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Industrial Design as contributor to relieving child anxiety in the course of MRI scanning procedures.

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The complexity of preparing young people for MRI examinations.

Magnetic Resonance Imaging provides an unparalleled view inside the human body. The process enables the creating of images for diagnostic analysis without recourse to the use of ionising radiation such as x-rays. This is particularly relevant in diagnostic evaluation in paediatrics where there is the danger of cumulative radiation exposure (Barkovich, 2000). However the physically imposing characteristics of MRI equipment, noise, temperature, and long periods of keeping still contribute to the already high levels of anxiety experienced by the child and his or her accompanying family members. In very young children (under two years of age) sedation or general anaesthetic is required. The referring physician assesses older children as to their sedation requirements and suitability for the procedure. Sedation is considered to be relatively safe and complications rarely occur however it does introduce a higher risk to the child through decreased respiratory rate and airway obstruction. General anaesthesia therefore turns an otherwise non-invasive procedure into an invasive one with additional implications upon imaging productivity; number of personnel involved and associated costs.

Anxiety is the condition created when the part of the mind responsible for subconscious behaviour, the Amygdala, which controls the anxiety response, becomes stimulated. When this anxiety switch is 'off', we go about our lives normally, but when it is needed, the Amygdala activates an anxious reaction, for example when attacked by a dog or stepping out in front of a tram. Its purpose is to prepare the body to react quickly when needed. When this 'anxiety switch' becomes 'stuck' as a result of constant anxious stimulation such as bereavement, trauma or medical stress, the anxiety level is raised and constant. This extreme condition can cause an anxiety disorder.

Anxiety in children is most commonly experienced as fear or worry particularly of the unknown that can intimidate or appear threatening. Young children by default have little experience of the world outside their home and therefore the unknown presents more opportunity for worry. The anxiety manifests itself in an unwillingness to undergo the examination and in particular a failure to retain a still posture essential for the clarity of the MRI images. Of the different types of anxiety experienced by children only some might directly relate to their experience in a hospital and may be exaggerated by the particular circumstances of their medical condition;

Fear of separation.
Children with this problem worry that something bad will happen to themselves or their parents whenever they are apart. As a result, these children often refuse to separate from parents. To rectify this parents are able to be present during the examination and even hold the hand of the child undergoing the examination although they are restricted in eye contact.

Post-Traumatic stress.
Usually following a severe, life-threatening trauma, many children experience nightmares, fears and other signs of distress.

Panic disorder and claustrophobia.
The design of most MRI equipment necessitates the lying down within the 'bore' of the machine and laying there still for prolonged periods. This restriction upon a young person so disposed to panic attacks triggered by claustrophobia is very debilitating creating anxiety prior to the examination.

Generalised anxiety.
These are children who are excessive worriers already. They worry about many different areas of their life including schoolwork, competition, family, and anything new. They often ask repeatedly for reassurance and may experience physical symptoms such as headaches, nausea, or diarrhoea.

Current strategies for addressing anxiety.
Prior assessment of an anxious and sick child's ability to undergo the requirements of an MRI examination is difficult without actually attempting the procedure itself. This is time consuming and wasteful on resources if the patient fails to feel comfortable enough to comply with the requirement to lie still for a prolonged period. However it has been observed that exposure to medical equipment prior to examination has an effect on reducing anticipatory anxiety in children (Melamed et al, 1982). Studies have been carried out by play therapists in which child patients have been shown photographs and acted out examinations with the use of scale models and dolls. Play therapy can be an effective way to help children and supports children as counselling or psychotherapy can for adults. Play therapy helps children work through emotional and behavioural difficulties and helps address their anxiety. These studies reported a decrease in the number of MRI examinations requiring sedation and a reduction in the number of failed examinations. It appears that prior simulation is an effective contributor to assessing a child capability to under go the examination without sedation. Research at one of Australia's leading paediatric hospitals led to the building of a full size 'mock' MRI in which the patient could 'play' at experiencing the procedure in much the way they would during the actual activity. The results of this study suggested that the mock MRI experience closely replicated an actual examination to the extent that radiographers where able to make qualitative judgements as to the requirements of the patient to undergo a

general anaesthetic or not during a real scan. From a qualitative point of view this process went someway to alleviating the amount of stress felt by the child that would otherwise have been surprised by the initial scanning experience. [Figure 1].

Figure 1. Photograph courtesy of Royal Children's Hospital Melbourne.

However the mock MRI does have some shortcomings. It does not simulate the high noise level of the actual scanner or replicate the material limitations placed upon the room environment in which the scanner is placed. Due to the existence of a very large and powerful magnetic field no ferrous-based metal or electronic equipment can be brought into the actual examination room. Therefore limiting the means of stimulating the patient to lie still and be calm. The current solution to this dilemma has been to project an image (usually a child's favourite video recording) on to a screen placed at the patient's feet. The video image is projected through the window of the adjacent control room protected by the installation of a Faraday cage. Viewing the image is difficult as the patient is required to lie flat on their back absolutely still and look upwards. In the case of brain examinations line of sight to the video and the child's parents is achieved by the installation of a mirror on the inside of the cradle that surrounds the patient's head. Thus this 'periscope' allows some visibility from inside the scanner tunnel into the room and wider environment. As the child has to be still to achieve a view of the film through the narrow confines of the cradle and periscope mirror. This arrangement has become the principle means of pacifying small children and encouraging them to remain still. (Slifer K.J 1994). [Figure 2].

Figure 2. Photograph courtesy of Philips Electronics.

Beyond this form of stimulation it appears to date that only one paediatric hospital in Australia at least, has experimented with decorating the examination room in which the MRI equipment sits surrounded by artwork that reflects what might be interpreted as a child friendly environment. To this end the room has been painted to reflect a seascape in order to present an impression that the MRI equipment is an entirely different object. In this case a submarine of a cartoon or naive nature. Whilst settling in child sensitivity the colour schemes of blue and yellow create reflective problems for anaesthetists concerned with observation of the patient. They need to detect blue or yellow skin tones indicative of negative reactions in the patients breathing and have found this to be problematic within a room with such interior décor.

Whilst the pilot study emerging from the use of the mock scanner's preparation methods and behaviour conditioning from role play activities indicated an improvement in identifying sedation requirements, the opportunity remains for a more user centred child friendly approach to the actual examination room to improve imaging outcomes and reduce anxiety still further. To this end an approach was made to Monash University undergraduates from the Bachelor of Industrial Design programme to use an appropriate design methodology to create some credible concepts in response to these discussed issues.

The complexity of choosing suitable methods in designing for children.

Problem based learning is an appropriate paradigm for industrial design education. It is goal directed focusing upon discovery rather than simply the acquisition knowledge. This real life 'case study' or 'live' project technique has been, as it has with many other institutions around the world, been the cornerstone of design education philosophy at Monash University. The experience of engagement with life outside the campus has proven invaluable in preparing the undergraduates for their professional life. (Coker 2004). The project to design a more sensitive MRI environment appropriate for children is a challenging one for young designers as there is little tacit prior knowledge of such a complex and apparently limited creative environment. The physical environment can be replicated to some degree to assist the designer to better understand the problem. However this simulation serves only to demonstrate the physical experience and not the psychological experiences of an anxious child. Thus demonstrating that despite the fact that we were all children once, designing for children is difficult to uncover and fully understand. Therefore the articulation of the child's needs and the transfer of the related data from user to design student is problematic. Added to this issue was the relatively short six week time constraint meaning that proposed solutions would not be fully realised or tested upon potential patients nor ethics committee approval achieved in the given timeframe.

However given the importance and opportunity to improve the current situation and at the same time engage students in a more fundamental design research context the activity was begun. Discussion with the cohort of students on the nature of the problem began with a briefing and presentation delivered on behalf of the paediatric hospital. Within the presentation video footage was displayed outlining the MRI scanning procedure and following up with a detail outline of the problems faced by the students in creating an effective solution. The anticipation was to harness the creative energy of the University environment and explore solution possibilities in a way that had not been fully investigated within the radiography profession.

With such a short time frame of only six weeks the cohort of students undertaking the project broke themselves into groups to tackle the problem using a number of different primary research methods and then 'pool' the results to best accumulate the most information from a limited period of time. Different methods for learning about design problems are reported by a number of authors on design methodology. Broadly speaking these methods fall into three categories (Allen 2002) namely;

- the procurement of existing information. (e.g. manufacturers literature)
- the generation of new information. (e.g. brainstorming ideation sketch work etc).
- other disparate methods. (e.g. informal contacts).

The students where divided up into four teams each employing a particular technique from the above sets to raise problem awareness or scope potential solutions. The choice of methods was at the discretion of the academic staff and discussed with groups with examples of their use in other research projects. The techniques ranged from deconstructive analysis to physical empirical processes. [Figure 3]

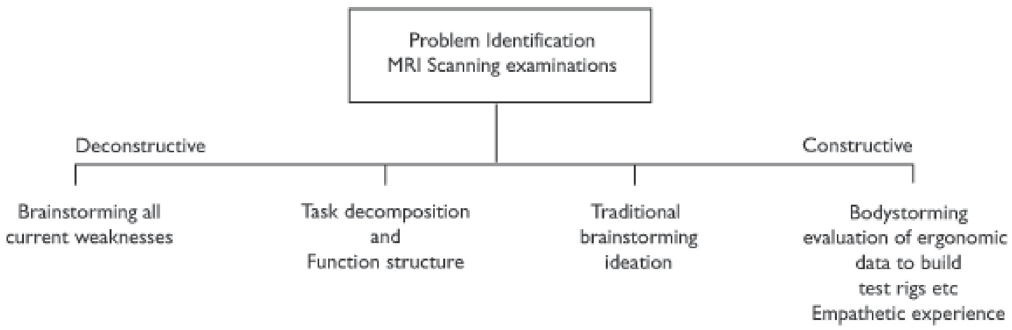

Figure 3. Authors diagram.

Group 1. The initial issue was identifying the problem correctly and to this end this group sort to use a strategy of 'destructive' brainstorming as a way of listing all the weaknesses of the current arrangement and associated technical hurdles that would filter out all the most apparently 'obvious' solutions. This group technique quickly raised problem awareness amongst the other groups.

Group 2. This group of students tackled the problem identification issue by 'body-storming'. This method combined the accumulation of ergonomic data with that of building a full size cardboard test rig to simulate the MRI scanner. The largely cardboard rigs were not very accurate, certainly in appearance although a good approximation in terms of size. The rig's real function was to stimulate thought about the product and its problems through an empathetic experience. Whilst the students were adults they could use the physicality of what they were doing to help find a deeper engagement with how a child might feel whilst undergoing an examination experience. The results of this activity where photographed and circulated amongst the rest of the students.

Group 3. This group of students undertook a classic 'brainstorming' technique in that they engaged in intensive group discussion in which strict rules applied to suspend criticism and promote a wide range of freethinking. The quantity of output was regarded superior in importance to the quality of any proposed solution. All the solutions both in word form and illustration where stored on 'butchers' paper and pinned up to be shared with the rest of the student groups.

Group 4. The final group of students undertook a site visit to see an operational MRI scanner in its environment and returned to campus to report on their experience. This afforded the group the opportunity to analyse the 'function structure' of the imaging activity. MRI scanning is not in itself a product in which the form is the major problem although the tunnel or bore is referenced as a contributor to the anxiety. In this analysis the kernel of the design problem lies in a series of steps that the user /child /patient goes through that is not delivering a pleasurable user experience. This particular student group looked at the active system that was aiming to fulfil the overall function. Their results broke down the problem into a series of discreet functions, that are relatively self-contained, so that one can focus on a particular task, This is in contrast to having to know about all the product functionality at once. This analytical break down of the product orientation, so commonly adopted in industrial design to function orientated thinking, was extremely beneficial in broadening the students understanding of the problem in a relatively short space of time.

The process of task decomposition was represented as a structure chart (similar to that used in Hierarchical task analysis, Simon 1969). For each activity, the question was asked 'how is this task done?' If a sub-task is identified at a lower level, it is possible to build up the structure by asking 'why is this done?' The task decomposition was carried out using the following stages;

1. Identifying the task to be analysed. E.g. getting into position on the scanner table.
2. Breaking this task down to subtasks. E.g. Approach to the machine and its initial impression upon the patient. Climbing onto the table and getting comfortable.
3. Deciding upon the level of detail to decompose the information.

The compiled information was presented as a task flow diagram including details of interactions between the child user and the current system, or other individuals, and any problems related to them.

All the student groups came back together to share what transpired to be a rich supply of information. From these first analytical explorations students went to work individually in the creation of solutions in a draft form. Each thumbnail drawn was either a response to the destructive brainstorming, observation of the body-storming, intuitive creation to the brainstorming ideas or an expression of product functionality. Within the time frame for the project there was no opportunity for more than the most perfunctory of scale models where they were thought appropriate for explaining or expanding upon a conceptual idea. Most of the solutions proposed by the students were contained in two-dimensional representational tools including computer modelling.

The educational experience of the project concluded with a presentation to the paediatric hospital of what amounted to the end of the conceptual design phase with little in the way of development optimisation and in particular evaluation because as stated earlier this would require building, testing and ethics committee clearance.

The proposed concept outcomes.
The results of the students' activities could be broadly split up into the following themes; -

- Those that chose to develop the scanner environment, which included 'dressing' the MRI machine.
- Those who re-orientated the child's lying down position.
- Those who sought to tackle claustrophobia.
- Those who incorporated garments into the process worn by the child but included a restrictive headgear to support the requirements of the scan.
- Those who combined both in a role-play scenario to pacify the child. Finally those who chose a technical solution that expanded upon the current projected video solution.

Dressing the machine and environment a surface treatment approach;

The first and perhaps most obvious approach adopted by students was to make both room and the scanner more visually appealing to children. Aesthetic cues coming from current playground architecture and rotationally moulded product for example. Although the panels of the scanner cannot be altered the suggestion within this cohort of young designers was that a level of superficial decoration combined with physical 'play' items might reassure the patient prior to the procedure and may indeed supplement the 'mock MRI' play therapy experience. Evidence of early learning behaviours in children indicates that brightly coloured environments create positive reactions. This acknowledged, an over stimulated environment could also create an excitement that is counter productive. These play concepts stimulated discussion over the relative qualities of colour in physical stimulation. Highlighting once again the issue of blue and yellow hues reflected within the environment causing inaccurate determination of skin tissue colouration for anaesthetists.

Changing examination posture;

A second group of students looked at changing the posture of the patient from lying on their back to lying on their stomachs. This has no effect upon the ability of the machine to carry out a scan. The downward lying posture lobbied for a design that would cater for imagery to be projected from outside the room to a position where the patient could see the video imagery with much less opportunity to tilt and move the head, especially backward. Although evidence suggests a certain level of comfort and familiarity with adopting this stomach down 'sleeping' position for extended periods it could also have the debilitating effect of making the child feel smothered especially as they would not be able to lift them selves out of the position once placed within the machine. [Figure 4].

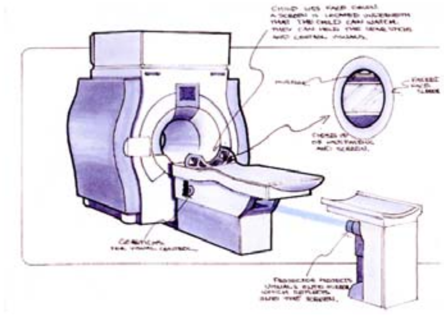

Figure 4. Image created by A Wilcox.

Addressing claustrophobia anxiety;

One of principle triggers for agitation during an MRI examination has been the sensation of claustrophobia as brought on by lying for extended periods within the central bore of the scanner. Claustrophobics may suffer from panic attacks, or fear of having a panic attack. Conversely, patients who are prone to having panic attacks will often develop claustrophobia by association. If a panic attack occurs while they are in a confined space, then the claustrophobic fears not being able to escape the situation. Some manufacturers have suggested room decoration around a room and indeed have gone so far as to develop open sided scanning machines. These machines however are less efficient than the complete circular bore and therefore prolong the scanning time significantly. One suggestion to come from the undergraduate group was the decorating of the interior and exterior of the tunnel wall and the scanner with a mirror finish (non ferrous metallic) so as to reflect the occupant and surroundings, thus attempting to alleviate the claustrophobic experience by suggesting greater space and the comfort of not feeling alone. This 'hall of mirrors' approach also supports the notion that wall surface might reflect the seated parents outside the scanner to a position inside the tube and also at an angle of sight that insists the child remain in the correct 'still' position for the scan to take place [Figure 5]. Application of mirrored surfaces to the exterior of the machine attempted to create the characteristics of depth, openness and depending upon what is reflected in the room tried to avoid disorder and complexity. Posters of savannah type environments have achieved this to some extent and are seen on some manufacturers literature of ideal MRI examination rooms. Calming anxiety with a sense of openness, even by mirrors, is a preference found across all age ranges and cultures and appears to be strongest in children. (Balling and Falkin 1982 & Kellert and Wilson 1993).

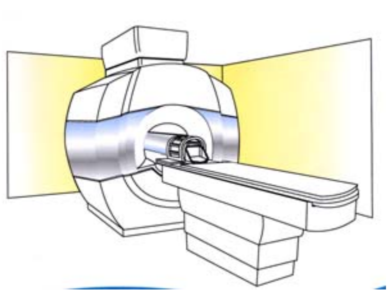

Figure 5. Image created by J A Davies.

Head restraint through costume and role-play;

A further group of students adopted a path of restraining the patient into the desired position but by way of role-play or costume wearing to relieve the associated anxiety of restriction. The solutions proffered to this activity took a number of forms from inflatable rings that sat the child in place and were of a decorative order and minimal restraint, to costumes in which the patient wore a head component that contained a rigid insert that would limit the capacity of the child to turn their head from side to side. Most of the costume solutions also contained the opportunity for the child to wear the product prior to the scanning procedure so as to gain some familiarity and assurance from its wearing. Some solutions also suggested that the characterisation of the suit would also contribute to positive associations enhanced by repeating the use of an associated video thus creating a link between costume character and video story. Role-play is an important part of child development and has been cited as a means of expressing confidence (Donaldson 1978). Simulations and role-playing exercises are one of the oldest of educational methods. (Young children role-play "doctor" and "nurse", "customers" and "shop owners" etc.). If the associated character in any featured story or video demonstrates traits that contribute to desired behaviours in the scanner then the success of the costume, particularly the headgear, will be encouraging. [Figures 6, 7, 8 and 9]. Costume based solutions did raise some concern over hygiene and the added cost of cleaning or disposal between patient examinations. Also the higher than normal room temperatures at the centre of the bore would have the potential to be exaggerated by the wearing of more clothing unless carefully specified.

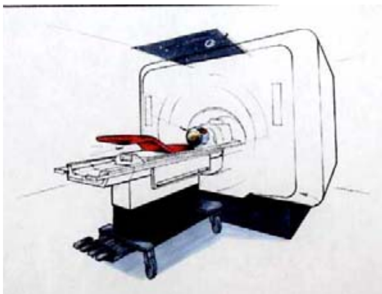
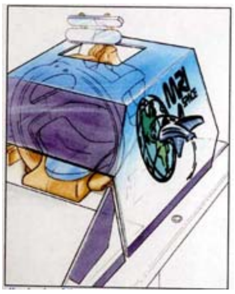

Figure 6. Space ride / astronaut theme created by J Kong.

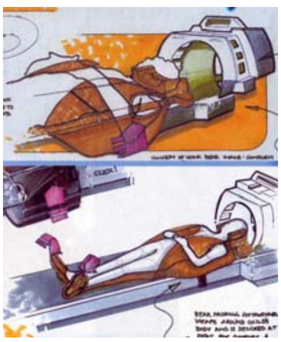

Figure 7. Teddy bear theme created by M Raciti.

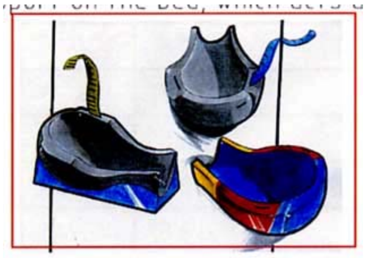

Figure 8. Head restraint moulding created by H Hockley.

Figure 9. Head restraint as a game console created by T Marminc.

Drawing conclusions from the concept outcomes.

It has been commented upon that prescriptive briefs do not usually predicate creative solutions particularly in student design activities (Coker 2004). One of the principle dilemmas faced by introducing case study type projects such this is that they are by their very realism highly restrictive when compared to an otherwise free-thinking University environment. However by applying a largely analytical methodology to a real design issue even relatively young and inexperienced designers with direct guidance have demonstrated that Industrial Design can provide the sort of creative solutions that might elude other disciplines. Even with severe technical limitations as in this project, medical practitioners have either waited for inspiration or adopt an exclusively empirical approach to problem solving. The design outcomes indicate that significant improvements can be made when an external process is introduced to a semi-mature discipline. In this way the relatively inexperienced undergraduate students can still be the catalyst for creative change within a particular domain. Design activity as a mode of research enquiry has a particular application where the aim is to construct objects and systems (Allen 2002).

The principle limitation of time spent on the project within the University curricular has negated the opportunity to build and test outcomes although this is intended in future research. The activity did reveal however that an enormous opportunity exists to investigate how medical products could be better designed to suit child patients and discover in particular how their response to procedures and environmental surroundings in hospital is different from adult patients. Further investigation is intended in this area. In addition to the complexities of designing for this specialist user group the shortcomings of such a case study also suggest further examination of the different roles of those stakeholders in the MRI process. In particular the role of manufacturers of the equipment and the hospitals. Each has their own set of design contexts not always focused upon the user experience especially in those of a very young age. The case study has stimulated debate within user groups of radiographers involved in the development of MRI techniques and placed the user experience and care of young patients into the spotlight of further research and investigation.

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