

**Design Development – Prototypes**

A modular approach to the design was decided upon using the Hospital Harry narrative throughout. This approach allowed the researchers to quantify certain aspects of the design and interaction approaches during the clinical trials.

The final device was produced as a 3D Computer Aided Design (CAD) Model and a rapid prototype was produced (Selective Laser Sintering). This prototype was integrated into an off the shelf 7” flat panel LCD display and web cam product. Custom electronics were also developed to complete the device.

Three versions of the device centered on the flat panel screen were produced. The simplest concept consists of a webcam integrated into the back of the unit where a child held the display and read the story. The marker was shown on the book and the child could rotate the object by focusing on the marker. The second concept developed a book which was overlaid on the screen and a webcam was worn by the child. The webcam would be focused on the marker located on the book / screen and the child could manipulate the character by rotating the device or rotating their head. The final and preferred concept (Figure 3) focused on overcoming the limitation of existing AR applications which are susceptible to external lighting conditions. This concept integrated the webcam and marker technology and
developed a weighted character to allow the manipulation of the virtual character. The child inserts a character into the side of the product. When the child rotates the screen the physical character moves accordingly, thereby rotating the virtual character on screen.

Clinical Trials
A prospective randomised controlled trial of fifty (50) patients aged between 3 and 16 years was undertaken [5]. They were randomised to a control or augmented reality group. Both groups received standard doses of analgesic and/or sedative medications. Simple distraction techniques such as age appropriate video programmes or music therapy were used in the control group and various prototypes of augmented reality systems were used with the study group. Pre and post procedural pulse and respiratory rates as well as oxygen saturations were recorded. These clinical measures were also taken at 10 minute intervals during procedures. Pain levels were monitored using standardised age appropriate tools including FLACC, Wong Baker Faces or simple analogue scales. The total duration of procedure was noted and Parents were asked to give a rating from 0–5 of their child’s tolerance of procedure.

Results show that the augmented study group recorded lower pain scores throughout the burns dressings changes when compared to control group patients. The study group also recorded lower pulse and respiratory rates. There was little difference in oxygen saturations between the two groups. Parents also indicated lower pain scores for the children in the augmented reality group. From this initial study it was concluded that the Augmented Reality prototype and its content is an effective tool in reducing pain scores in paediatric burn patients undergoing dressing changes. This equipment is a simple, non invasive adjunct to burn therapy. An additional study is currently under investigation which furthers this initial trial among a larger population sample.

Study Reflections / Conclusions
This paper has reported on a study which has developed a unique interaction design device for the purpose of alleviating pain and anxiety in paediatric burns patients. As demonstrated throughout the paper, the final design and its evaluation are significant as it has been shown through a clinical trial that this device is an effective tool in reducing pain scores in paediatric burn patients undergoing dressing changes.
A second finding relates to the observations made throughout the collaborative study which may be of interest to the wider HCI community. As noted in the paper, this study is unique as it spans design disciplines with medical and computing sciences. However two additional significant observations outside of the main finding of the design of a unique interaction device were observed. Firstly, the quantification through a prospective randomised controlled study of an interaction design device was completed. Typically such developments occur without the quantification of such studies and the consideration such studies have on the impact of by the users of such developments. In this study the project team was directed by the validation of such studies and assisted in the redesign of the interaction device.

The second observation outside of the main finding was the unification of the multidisciplinary team. The traditional boundaries of multidisciplinary collaboration, such as language difference and difference in research outcomes were quickly overcome through the use of visual representation when the team was required to jointly evaluate a product concept. However this did not impact on the team’s ability to consider discipline specific sub outcomes during the course of the project.

The next stage of the project will relate to the development of concepts which focus on an older population sample – specifically seven to 12 year olds. A new device and content will be developed and additional clinical trials will be undertaken.

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**References**


