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ORIGINAL ARTICLE

# Animated educational video to prepare children for MRI without sedation: evaluation of the appeal and value

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**Abstract**
*Background* MRI scans can be distressing for children and often require sedation. Educating children about what to expect reduces anxiety and increases likelihood of successful non-sedated MRI scans. Multimedia tools are a popular means of education. Animated video could provide a free, accessible method of preparing children for MRI scans.
*Objective* To evaluate a new animation video for preparing children for MRI, specifically for decreasing in-scanner motion and examination failure.
*Materials and methods* We recruited 24 healthy children ages 5–11 years. Participants underwent pre- and post-viewing questionnaires and structured interviews. We then compared median Likert scale score changes between pre- and post-animation questions and analyzed the interview framework. Participants were filmed viewing the animation to calculate time spent looking at the screen to assess how well the video retained children's attention.
*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 anxiety-based topics. On average, children watched the screen for 98.9% of the 174-s 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 ages 5–11 for having an MRI scan.

**Keywords** Child · Education · Magnetic resonance imaging · Multi-media · Preparation

## Introduction

Studies have found that a number of factors contribute to anxiety felt by children undergoing MRI scans, including the 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 often leads to poor-quality or non-diagnostic studies. As a result, younger children are often sedated. However, risks and complications have been associated with anaesthesia to which children can be particularly vulnerable, 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.

Several preparatory strategies have been proposed for increasing the proportion of successful MRI scans without sedation. These are generally based on findings that if children are better informed, then they are likely to be less anxious [4,

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5]. Preparatory methods include play therapy and mock MRI scans that educate children in an interactive way. Studies have shown that these interventions are often successful in increasing the proportion of children who can complete an MRI scan without sedation [6, 7]. Although these interventions have a high success rate, access can be limited by a lack of mock MRI facilities, shortage of appropriately trained staff or lack of staff/facility time to offer adequate preparation. To increase the number of children who can benefit from adequate preparation for MRI scans, more widely accessible, child-friendly methods need to be developed.

Multimedia tools have been used to teach children about other health care 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 because they might associate watching an animation video as a leisurely activity. Animations can be advantageous over some other preparatory methods because videos can be made available over the Internet, allowing distribution that is widely accessible and free. On this basis, we have developed a short animation (Supplementary material 1) that illustrates the MRI process with the aim of improving preparation for children undergoing MRI without sedation. The animation video was designed to appeal to children ages 5–11 years; younger children are unlikely to comprehend the information in the video. In this study, we evaluate the MRI animation in terms of four key objectives: (1) how well the animation increases knowledge about the process of having an MRI scan, (2) how well the animation decreases anticipated anxiety about having to have an MRI, (3) participants' opinions about the animation and (4) how well the animation retained the participants' attention.

## Materials and methods

The University of Nottingham Medical School Research Ethics Committee approved this study. We obtained informed written consent from parents and verbal consent from participants.

### The MRI animation

The animation video lasts 2 min 54 s (Fig. 1 and Supplementary material 1, animation © Rachel Man 2014) and follows the story of a girl named Jess as she experiences an MRI scan. The video was created by two of the co-authors (R.M., A.L.) with medical input from a paediatric neuroradiologist (R.A.D.8 years experience as fully certified specialist). Whilst creating the video, it was found that 3 min 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 was developed to represent a typical child who the target audience of children ages 5–11 years could easily relate to. A second character, Sam, was developed to represent the MRI technologist/radiographer. Throughout the animation Jess talks to the audience directly, explaining the process of the MRI scan. 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 mentioned by Sam are interpreted and explained by Jess in a way that a child could understand.

Jess displays greater independence than would be expected from a child in the target audience age range (for example, she is at the hospital alone), but this was done to allow Jess to present the MRI process with a mild air of adventure, which it was thought 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. The space rocket analogy provides a coping mechanism for children to draw upon during their real-life MRI scan to counter 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 the Sir Peter Mansfield Imaging Centre, University of Nottingham, Nottingham, United Kingdom. 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 be consistent in style throughout. 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 inside the scanner.

### Recruitment

Twenty-four participants ages 5 years to 11 years were recruited from one primary school and one sports club. 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). Socioeconomic status of individual participants was not collected. Based on UK Census data from 2001, the primary school

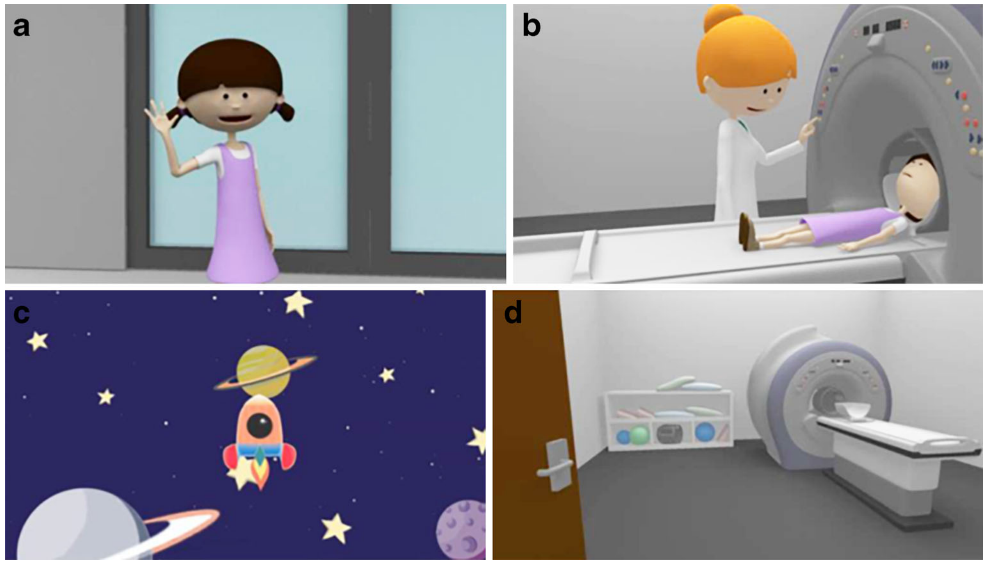


**Fig. 1** Screenshots from the educational video. **a** The main character, Jess, who is having an MRI scan and who narrates throughout the animation. **b** Radiographer Sam with Jess as she goes into the scanner. **c** The rocket scene imagined by Jess to help cope with the loud noises produced by the scanner. **d** Animated MRI scanner with directly proportional measurements to the MRI scanner at the Sir Peter Mansfield Imaging Centre, University of Nottingham, Nottingham, United Kingdom

was located in an electoral ward in which 39% of people aged 16 and over fall within the ABC1 (middle class) demographic groups; the comparable figure for the electoral ward in which the sports club was located is 45%, and for England the figure is 52%. This indicates that the children recruited were from institutions in areas with socio-economic status lower than the average for England.

## Questionnaires and interviews

A questionnaire (Supplementary material 2) and interview (Supplementary material 3) 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 because this scale has 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 might 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 discourage participants from choosing a neutral answer. 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 and (7) length of scan. The anxiety-based section focused on two topics: (1) feeling nervous and (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, with the goal of gaining a more detailed view of the participants' understanding, anxiety and opinions.

The questionnaire and interview were then reviewed for content validity by two experts in the fields of child-health and e-learning. Following this, face validity was tested by recruiting two children ages 6 years 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 (S.S.) administered all questionnaires and participant interviews. Before beginning, children were each told to imagine being 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 they 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. Once it was ensured that the participants understood the question, no further prompts were given. Participants rated their own anxiety entirely independently.

### Data analysis

Data were 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 because the Likert scale scores were considered ordinal values. Results were deemed statistically significant at $P<0.05$.

To analyse the participants' opinions about the animation, we calculated the frequencies of different responses in the opinions-based section of the questionnaire. 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 number of seconds spent looking away from the screen.

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

Several questions were asked in both the questionnaire and interview, with the initial goal 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

Twenty-four parents consented to their child's participation. Of these, one participant withdrew prior to data collection on the grounds that the child was unwilling to co-operate with the data collection process. Of the remaining 23 participants, 13 were boys and 10 were girls. The ages were distributed across the age range, with a mean age of 7.65 years (standard deviation [SD] 2.01 years) (Fig. 2).

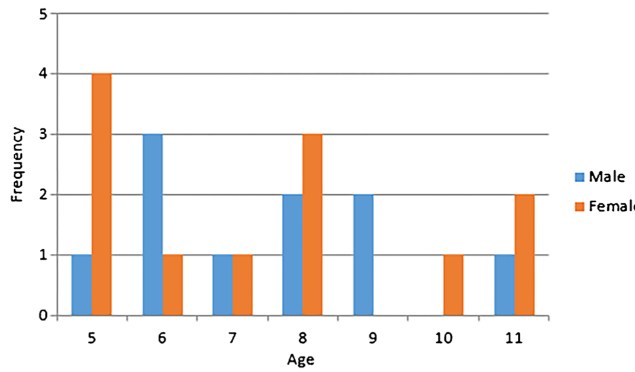


**Fig. 2** Graph shows age distribution of male and female participants. There was a minimum age of 5 years and a maximum age of 11 years, with a mean of 7.65 years (standard deviation 2.01 years), so ages of participants were spread sufficiently equally across the age range of the study

### Questionnaires

There were statistically significant improvements in children's knowledge in three of the seven questions when comparing pre- and post-animation scores ("What to expect", "checking for metal objects" and "keeping still"). All three increases were by a median score change of +1 (Wilcoxon signed rank test, $P<0.01$, Table 1).

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, $P<0.01$, Table 2). There was a high number of participants with increased or unchanged individual scores with a very small minority showing decreased score changes.

All 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. Twenty-two of 23 (96%) said that they liked the MRI animation overall. Twenty of 23 (87%) said 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, 15/23 (65%) responded that if they had to have an MRI scan in the future, they would imagine they were in a space rocket like Jess.

### Interviews

Fear and anxiety were the two main themes elicited as the pre-animation feelings regarding MRI scans. 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 that the MRI scan might find something wrong.

**Table 1** Changes in 4-point Likert scale score for questionnaire responses to knowledge-based questions

| Knowledge-based questions | Pre-animation median score | Post-animation median score | Change in median score | Number of positive changes in score | Number of negative changes in score | Number of no changes in score | Wilcoxon signed rank test, *P* |
|---|---|---|---|---|---|---|---|
| What to expect during an MRI scan | 3 | 4 | +1 | 19 | 0 | 4 | 0.001 |
| Having to check for metal in pockets | 3 | 4 | +1 | 12 | 2 | 9 | 0.006 |
| Having to wear headphones | 3 | 4 | +1 | 7 | 6 | 10 | 0.742 |
| Amount of room inside the scanner | 2 | 2 | 0 | 4 | 6 | 13 | N/A |
| Having to keep still in the scanner | 3 | 4 | +1 | 15 | 1 | 7 | <0.001 |
| Level of noise | 3 | 4 | +1 | 6 | 0 | 17 | 0.260 |
| Length of scan | 2 | 2 | 0 | 7 | 7 | 9 | N/A |

*N/A* No change in median score; *P*-value cannot be calculated

The main theme in the post-animation feelings regarding MRI scans 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 was 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 min 54 s animation was 1.8 s (SD. 1.77), meaning that the average child spent 98.9% of time watching the screen during the animation. The longest a child spent not looking at the screen was 6 s. One-third of the children looked at the screen for the duration of the movie. No correlation was found between age and number of seconds spent looking away from the screen.

## Questionnaire responses vs. interview responses

Six questions featured in both the interviews and the questionnaires, allowing comparison for consistency. High levels of consistency (73% to 100% consistent) were found 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. 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

**Table 2** Changes in 4-point Likert scale score for questionnaire responses to anxiety-based questions

| Feelings-based questions | Pre-animation median | Post-animation median | Change in median | Number of positive ranks | Number of negative ranks | Number of no changes in score | Wilcoxon signed rank test, *P* |
|---|---|---|---|---|---|---|---|
| Anxiety about scan | 2 | 3 | +1 | 10 | 2 | 11 | 0.007 |
| Looking forward to scan | 2 | 3 | +1 | 11 | 1 | 11 | 0.003 |

$P < 0.05$ deemed statistically significant 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.

After 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 that 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 might not be representative of the participants' actual increase in knowledge. Although no participants gave 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. Additionally, in the post-animation interview many participants did adequately explain what happens during an MRI in the interview, even after they had selected in the questionnaire that they would not be able to explain this. This over-estimation of knowledge in the pre-animation questionnaire and under-estimation in the post-animation questionnaire suggests 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 that 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 might be a result of 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 because neither of the answers to these questions is 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 been created in which these corrections have been applied (Supplementary resource 4).

With a statistically significant score improvement of +1 in both anxiety-related questions, the animation appears to be successful in reducing anticipated anxiety and shows that participants' feelings changed from 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 address, nor one that could be easily addressed in a video.

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

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 past findings that age is a significant factor in children's ability to use and apply analogies [13]. In this case age was not found to be a significant factor in considering applying the analogy.

Results demonstrated that the animation was highly successful in keeping the participants' attention, so it is unlikely that any lack of attention led to gaps in the participants' knowledge as found in the post-animation questionnaires. Maintenance of attention was independent of age. This shows that despite the fact that children's visual attention develops with age [14], the length and content of the animation appears to be suitable even for the youngest members of its target audience. The changes in attention known to occur with normal development [14] over the age range of our study population means that a longer animation could potentially lead to significant negative correlation between age and time spent looking away from the screen, although this was not tested by our study. 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 the underlying cognitive processing beyond gaze direction.

Several limitations need to be acknowledged. The sample size was small. A larger sample size might have allowed some of the non-significant increases in scores from the questionnaires to reach statistical significance, but we were limited in sample size by practical constraints. The socioeconomic status of the participants was not recorded, therefore the relationship between socioeconomic status 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. 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 true 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 because these children 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 their attention. 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 (Supplementary material 4, animation © Rachel Man 2015) can be accessed freely via the internet at the YouTube channel "MRI for Kids".

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**Compliance with ethical standards**

**Conflicts of interest** None

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