Animated educational video to prepare children for MRI without sedation: Evaluation of the appeal and values

Szofia Szeszak[1], Rachel Man[2], Andrew Love[2], Gill Langmack[3], Heather Wharrad[3], Robert A Dineen[1, 4, *]

Author Affiliations

1 Radiological Sciences, Division of Clinical Neuroscience, University of Nottingham, Queen's Medical Centre, Derby Road, Nottingham, NG7 2UH, United Kingdom.

2 School of Art & Design, Nottingham Trent University, Waverley Building, Waverley Street, Nottingham, NG7 4HF, United Kingdom.

3 Health E-learning and Media group, School of Health Sciences, University of Nottingham, Queen's Medical Centre, Derby Road, Nottingham, NG7 2UH, United Kingdom.

4 Sir Peter Mansfield Imaging Centre, University of Nottingham, Queen's Medical Centre, Derby Road, Nottingham, NG7 2UH, United Kingdom.

* Corresponding author:

Dr Robert A Dineen

rob.dineen@nottingham.ac.uk

Phone: +44 1158231173

Fax: +44 1158231180

Research Ethics Committee approval

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Abstract

Background. MRI scans can be distressing for children, often resulting in sedation. Educating children about what to expect reduces anxiety and increases likelihood of successful non-sedated MRI scans. Multimedia tools are popular as a means of education. An animation could provide a free, accessible method of preparing children for MRI scans.

Objectives. To evaluate a novel child-friendly animation, in terms of preparing children for MRI and decreasing motion and exam failure

Methods. Following written parental consent and verbal consent from participants, 24 healthy children aged 5-11 years were recruited. Participants underwent pre- and post-viewing questionnaires and structured interviews. Analysis was by comparison of median Likert scale score changes between pre- and post-animation questions and framework analysis of interviews. Participants were filmed viewing the animation to calculate time spent looking at the screen to assess how well attention was retained.

Results. There were significant improvements in median scores regarding what to expect, checking for metal and keeping still. There were no significant changes in other knowledge-based topics. There were significant improvements in median scores for both anxiety-based topics. On average, children watched the screen for 98.9% of the 184 second animation.

Conclusion. The animation improved knowledge, reduced anxiety, retained attention and was enjoyed by participants. It can be accessed freely via the internet to help prepare children aged 5 to 11 for having an MRI scan.

Key words

MRI, Paediatrics, Preparation, Animation

Introduction

Previous studies have found that a number of factors contribute to anxiety felt by children undergoing MRIs, including confined space, the need to be still for a prolonged period of time and the loud noises produced by the MRI scanner [1, 2]. A lack of compliance with the procedural requirements leads to poor quality/non-diagnostic studies. As a result, younger patients are often sedated. However, there are reasons why sedation might not be considered preferable. There are risks and complications associated with anaesthesia which paediatric patients can be particularly vulnerable to including airway compromise and respiratory depression [3]. There is also an increase in resources needed with regard to bed space, anaesthetic staff and MRI compatible equipment.

In an attempt to increase successful completion of MRI scans without sedation, a number of preparatory strategies have been proposed. These generally rely on the basis that if a child is better informed, then they are likely to be less anxious [4, 5]. Preparatory methods include play therapy and mock MRI scans which educate children in an interactive way. Studies have shown that these interventions are often successful in increasing the number of children able to complete an MRI scan without sedation [6, 7].Though these interventions have a high success rate, access can be limited due to lack of mock MRI facilities, shortage of appropriately trained staff or lack of staff/facility time availability to offer adequate preparation. To increase the number of children able to benefit from adequate preparation for MRI scans, more widely-accessible child-friendly methods need to be developed.

There are already examples of multimedia tools to inform children about other healthcare related topics such as the "One of a kind" animation to prepare children for radiotherapy [8]. The presentation of educational materials about hospital procedures in the form of animations can be appealing to children as they may associate watching an animation as a leisurely activity. Animations can be advantageous over some other preparatory methods as they can be made available over the internet allowing distribution that is widely accessible and free. On this basis, we have developed a short animation (Online Resource 1) which illustrates the MRI process with the aim of improving preparation for children undergoing MRI without sedation. The animation was designed to appeal to children aged 5-11 as younger children are unlikely to comprehend the information given in the video. In this study we evaluate the MRI animation in terms of 4 key objectives: (1) to evaluate how well the animation increases knowledge about the process of having an MRI scan, (2) to evaluate how well the animation decreases anticipated anxiety about having to have an MRI, (3) to evaluate the participants' opinions about the animation, and (4) to assess how well the animation retained the participants' attention.

Methods

The MRI animation

The animation lasting 2 minutes 54 seconds (Fig.1 and Online Resource 1), which follows the story of a child named Jess as she experiences an MRI scan, was created by two of the co-authors (RM, AL) with medical input from an experienced paediatric neuroradiologist (RAD). Whilst creating the video, it was found that 3 minutes was the minimum time needed to deliver the key facts. This is also the maximum ideal length of an educational video [9].

The character 'Jess' (Fig. 1a) was developed to represent a typical child who the target audience of children aged between 5-11 years could easily relate to. A second character, 'Sam' (Fig. 1b), was developed to represent the MRI technologist / radiographer. Throughout the animation Jess talks to the audience directly, allowing her to explain the process of the MRI scan without the need for a narrator. Additional information is delivered in the form of explanations that Sam gives to Jess before and during the MRI scan. The script was developed to allow the key basic facts regarding the MRI scan process to be explained in an age-appropriate form. The dialogue between the characters was kept simple, and any technical terms that were mentioned by Sam were interpreted and explained by Jess in a way that a child could understand.

The 'Jess' character displays greater independence than would be expected from a child in the target audience age range (for example, she attends hospital alone), but this was done to allow Jess to present the MRI process with a mild air of adventure, which it was felt would appeal to the target audience and help to retain attention. The animation also includes a carefully thought out imagined space rocket scene in which Jess pretends to be in a space rocket when she goes into the scanner (Fig. 1c). The space rocket analogy aimed to provide a coping mechanism that children could draw upon during their real life MRI scan for some of the key factors identified as causes of MRI-related anxiety in children. For example, the loud noises produced by the scanner can be imagined to be rockets flying past, or the need to have a close fitting head coil for brain MRI could be imagined as wearing an astronaut's helmet.

The design of each scene in the animation was based on real-life MRI equipment at Sir Peter Mansfield Imaging Centre, University of Nottingham. Based on photographs taken at this facility a realistic representation of a clinical MRI scanner was created, modelled in the cartoon-like style to match the characters and to keep consist style across the whole animation (Fig. 1d). The scaling of the modelled MRI scanner was based around the size of Jess. The intention was to show that when Jess is lying on the bed and moved into the scanner, there is very little space around her; indicating to the children watching the animation of the approximate space that there would be once they are in the scanner.

Recruitment

Twenty four participants between the ages of 5-11 were recruited from a primary school and sports club to reflect the. It was thought that the animation would be to too difficult to comprehend for younger children

Exclusion criteria were (1) previous experience of MRI scans (2) history of neurodevelopmental disorder (3) poor English language comprehension (e.g. children for whom English is not their first language and who have only recently arrived in the UK). Informed parental consent was obtained in all cases prior to the child's participation.

Questionnaires and interviews

A questionnaire and interview were designed to ascertain the participants' knowledge of MRI and anticipated levels of MRI-related anxiety before and after watching the animation, and to determine their opinions about the animation.

The questionnaires were designed in the format of a 4 point Likert scale, as Likert scales have been found to be preferred by children over other scales such as simple visual analogue scales and numerical visual analogue scales [10]. The Likert scale was designed as both verbal and pictorial so that children in the lower range of the age group who may have difficulties with reading could still have a clear understanding of which option corresponded with their answer. The options for the Likert scale responses to each question were assigned scores of 1 to 4, with 1 being the worst answer and 4 being the best answer. A four point Likert scale was chosen in order to encourage the participants to discourage participants from choosing a neutral answer as this would be the easiest option. This meant that the children had to concentrate on listening and understanding the questioning to make a decision rather than relying on choosing a neutral option. Removal of the "uncertain" option also decreases "social desirability bias" [11] which is caused by the participants' desire to give the most socially acceptable answer in order to please the interviewer.

The knowledge-based section of the questionnaire was designed to determine the participants' understanding about key elements of the MRI procedure using the following topics: (1) "What to expect" (2) "Checking for metal objects" (3) "Wearing headphones" (4) "Amount of room in the scanner" (5) "Noise of the scanner" (6) "Keeping still" (7) "Length of scan". The anxiety-based section focused on 2 topics: (1) "Feeling nervous" (2) "Looking forward to scan". With regard to the opinion section of the questionnaire, the questions focused on the audio-visual aspects of the animation as well as overall enjoyment.

The interview schedule also consisted of these three sections and aimed to gain a more detailed view of the participants' understanding, anxiety and opinions than the questionnaire.

The questionnaire and interview were then reviewed for content validity by 2 experts in the fields of child-health and e-learning. Following this, face validity was tested by recruiting 2 children aged 6 and 8 years from a local primary school to read through the questionnaire and report back on any words, phrases or questions that they did not fully understand. Both children reported that they had no difficulties with understanding any aspect of the questionnaire.

Data collection

To standardise data collection, a single researcher (SS) administered all questionnaires and participant interviews. Before each child began, they were told to imagine that they had been told that they would have to have an MRI scan. They then completed the pre-animation questionnaire and undertook an audio-recorded interview. Participants then watched the animation whilst being video recorded, and finally completed the post-animation questionnaire and interview. The role of the researcher was only to administer the questions and to assist in helping participants to understand questions if there was a problem with comprehension. The answers given were the participants themselves and they rated their own anxiety entirely independently.

Data analysis of questionnaires

Data was analysed using a mixed methods approach. Differences between pre- and post-animation Likert data based on knowledge and anticipated anxiety were tested using the Wilcoxon signed rank test as the Likert scale scores were considered ordinal values. Results were deemed statistically significant when $p<0.05$.

To analyse the participants' opinions about the animation, the frequencies of different responses in the opinions-based section of the questionnaire were calculated. Particular attention was paid to opinions surrounding the rocket analogy, with age-preference for this component of the animation examined by comparison of mean ages of participants who did and did not like this section.

Video recordings were analysed by calculating the mean and range of time (in seconds) that the participants spent looking away from the screen. Further analyses were done by testing for correlation between the ages of participants and the amount of seconds spent looking away from the screen.

Framework analysis [12] was carried out on the anxiety-based interview responses, allowing reflection of the participants' responses through organising them into emerging themes.

A number of questions were asked in both the questionnaire and interview with the initial aim of ascertaining both quantitative data from the questionnaires on which numerical data analysis could be carried out and qualitative data from the interview to give a deeper insight into the participants' knowledge and opinions. However, these questions were also used to test for consistency between questionnaire and interview responses, with calculation of the number of inconsistencies for each question and comparing the mean ages of participants giving consistent responses to the mean ages of participants giving inconsistent responses. This tested validity retrospectively to ascertain how reliable the results of the numerical data analysis were.

Results

24 parents consented to their child's participation. Of these, one participant withdrew prior to data collection on the grounds that they were unwilling to co-operate with the data collection process. Of the remaining 23 participants, 13 were female and 10 were male. The ages were distributed across the age range with a mean age of 7.65 (SD.2.01) (Fig. 2).

Knowledge-based questionnaires

There were statistically significant improvements in children's knowledge in 3 of the 7 questions when comparing pre- and post-animation scores ("What to expect"," checking for metal objects" and "keeping still"). All 3 increases were by a median score change of +1

(Wilcoxon signed rank test, ($p<0.05$), Table 1).

A further 2 topics ("having to wear headphones" and "the level of noise") showed increases in median scores which were not statistically significant (Wilcoxon signed rank test, ($p>0.05$,) Table 1). The remaining 2 topics ("amount of room inside scanner" and "length of scan") showed no change in median score. For these 4 topics, the majority of participants showed no change in individual score. The number of positive changes compared to the number of negative changes for the remaining participants were generally similar.

Anxiety based questionnaires

Questions regarding anticipated anxiety relating to MRI ("anxiety about having a scan" and "looking forward to having a scan") showed significant improvements of +1 in median score (Wilcoxon signed rank test, ($p<0.05$), Table 2). There were a high number of participants with increased or unchanged individual scores with a very small minority showing decreased score changes.

Opinion Questionnaires

100% of participants responded that they liked the way the animation looked, that the people in the animation looked friendly, and that they found it easy to hear what the people were saying. 95.7% of participants reported that they liked the MRI animation overall. 87% of participants reported that they would like to see more animations of this sort for other hospital tests and treatments.

With regard to opinions about the rocket analogy used, 65.2% of participants responded that if they had to have an MRI scan in the future, they would imagine they were in a space rocket like Jess. The mean age of participants giving this response was 8.53 (SD. 3.89), whilst the mean age of the remaining 34.8% of participants responding that they would not apply the rocket analogy was 7.25 (SD 1.28). There was no statistically significant difference between the two mean ages.

Interviews

Pre-animation feelings regarding MRI scans - Fear and anxiety were the two main themes elicited. The reasoning behind these emotions was fairly consistent across most participants. Common ideas were "fear of the unknown", a complication in the MRI process e.g. "I might not go in it properly", or most commonly of all that the MRI scan might find something wrong.

Post-animation feelings regarding MRI scans - The main theme within this section was an overall increase in confidence surrounding MRI scans. All participants reported that they felt better about the idea of having an MRI scan, and that the animation had made the MRI experience seem less frightening. A common recurring idea was that though the MRI process might still seem a little frightening, it is doable e.g. "You might be nervous at first but it will be alright" and "Jess was scared but she still did it". Despite participants reporting that they felt better about the MRI process, areas of anxiety were still found. Reasons for this were related to worries about their ability to comply with specific parts of the process e.g. "I might think I've got all the metal stuff (out of my pockets) and I wouldn't have". The most common reason for continued anxiety was worry that the MRI scan might find something wrong.

Video recordings

The mean number of seconds spent not looking at the laptop screen during the 2 minutes 54 second animation, was 1.8 seconds (SD. 1.77), meaning that the average child spent 98.9% of time watching the screen during the animation. The longest amount of time that a child spent not looking at the screen was 6 seconds, and the shortest was 0 seconds. One third of the children spent 100% of time during the animation looking at the screen. No correlation was found between age and number of seconds spent looking away from the screen ($r = 0.19$, $p = 0.43$).

Questionnaire responses vs Interview responses

6 Questions featured in both the interviews and the questionnaires allowing comparison for consistency. High levels of consistency (73% to 100% consistent) were found for between responses in the interviews and questionnaires concerning participants' opinions about the cartoon ("I thought the people on the cartoon looked friendly", 100% consistent responses; and "Overall I liked the MRI cartoon", 100% consistent responses), and participants' feelings towards having an MRI scan ("I would be worried about having an MRI scan", 73.9% consistent responses; "Hearing Jess's story would make me feel happier about having a scan", 95.7% consistent responses).

There was, however, a high level of inconsistency between questionnaire and interview responses for the question examining participants' knowledge about MRI scans before watching the animation ("I would know what to expect if I needed to have an MRI"). Only 26.1% of responses were consistent. Participants that gave consistent responses were on average older than those giving inconsistent responses (8.8 +/- 2.3 years vs 7.3 +/- 1.9 years), but this difference was not statistically significant. Of the inconsistent responses, all were participants responding that they would know what to expect from an MRI scan in the questionnaire, but giving inadequate answers in the interview.

When participants' knowledge about MRI scans was tested after watching the animation ("I could tell other children what happens when you have an MRI scan"), 73.9% of responses were consistent responses between the questionnaire and the interview. Of the inconsistent responses, all were participants responding that they would not be able to tell other children what happens when you have an MRI scan when asked in the questionnaire, but being able to explain what happens adequately when asked in the interview to describe what they would say if they had to explain what happens during an MRI.

Discussion

We have demonstrated that the novel animation improves knowledge about MRI, reduces anticipated anxiety, retains attention and is enjoyed by children in the target age range.

Knowledge

Following watching the animation there were statistically significant improvements in knowledge for three of the seven questions. Having to keep still in the scanner and having to take metal out of pockets were topics which were well covered by the animation. This was reflected by the significant increases of +1 in median scores for each. For the question related to knowing what to expect from an MRI scan, there was also a statistically significant median improvement of +1. In this case however, comparisons between questionnaire and interview questions suggested that this median increase may not be representative of the participants' actual increase in knowledge. Though no participants were able to give adequate answers to what they would expect from an MRI scan in the pre-animation interview, many participants selected the option that they would know what to expect in the questionnaire. As well as this, in the post-animation interview, many participants were able to adequately explain what happens during an MRI in the interview, but selected that they would not be able to explain in the questionnaire. This over-estimation of knowledge in the pre-animation questionnaire and under-estimation in the post-animation questionnaire suggests that there is a strong possibility that had the participants answered the questionnaires in a way that was representative of their knowledge, then the median improvement for this question would be higher.

The responses to questions about wearing headphones and the noise inside the scanner showed increases in median score which were not statistically significant, despite both of these topics being clearly presented in the animation. Once again, when asked about these topics in the post-animation interview, participants were able to answer them well, suggesting that the non-significance change may be due to difficulties in using or understanding the Likert scale questionnaire.

The questions surrounding the amount of room in the scanner and the length of the scan showed no median increase in score. This is likely due to the fact that neither of the answers to these questions are confirmed verbally in the animation. The amount of room in the scanner is only presented visually by the size of the scanner in comparison to Jess. The length of the scan isn't mentioned in the animation and it appears that Jess spends very little time inside the scanner which is misleading. A subsequent version of the animation has since been created in which these corrections have been applied (Online Resource 2).

Anxiety

With a statistically significant score improvement of +1 in both anxiety-related questions, the animation appeared to be successful in reducing anticipated anxiety and showed that participants' feelings changed from feeling anxious or scared to looking forward to the scan. Unlike with knowledge-based questions, the consistency between questionnaire and interview questions was high, suggesting that the results from the questionnaire were an accurate representation of the participants' opinions.

Despite the success of the animation in reducing anxiety, a number of participants reported that they would still feel a little anxious about having an MRI scan. The main reason given for this was that the scan might find something wrong. This cause of anxiety was not something that the animation was designed to, or easily could, address.

We acknowledge that this is a simulated situation, in that none of these participants were going to actually undergo a MRI scan; we were asking the participants to imagine how they would feel if they were told that they were going to have a MRI scan. Consequently it is difficult to be certain how this apparent reduction in MRI-related anxiety would translate into a real-world setting.

Opinions

Results show that the animation was very well received overall. The responses to the questions surrounding the audio-visual aspects of the animation were very positive. The participants' opinions surrounding the characters were also positive with all participants reporting that the characters looked friendly.

Concerning the rocket analogy, a majority of participants (65.2%) responded that they would apply it to a future MRI scan. Despite findings in the past that age is a significant factor in ability to use and apply analogies in children [13]. In this case age was not found to be a significant factor in considering applying the analogy.

Attention

Results demonstrated that the animation was highly successful in maintaining the participants' attention throughout the animation so it is unlikely that the animation's ability to maintain the participants' attention was a factor in the gaps in the participants' knowledge found in the post-animation questionnaires. Maintenance of attention was independent of age. This shows that despite the fact that children's attention-span lengthens with age [14], the length and content of the animation appears to be suitable even for the youngest members of its target audience. By the age of 5, children are able to give their full attention but only for short periods of time [15], so it may be likely that if the animation would be longer, then there may be a more strongly (and potentially significant) negative correlation between age and time spent looking away from the screen. Therefore, the animation as it currently stands is an ideal length to maintain the attention of the whole age range of its target audience. Filming the participants allowed analysis of visual attention. It should be noted that these findings are based on visual attention only and therefore without definitive knowledge of mental attention.

Limitations

The sample size was small at n=24. A larger sample size may have allowed some of the non-significant increases in scores from the questionnaires to reach statistical significance, but were limited in sample size by practical constraints. This sample size did allow us to find statistically significant improvements in key areas relating to knowledge and anticipated anxiety.

The Socioeconomic status (SES) of the participants was not recorded, therefore the relationship between SES and the success of the animation was not calculated.

The study was carried out using healthy participants who did not have an MRI scan following the animation. Therefore, the results surrounding the animation's ability to reduce anxiety were based on anticipated anxiety only. To fully evaluate the success of the animation, a further study could be carried out where participants have an MRI scan following the animation. A post-MRI questionnaire about anxiety would give a result that is more representative of the animation's ability to reduce anxiety rather than anticipated anxiety.

The post-animation questionnaire and interview were carried out immediately after viewing the animation. In order to assess long term learning retention, a follow up study could be carried out by inviting the participants back and repeating the post-animation questionnaires and interviews at a later date.

There are also limitations to the animation itself that could be improved upon if later versions were to be created. The astronaut analogy is probably most relevant to children undergoing cranial MRI scanning, as these children have to have their heads placed inside a head coil that resembles a helmet. Ideally other animations should be developed for children undergoing other types of MRI scanning such as body or extremity imaging.

Conclusion

The animation improved knowledge and reduced anticipated anxiety regarding having an MRI scan. The animation was enjoyed by participants and retained attention well. This animation can be used to help prepare children in the 5 to 11 year age group for having an MRI scan. The version in which the knowledge-based improvements have been applied (Online Resource 2) can be accessed freely via the internet at the YouTube channel 'MRI for Kids'.

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Figure legends

Fig.1a The main character Jess who narrates throughout the animation

Fig.1b Radiographer Sam with Jess as she goes into the scanner

Fig.1c The rocket scene imagined by Jess to help cope with the loud noises produced by the scanner

Fig.1d Animated MRI scanner with directly proportional measurements to the the MRI scanner at Sir Peter Mansfield Imaging Centre University of Nottingham

Fig.2 Age distribution of male and female participants showing a minimum age of 5 and a maximum age of 11 with a mean of 7.65 (SD. 2.01) so ages of participants were spread sufficiently equally across the age range (5-11) of the study

Table 1 Table shows changes in Likert scale score for questionnaire responses to knowledge-based questions and whether the changes were significant where $p<0.05$

Table 2 Table shows changes in Likert scale score for questionnaire responses to anxiety-based questions and whether the changes were significant where $p<0.05$

Online Resource 1 Original animation

Online Resource 2 Edited animation which includes information about length of scan and size of scanner