

Improving Patients' Experience of MRI: Why and How Reducing Stress and Anxiety in Patients May Enhance Clinical Operations

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Introduction

Magnetic resonance imaging (MRI) is non-invasive and painless, with excellent spatial resolution and soft-tissue contrast. These numerous benefits have rendered MRI one of the most important diagnostic tools in modern medicine. In Germany, 150 MRI examinations are performed per 1,000 inhabitants every year [1]. Yet, MRI also has substantial drawbacks: Most MRI protocols are time-consuming and very dependent on the patient's cooperation and ability to lie motionless. One of the main roots for disruptions to MRI workflows is stress and anxiety in patients, who often experience MRI as uncomfortable and frightening [2, 3]. Beyond creating a negative patient experience, feelings of anxiety and stress may relate to unexpected patient-related events such as motion artifacts, the need for sedation, or failed scans; these events result in a substantial amount of revenue lost [4–6]: Andre et al. [4] calculated that US\$ 115,000 are lost per scanner every year due to unexpected patient behavior.

The aim of this article is to provide a holistic picture of patients' experience of MRI, related unexpected behaviors and consequences, and approaches to improve the situation for all concerned: patients, healthcare staff, and the medical institutions. The focus is to provide insights into the "Patient Experience (PX) in MRI" collaboration project between Siemens Healthineers, the Chair of Health Psychology (FAU Erlangen-Nürnberg), and Universitätsklinikum Erlangen, Department of Radiology. During this collaboration project, two empirical studies and one systematic review with meta-analysis were conducted and will be presented in the following.

Take-home points

- Although most patients tolerate MRI well, a substantial number of patients experience clinically relevant levels of anxiety; related unexpected patient behaviors disturb clinical workflows and impede efficiency of healthcare providers.
- Patients' response to MRI depends on many different factors; previous negative experiences with MRI and female sex seem to be particularly predictive of a negative patient experience.
- In order to address individual patients' needs, different materials for patient preparation should be offered: Not only informational material, but also measures to support active modulation of anxiety, e.g., relaxation exercises.
- Patients who experience high levels of stress or anxiety tend to lie less still, which may provoke motion artifacts and the need for scan repetitions, thereby prolonging procedural times. Therefore, reducing stress and anxiety in patients might not only improve the patient experience, but also lead to clinical workflows running more smoothly.

Patients' experience of MRI: An introduction

How patients experience MRI has been a topic of interest since the very beginnings of MRI. In the course of MRI paving its way from the 1980s on, it soon became apparent that many patients fear this medical "coffin" [7]; Figures 1A and 1B show that, indeed, early MRIs resembled "mechanical monster[s]" [7]. Since then, many technological advancements have made MRI more patient-friendly: Recent MRI machines produce less noise, are equipped with shorter, wider bores that are open at both ends, and acquire images much quicker, thereby reducing scan duration [8, 9]. Some studies report that these advancements have resulted in reduced levels of stress and anxiety, as well as related operational issues [6, 10, 11]. Yet, others find that – although most patients tolerate MRI well – stress and anxiety are still widespread phenomena reaching levels that are considered clinically relevant in around 30% of patients [12, 13]. Two questions arise from these findings:

- 1) What factors differentiate patients who fear MRI from the rest?
- 2) To what extent have technical advancements brought about improvements regarding the patient experience of MRI examinations and related behaviors?

Adequate patient preparation seems to be most decisive in preventing a negative patient experience and fostering smooth clinical workflows

In our "baseline" study, our aim was to analyze patients' response to MRI in detail including influencing factors and consequences [12]. We thereby considered patients' psychological response (i.e., anxiety), the physiological response (i.e., salivary stress markers), and operational effects on clinical processes (i.e., scan repetitions due to motion artifacts, scan duration).

The study was conducted in the department of radiology of Universitätsklinikum Erlangen. We examined anxiety and physiological stress markers in 96 patients undergoing MRI ($M = 49$ years, 61.5% female). Anxiety was assessed via questionnaires before and after MRI; at the same time-points, we took saliva samples to measure salivary stress markers (cortisol, alpha-amylase).

In general, most patients tolerated MRI well. Yet, every third patient experienced moderate to severe levels of anxiety in anticipation of the examination and experienced relief only after having endured the examination. As suggested by Ahlander et al. [14], this implies that efforts to improve the patient experience might be most effective



1 (1A, B) While the first MAGNETOM MRI scanner from 1983 [41] might have been a scary sight, only a few years later product development focused also on patient comfort. (1C) In 1993, Siemens introduced the 0.2T MAGNETOM Open. (1D, E) In 1996 the product line around MAGNETOM Symphony featured a flared bore. (1F) In 2004 MAGNETOM Espree was the world's first 1.5-tesla system with a 70-centimeter opening. (1G) Today a relaxing atmosphere, noise reduction and fast sequences make MRI easier to tolerate.

when applied in advance. Materials for patient preparation can only reduce anticipatory anxiety when given with sufficient lead time, ideally a few days/weeks before the examination.

We examined a broad range of potentially influencing factors (sex, age, positioning, accompanying persons, pain, previous experiences, examined body part) and found them to interact with patients' response in a complex way. Women receiving breast examinations had a particularly high risk of anxiety. This is in line with previous studies that reported a more negative response to MRI in women vs. men [6, 12, 15]. Further, we found that negative experiences made during previous MRI examinations significantly predicted a negative experience during the current examination. That means that patients who once have a negative MRI experience tend to keep on having bad experiences. When integrating our results on the impact of age and positioning with other studies, the state of research appears to be less clear [6, 12, 16–18]. Most certainly, it can be deduced that patients differ considerably regarding their response to MRI and their needs, which is why they also require different approaches to address these needs.

Furthermore, we found evidence of a link between patients' experience and clinical workflows: Patients' response to MRI predicted the probability of scan repetitions and scan duration [12], thereby supporting previous results that reported a connection between the patient experience and the prevalence of unexpected patient-related events [5, 19–22]. For example, an increase of 1 nmol/L in the stress marker salivary cortisol predicted a prolongation of the scan duration of more than 4 minutes [12].

Apart from individual factors that influence patients' experience of MRI, technological advancements have been proposed that aim to have a positive impact on stress and anxiety as well as related behavioral issues in patients. Yet, until now, no systematic review has summarized the patient experience of MRI, related unexpected patient behaviors, and their evolution along with technological advancements holistically. We sought to overcome this research gap in a systematic review with a meta-analysis that we conducted on patients' response to MRI, its effects (i.e., unexpected patient behaviors related to stress and anxiety), and their evolution over time [20].

Evolution of patients' experience of MRI and related unexpected patient behaviors over time: A systematic review and meta-analysis

We searched four databases and screened more than 12,000 studies. Meta-analysis of 44 studies revealed that, despite the common understanding of patient anxiety, there have been no significant improvements over time in the amount of anxiety experienced: Average values of reported anxiety were close to the cut-off considered

as clinically relevant and around 4% of patients reported to be unwilling to undergo further MRI examinations. Similarly, the rates of unexpected patient-related events such as no-shows, failed scans, motion artifacts, and sedation, have not significantly reduced over time. While these findings could be traced back to statistical issues or the fact that we had to use the year of study publication as an indicator of MRI technology as more exact data on scanner technology was unavailable for most studies, it might as well reflect the fact that patients still experience substantial stress and anxiety in the context of MRI. An additional interesting finding was that claustrophobia significantly moderated the overall number of unexpected patient events. The rates of unexpected behaviors such as no-shows, motion artifacts, failed scans, and sedation were higher in patient groups with higher levels of claustrophobia. This supports the notion of a link between the patient experience and clinical workflows as has been postulated previously [5, 19, 21, 22].

Based on the results of the baseline study and meta-analysis, it can be concluded that stress and anxiety in patients have always been and still are a relevant topic in the context of MRI. In short, technological advancements of the MRI scanners alone might not be sufficient to improve the patient experience of MRI or related unexpected events – at least until now. There seems to be a need for interventions that target patients' needs more explicitly. The evidence generally suggests that MRI-related patient anxiety and related effects can be prevented when we enrich standard care and properly address patients' needs.

How patient's experience of MRI can be improved: An overview

A wide variety of interventions to improve patients' experience of MRI has been developed and tested in the past. Approaches range from easy-to-implement measures to very elaborate and complex ones: From the supply of music or having someone accompany the patient, to variations in patient positioning or the environment, mock MRI, aromatherapy, amended patient information, distraction via VR, hypnosis and other relaxation strategies, to communication training for the medical personnel.

Many of these approaches have been proven to be effective (see Munn et al. [17] for an overview), but this article will focus on interventions specifically targeted at patient preparation.

Two major types of interventions for patient preparation can be distinguished:

- The aim of informational interventions is to reduce ambiguity and feelings of uncertainty that may constitute a stressor for patients [2, 23, 24]. Although

many studies report beneficial effects of additional information, others find even negative effects when information is provided exclusively [17].

- A different approach aims at enhancing a patient's ability to cope with the stressful situation more successfully, e.g., via relaxation techniques [25, 26]. Although consistently positive, the effect sizes of these interventions vary considerably [17].

The majority of the literature points toward substantial benefits of interventions to improve the MRI patient experience; yet, some questions remain unresolved: Why do some studies report positive effects of informational interventions but others don't? Where do the considerable variations in the reported effect sizes of coping interventions trace back to? And is there a link between patient experience and clinical processes?

Patient preparation should cover different needs of patients

In order to address these questions and help to enhance the patient experience of MRI, we developed a patient

education toolkit (see Fig. 2) in collaboration with Siemens Healthineers MR marketing and tested it in clinical trial. We based our approach on the assumptions of the "Model of Coping Modes" [27, 28], which may contribute to explaining the inconsistencies described above. The model describes different ways of coping with stress-inducing situations that people tend to employ habitually. The model proposes vigilance and cognitive avoidance as two basic dimensions of how attention shifts when facing stressful situations. While cognitive avoidance means the tendency to divert attention from threatening cues to reduce the bodily arousal induced by these, vigilance refers to the opposite: An increased focus on threatening cues to enhance knowledge about the situation and reduce feelings of uncertainty [25, 27]. Figure 3 depicts the four coping styles that can be differentiated on the basis of these two dimensions. According to this scheme, it can be expected that sensitizers benefit from receiving additional information: It should enable them to reduce feelings of uncertainty successfully. By contrast, repressors should benefit from distraction and relaxation, which supports distracting attention away from the threatening cues that induce arousal.



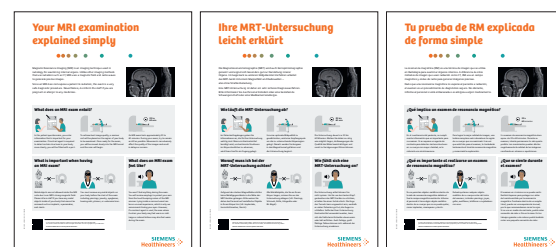
MRI Patient Education Toolkit

www.magnetomworld.siemens-healthineers.com/toolkit/mri-patient-education

Patient Education Video



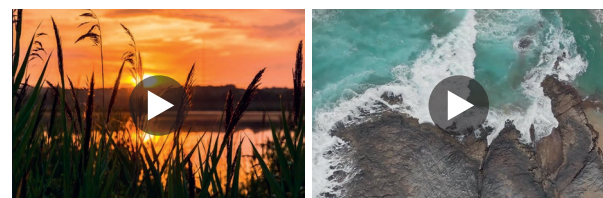
Patient Education Poster



Children's Book and Movie



Patient Meditation



2 QR code for access to the Patient Education Toolkit including the two patient preparation videos and the MRI book for children.

Patient preparation that matches the coping style (“congruent preparation”) has been shown to improve patient-related outcomes such as pain, anxiety, and adaptation in other medical fields like surgery [29, 30], cardiac catheterization [31], cancer survivorship care [32], or colonoscopy [33]. We therefore hypothesized the same pattern to apply to MRI patients: We expected the psychological and physiological response of patients to improve when they received an intervention congruent with their coping style vs. when they received incongruent preparation or no additional preparation (i.e., standard care control group).

We tested this assumption in a study with a randomized controlled design with 142 patients. While sitting in the waiting room, the patients randomly watched one of two videos developed to address the needs of sensitizers (information video) or repressors (relaxation video) or received standard care (no video). Both videos can be accessed via the QR code presented in Figure 2. We assessed the patients’ psychological and physiological responses to the examination, their evaluation of the videos, and recorded procedural outcomes (scan duration, repeated scans, interruptions). Anxiety was assessed via questionnaires on arrival at the hospital, after watching the video (or after a comparable amount of time in the control group), and after MRI. Cortisol as a physiological stress marker was assessed on arrival and after the MRI scan.

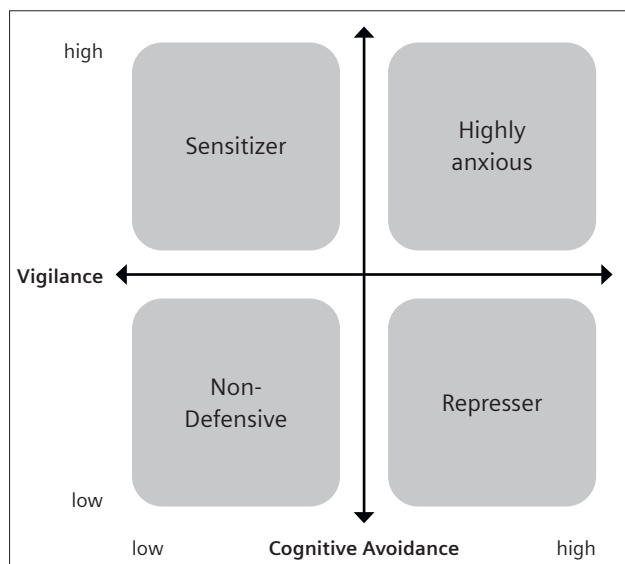
We found that cortisol levels were elevated compared with a “normal” day, which meant that undergoing MRI induced physiological stress in patients [34]. As cortisol still followed its normal circadian rhythm, we concluded that

this elevation most likely reflected anticipatory effects, which is in line with our findings from the baseline study [12]. The videos were very well received by the patients [35]: Almost all reported that they found them helpful and that they increased their confidence regarding the examination; whereby the information video was evaluated even more positively. When the patients’ preparation matched their coping style, anxiety decreased even before MRI, whereas this relief was only observed after the examination in patients whose preparation did not fit their needs. Beyond the positive effects at the patient level, we also found scan duration to be 10–20% shorter in the interventional groups and, descriptively, rates of scan repetitions or interruptions were 30–50% lower. Although our hypotheses were supported on a descriptive level, results failed to reach statistical significance. We believe that this is most likely due to power issues but there has, as yet, been no statistical confirmation of the effects on clinical processes and results must be interpreted with caution.

Improving patients’ experience of MRI by addressing individual needs in advance can reduce stress and anxiety in patients and support smooth clinical workflows

Anxiety and stress in patients have always been and still are relevant phenomena in the context of MRI examinations. Based on the results of our studies [12, 34, 35] and the consideration of Ahlander et al. [14], we suggest that patients’ response to MRI is most negative in anticipation of the examination. Therefore, changing the way patients are prepared for MRI seems to be a crucial step for improving MRI-related healthcare. Enriching standard care with additional patient preparation can have a positive impact on patients’ experience of MRI. Our research suggests that patients vary greatly regarding their needs. Therefore, considering interindividual differences in patients’ needs may be a promising approach to reduce stress and anxiety in patients most effectively. We therefore suggest that medical institutions should start providing tailored medicine, also in respect to the patient experience. This may be achieved by providing a variety of different materials for patients to choose from – or amendments of standard care, when thinking more generally. Thereby, it seems to be crucial to reach out to patients in advance: Providing patients with the opportunity to prepare themselves according to their own needs in a calm environment has the potential to maximize the beneficial effects.

Apart from being a relevant end in itself, we found in line with previous research that improving the patient experience could also have beneficial effects on clinical



3 The Model of Coping Modes (based on Krohne [42]).

workflows [5, 12, 17, 19, 21, 35–37]. Research suggests that patients who are calmer are less likely to be no-shows, have a lower need for sedation, premature terminations are less likely to happen, and patients move less, which could result in less need for scan repetitions and therefore shorter scan duration times [17, 19, 21, 36–40]. These effects might be even more pronounced when considering that time for patient education and preparation could also be reduced if patients were to arrive in an enhanced state of preparation. We therefore propose that improving the patient experience could result in positive effects for all stakeholders: Patients will be more relaxed, which also reduces stress for the medical personnel; furthermore, workflows will run more smoothly, thereby also increasing the revenue of an institution.

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