

The neuroimaging research process from the participants' perspective

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## Abstract

The aim of this study was to investigate participants' experiences of taking part in research conducted using fMRI or MEG procedures. Forty-four participants completed a questionnaire after taking part in either fMRI or MEG experiments; the questionnaire asked about experiences of and attitudes toward fMRI/MEG. Ten follow-up interviews were conducted to enable an in-depth analysis of these attitudes and experiences. The findings were generally positive: all participants thought fMRI and MEG were safe procedures, 93% would recommend participating in neuroimaging research to their friends and family, and participants were positive about participating in future neuroimaging research. However, some negative issues were identified. Some participants reported feeling nervous prior to scanning procedures, several participants reported side-effects after taking part, a number of participants were upset at being in a confined space and some participants did not feel confident about exiting the scanner in an emergency. Several recommendations for researchers are made, including a virtual tour of the scanning equipment during the consenting process in order to better prepare potential participants for the scanning experience and to minimize the potential psychological discomfort sometimes experienced in neuroimaging research.

**Keywords: fMRI, MEG, side-effects, consent, screening, perceptions, interviews, questionnaires**

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## The neuroimaging research process from the participants' perspective

Cognitive neuroscientific techniques, such as functional magnetic resonance imaging (fMRI), magnetoencephalography (MEG), and transcranial magnetic stimulation (TMS) have become dominant research tools within contemporary psychophysiology. The advantages of such techniques are clear and readers are referred to the various reports in this special issue for detailed descriptions of their application (see Bandettini, and Rippon, this issue, for descriptions of fMRI and MEG procedures respectively). What is currently unknown is how healthy participants' expectations of and reactions towards these techniques impact on their experience as experimental participants, and whether these experiences influence future participation in neuroimaging research.

Research has been conducted to examine the experiences of medical patients who are referred for neuroimaging procedures. For example, Grey et al. (2000) found that neurological and neuropsychiatric patients about to undergo MRI procedures exhibited anxiety prior to these procedures, and that this anxiety was alleviated if patients were presented with an information booklet which described the MRI procedure and what they could expect. Patients also appreciated being taken into the control room, to see the scanning equipment, prior to their scan. In addition, Walter et al. (2001) reported that patients classified as depressed found transcranial magnetic stimulation (TMS) a positive procedure and would recommend it to friends and family. Despite these findings, no research has been conducted to examine the experiences of healthy individuals who participate in neuroimaging procedures for experimental purposes.

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The objective of this study, part of an ongoing research venture (see also Cooke et al., 2005; Peel et al., 2005; Senior et al., in press), is to gain some insight into participants' psychological satisfaction with the scanning procedures of two cognitive neuroscientific techniques, fMRI and MEG, in order to review current practice regarding informed consent and screening. The level of knowledge participants have of fMRI and MEG is unclear, making it impossible to know for certain whether sufficient guidance is given to enable an informed decision when consenting to an experiment. The ethical implications of potentially inadequate or inappropriate consenting or screening procedures are clear in both research and clinical contexts. It is therefore crucial to understand participants' attitudes toward and experiences of fMRI and MEG in order to ensure best practice in neuroimaging research.

Usually the first contact potential participants have with researchers when responding to an invitation to participate in an experiment involving fMRI or MEG is the screening process. Screening serves to make participants aware of safety issues and ensures eligibility; in short, it aims to reduce risk. The consent procedure will vary depending on the substance of the experiment, its hypotheses and nature of stimuli, but generic information about the scanning procedure will be relevant to all studies.

There are differences between fMRI and MEG procedures in terms of screening and procedures followed. Unlike MEG, there are certain restrictions imposed on who can participate in fMRI research. Participants are screened for a number of conditions which preclude participation, including having surgical clips or hearing aids, dental work, tattoos, epilepsy, heart disease and diabetes. Participants are also screened for

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claustrophobia. These restrictions do not apply to MEG screening procedures. In addition, the scanning equipment means participants follow different procedures in fMRI and MEG. Participation in fMRI involves lying horizontally in the centre of a magnetic bore, and participants have to wear ear plugs because of the noise caused by the rapid switching of the radiofrequency coils. In contrast, MEG procedures involve participants sitting upright and there is no need to wear earplugs as MEG does not generate as much noise as fMRI.

However it remains uncertain whether these differences are apparent to participants, whether they impact upon the consenting process, and, if there is an effect, what is its nature and significance for neuroimaging research. These questions were addressed using a mixed method approach to establish the nature of participants' expectations of scanning, their experiences and their reflections of participating in fMRI and/or MEG research.

## Method

### Participants

Twenty-one (nine male, 12 female, 18-41 years, Mean = 23.52, SD = 7.17) participants completed a questionnaire specific to fMRI, while 23 (10 male, 13 female, 18-60 years, Mean = 24.83, SD = 11.27) participants completed one specific to MEG, after participation in either of the procedures (total N = 44). Seven participants had experience of fMRI prior to this study and five participants had experience of MEG prior

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to the study. However, a majority of participants in both samples (14 fMRI, 18 MEG) had no experience of either technique prior to the study.

Ten (4 male, 6 female, 18-47 years, Mean = 29.67, SD = 8.70) participants agreed to be interviewed following their scanning procedures and completion of the questionnaire. All participants had participated in fMRI research and eight had been through a MEG procedure as well. Four of the participants were undergraduate students, two participants were PhD students, one was a post-doctoral researcher, two were administrators and one was a specialist psychology technician.

### Measures

Participants were given a questionnaire focusing either on fMRI or MEG (see website for the fMRI questionnaire). Questionnaires were identical except for distinctions between scan techniques, for example, the fMRI questionnaire is slightly longer because there was an extra question “How upsetting was the loud noise of the scanner?” This is because the fMRI scanner generates a loud noise, whereas MEG is a passive recording device (see above). The questionnaires began with items on age and gender and then asked if participants had experienced the procedure before. Questionnaires were divided into three sections, experience of fMRI/MEG, knowledge about fMRI/MEG, and attitudes towards fMRI/MEG. All items in the questionnaires and subsequent interviews (see below) were carefully constructed to concentrate on the generic aspects of the scanning process so that subsequent findings could be easily extrapolated to inform best practice in other laboratories.

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In this paper, we focus on the questions in the experience and attitudes section. Experience questions asked about expectations prior to the scan, reactions after leaving the scanner (including any perceived side effects), experiences of the scan, and how confident participants' felt about exiting the scanner in an emergency. The attitudes section asked participants if they would recommend fMRI/MEG to their friends and family, who they would tell about their procedure, and about their plans to participate in future scanning research.

The interviews were semi-structured in that a series of topics to be covered were identified in advance, but the process was flexible enough to incorporate unexpected themes as they arose (Burman 1994; Kvale, 1996). A set of open-ended questions, which acted as an aide mémoire, were devised to ask participants about their reasons for consenting to the experiment, their expectations, the screening process, the experience of being inside the scanner and their subsequent reactions to being scanned. A set of prompts were also included in the interview schedule in case participants were not forthcoming about their experiences (see website for the interview schedule).

### Procedure

Data were collected from participants attending a number of scanning experiments. After completing the experiment, participants were approached and asked to complete either the fMRI or the MEG questionnaire. At the end of the questionnaire was an invitation to be interviewed for the second phase of this study. Participants were asked to include their contact details on a tear-off reply slip if they wished to be interviewed

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which was returned separately from the anonymous questionnaire. Participants were given two envelopes in which to return the questionnaire and reply slip to the investigators. Once participants had volunteered to be interviewed they were taken through a separate consent process for this follow-up interview. If consent was obtained a date and time for the interview was arranged. Interviews were audio-recorded and transcribed verbatim.

### Analytic Approach

Due to the exploratory nature of this study descriptive data only are reported. Parametric tests of significance are inappropriate due to the small sample size. Interview data<sup>1</sup> were analysed using thematic analysis (Boyatzis, 1998), a qualitative method which involves a series of systematic stages. Transcripts are read thoroughly in order that the analyst familiarizes him/herself with the data. These accounts are then re-read in more detail to identify the themes raised by participants. Similarities and differences across the data set are investigated in order to establish the range of experiences among participants. Contradictions within individual participants' accounts are also interrogated and hypotheses for why these contradictions occur are formulated. The objective of thematic analysis is twofold: to accurately portray participants' accounts; and to understand these accounts in terms of their significance to the research question. In other words, these interviews were conducted to reveal, from the participants' perspective, the nature of the

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<sup>1</sup> The interviews were transcribed orthographically, but in the quotations taken from the interviews to illustrate the themes dashes indicate cut-off speech, underlining denotes emphasis, omitted speech is shown by ... and additional information is contained in square brackets. Final version of published article: Cooke, R., Peel, E.A., Shaw, R.L. & Senior, C. (2007). The neuroimaging research process from participants' perspective. *International Journal of Psychophysiology*, 63(2), 152-158.

fMRI and MEG scanning procedures starting with consent and screening through to the scans themselves and ending with post-scan reflections.

## Results

### fMRI: Questionnaire Data

Emotional perceptions and side effects We asked participants to indicate if they were (or were not) experiencing different emotions prior to entering the scanner. None of the participants said that they were “worried”, “agitated”, or “scared” prior to the scan. Nonetheless, there was evidence that some participants were experiencing emotional arousal: even though 17 participants said they were not anxious or nervous, nine said they were not “calm” which suggests that their experience fell between these extremes. For the majority of participants this was their first time in the scanner, so a degree of uncertainty about the process was expected among participants. However, participants did report interest in fMRI; 14 said they were “intrigued” prior to entering the scanner.

Seven participants reported perceived side-effects after participating in an fMRI procedure. Three participants reported having a headache and one other said s/he had a headache and ringing ears. It is possible these effects were caused by the noise of the scanner. One participant reported a muscle ache, which may have occurred due to restriction inside the scanner.

Experience of the procedure Participants were asked if being in a confined space, in the fMRI scanner, was upsetting. Nine participants reported that being in a confined space was “a bit upsetting” but when asked to rate the whole experience of taking part in a fMRI scan, 18 participants said it was not at all upsetting (one participant said “don’t

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know”, one said “a bit upsetting” and one said “moderately upsetting”). The noise in the fMRI scanner was described as “not upsetting” by 12 participants, eight said it was “a bit upsetting” and one participant found it “moderately upsetting”. Participants were also asked how confident they were that they could exit the scanner in the event of an emergency. Three participants were not at all confident of being able to exit the scanner while 18 felt confident they could. Nonetheless, all participants believed fMRI was a safe procedure to experience.

Communication about the procedure Participants were asked who they would tell about their scan in order to explore possible stigma associated with taking part in brain scanning research. None of the participants intended to hide the fact that they had had a brain scan. When asked to whom they would recommend the procedure, 20 fMRI participants were happy to recommend the procedure to a friend or family member assuming researchers spoke to them in advance and/or the study followed the correct procedures. The other participant answered “don’t know”. Finally, when asked about future participation in fMRI research, participants were positive about participation (Mean = 3.90 on a 5-point scale) implying they would consent to similar experiments in the future.

fMRI: Interview Data Participants reported feeling at ease in the scanning situation and were confident researchers knew what they were doing. This corroborates the questionnaire finding that participants believed fMRI procedures were safe.

Furthermore, some participants’ reactions involved very positive emotions: they described it as “quite enjoyable” (P3), “exciting” (P7) or “surprisingly relaxing” (P1).

Indeed, most of the evaluations interviewees made about their fMRI experience were

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positive. One of the advantages of semi-structured interviews is their capacity to reveal issues that are unexpected. Several themes did emerge from the interviews which were not addressed in the questionnaires; these relate to the visibility of the brain and the perceived relationship between neuroimaging research and scanning for clinical purposes.

The Visible Brain One of the aspects of the fMRI procedure that participants particularly liked was the chance to ‘see’ their brain by looking at the anatomical scan:

“it [fMRI] was quite enjoyable to take part in, especially afterwards being able to see like your own brain, it’s quite good to see” (P3)

This view was echoed by other fMRI participants who reported being “fascinated to see what it looks like” (P7) and “really looking forward to seeing my brain” (P8). It was not all positive, however, there was some concern about medical implications if a problem was identified.

Risking the brain A generic procedure common to most MRI laboratories around the world is informing the participants that their general practitioner (internist) will be notified directly should an anomaly be identified. The implications that the scan could identify medical concerns but that these would not be divulged were considered carefully by participants:

“you have to think of the ethical... repercussions of what would happen if you gave somebody a picture of their brain and then they later found out, because you had contacted their GP [general practitioner] that there was actually a problem with them, take for instance a tumour or something... If that was me who’d been led down the garden path ‘oh this is a picture of your brain doesn’t it look great’ only to find three weeks later that I’ve got a letter from my GP saying... ‘we think you’ve got a problem’... I certainly wouldn’t like it to happen to me” (P10)

“What if they find something that they have to disclose to you, no that didn’t really enter my head, because I – well it did sort of enter my head” (P7)

“I mentioned it to sort of friends and family, you know go home ‘ooh I had my head scanned today’ [laughs] my husband was a bit worried he said ‘what did you have that done for?’ he thought there was something wrong [laughs]” (P9).

These extracts reveal that participants consider their scanning experience within the wider context of medicine and health and not just simply as taking part in research.

Experimental research as benign investigation      The previous quote reveals the anxiety felt by P9’s husband when she told him she had undergone a brain scan. Other participants also highlighted the fact that they were taking part in a scan for experimental research rather than as part of a medical procedure:

“in terms of doing an experiment there’s no stigma attached to that. It’s not like it’s not like you would say ‘I’ve had an MRI scan’ and people would go ‘Oh you must have a disease or something’” (P1)

“the thing is it’s much more reassuring when you’re not having it done for medical reasons” (P7)

These quotes illustrate the common misconception that fMRI scans are only necessary to confirm the presence of a brain tumour, as indicated by P10 above. In its medical context, having an fMRI scan has the associated stigma of being connected to revealing brain pathology. However, when conducted for research the scan is considered to be a benign procedure.

### MEG: Questionnaire Data

Emotional perceptions and side effects      Prior to entering the MEG scanner only one participant described their emotional state as either “worried” or “sad”, although three participants did describe themselves as “anxious”. Eight participants reported being “scared” prior to entering the MEG scanner, 15 described not feeling scared and six said they were “nervous”. Fifteen participants described themselves as “calm” before entering

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the scanner and eight said they were not. The majority of participants were taking part in MEG research for the first time and 13 described themselves as “intrigued” prior to the scan.

Eight participants reported some kind of side-effect after participating in a MEG procedure, with some reporting more than one. Overall, four participants reported headaches, six reported muscle aches, and one ringing in the ears. The frequency of headaches and muscle aches being interpreted as side-effects of the scanning procedure suggests that further research is needed to explore this potential link.

Experience of the procedure Participants were asked if the restricted movement in the MEG scanner was upsetting. Thirteen participants said it was “a bit upsetting” being in a confined space. Ratings of the whole experience of taking part in a MEG scan showed that 15 participants found it “not at all upsetting” and eight said it was “a bit upsetting”. On being asked how confident they were that they could exit the scanner in an emergency, 16 participants felt confident that they could, four participants were not confident and three were unsure. Despite this, all participants believed MEG was a safe procedure.

Communication about the procedure When asked who they would tell about their participation in MEG research nobody said they would hide their MEG experience from others. Eight participants said they would recommend participation in MEG research to friends or family assuming correct procedures were followed and 13 would recommend it as long as participants talked to researchers. One participant’s response was “don’t know” and one said s/he would not recommend it under any circumstances. Nevertheless,

participants were positive about participating in MEG research in the future (Mean = 3.87 on a 5-point scale).

#### MEG: Interview Data

MEG was talked about less often than fMRI in the interviews but when it was, the general reaction was unfavourable, even the description of “nothing unpleasant” implies negativity:

“there was nothing unpleasant about it” (P1)

“MEG was in a dark room I didn’t like that... because it was dark with this computer screen your eyes start going funny, because you were concentrating on just one tiny bit of light and it was, it just wasn’t as nice [as fMRI]. It was hard to concentrate and just a bit more claustrophobic” (P3)

“physically it was a bit of a squeeze in the chair and everything that they put on your head” (P4)

If participants had received both MEG and fMRI, they reported being less impressed by their experience of MEG. In fact, the main theme in participants’ accounts of MEG revealed a relational appraisal process, MEG was constantly compared with fMRI and was often classified as experientially the poorer of the two techniques.

fMRI versus MEG Several participants explicitly compared the techniques:

“Out of the two, to be honest I prefer the MRI scanner” (P10)

“it [fMRI] was nicer, it was more comfortable... I felt a lot more comfortable and a lot less claustrophobic than I did in the MEG scan” (P3)

“the MEG is a little bit more invasive than the MRI, the fact that when you go in the MEG you have to take an imprint of your teeth” (P10)

These quotes show that MEG procedures were often compared unfavourably with fMRI. However, this preference was not conveyed across the board, some participants

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discussed their experience within the MEG scanner as “less constrained” and as having “more freedom” than fMRI despite having the head physically restrained.

“[MEG] felt very different, first of all you’re not cooped up in a tube erm so you just feel a little bit more freedom, obviously your head’s clamped...it’s like a big hairdryer on top of your head, and erm you just have things taped to your head and you’ve got to stay really still, that was probably the most difficult part.” (P5)

“in a way you probably feel a bit less-less less constrained [in the MEG scanner] erm well cause if-if I did actually want to get out of the scanner I probably could just put my head down and physically get out whereas-whereas if I’m actually in the MRI obviously it’s enclosed so if I do wanna get out I have to press the buzzer first then wait for someone to come in and-and wheel me out.” (P6)

These extracts reveal different experiences of fMRI and MEG across participants. Some participants expressed concern about being “enclosed” inside the fMRI scanner but others discussed finding that the way the MEG scanner “clamped” the head was “more claustrophobic”.

## Discussion

This study aimed to explore participants’ attitudes toward and experiences of taking part in neuroimaging research. Participants’ expectations prior to being scanned, their beliefs about what the process involved, their assessment of the screening process and their reflections following the scan were investigated. The objective was twofold: to determine whether current procedures for screening, consenting and scanning are adequate; and to establish the nature of participants’ experiences of scanning in order to identify whether any changes in process are necessary to ensure best practice in neuroimaging research.

Evidence that participants were satisfied with the neuroimaging procedures was identified: all participants described fMRI and MEG as safe and only three out of 44

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participants would not unequivocally recommend them to friends and family - ensuring they talked to researchers and correct procedures were followed. This confirms that current procedures are satisfactory. Nevertheless, a number of concerns were raised: first, several participants experienced negative emotions prior to their scan; second, several participants reported side-effects after participating in neuroimaging procedures; third, physical elements of the scan equipment, such as being in a confined space and the loud noise of the fMRI scanner, led participants to report dissatisfaction; and finally, the equipment was not always viewed as easy to exit in an emergency. The interview data revealed other issues: participants were fascinated by fMRI procedures and were very keen to get a look at their brain; they were less impressed by the MEG scanner talking mainly about fMRI during the interviews; and finally, the potential medical implications of having a brain scan affected participants' perceptions of risk and anxiety prior to participation. Despite a general consensus that procedures are sound and participants happy, in response to the concerns outlined above, several recommendations are proposed to enhance the research process for participants.

### Emotional Perceptions

Participating in neuroimaging research was not an emotionally neutral process. Both fMRI and MEG participants described themselves as “not calm” or “nervous” prior to the scan. Furthermore, over a third of MEG participants admitted being “scared” prior to their scan. These results support Grey et al.'s (2000) data, which found that MRI procedures produced anxiety among medical patients. Fear of the unknown is an expected cause of anxiety prior to a novel experience. It is possible this effect was magnified however due to the highly technical nature of the equipment, their complex

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scientific mechanisms and function as tools to reveal the nature of one's brain, which to the layperson (and psychophysicologist) is possibly the most intriguing and mysterious of human organs. These negative emotions may be counteracted by providing more detailed information which enables potential participants to gain a clearer understanding of what the procedure would entail (see Grey et al., 2000, for an example). During the interviews, participants suggested that seeing a video of the scanning procedure would reduce anxiety, as would witnessing another person being scanned prior to their own scan. Alternatively, researchers could utilize a virtual tour of the scanner during the consenting process using computer-generated animation of what happens (see Rosenberg et al., 1997, for an example of a simulator). Either of these suggestions could be easily incorporated into the scanning procedure and they would serve as a comprehensive guide to the scanning experience. This would reduce anxiety associated with these novel techniques.

### Potential Side-Effects

The scientific literature has not identified any side-effects to receiving an fMRI or MEG scan. Nevertheless, the *ex silentio* conclusion that side effects do not occur during these procedures is not supported by the current study. The questionnaire data revealed that participants did experience side-effects. This does not mean these experiences were actually caused by the scanning procedure, to demonstrate that would involve manipulating the conditions under which individuals participate in scanning procedures; e.g., varying the length of time participants are in the scanner to see if shorter scans are associated with fewer side-effects. What it does mean is participants experienced discomfort during or following participation in the experiment. It is the responsibility of

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experimenters to minimize the occurrence of this discomfort. Seven participants reported a headache after either fMRI or MEG and six MEG participants mentioned muscle ache following that procedure. The muscle aches may have been caused by a combination of anxiety and sitting still for long periods of time. The fact that such aches were not described following fMRI scans indicates that participants were able to relax more easily in the horizontal position needed for fMRI than in the sitting position required for MEG. It may therefore be beneficial for researchers to conduct MEG scans with the participants in a supine position. Further suggestions to overcome this problem include the introduction of more breaks in studies during which participants are encouraged to move around; this could be accompanied by some relaxation techniques prior scanning to ensure the muscles are relaxed (Lukins et al., 1997; Quirk et al., 1989; Weinman & Johnston, 1988).

Accounting for the headaches is more challenging. The very nature of both fMRI and MEG render straightforward solutions to headaches difficult to implement. Being required to remain still in the MEG may cause tension headaches in a similar way to the muscle tension described above.

#### Being in a confined space

Being in a confined space was reported as “a bit upsetting” by 43% of fMRI and 57% of MEG participants which suggests that the situation itself (i.e., being inside a scanner) is stressful for some participants. The virtual tour described above may serve to reduce this problem. Providing an accurate representation of the physical confines of scanners (in some form), prior to participants consenting to take part in neuroimaging research, is important. If potential participants have a clearer idea of how restricted they

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will be inside the scanner they will be able to make an informed decision about whether they would feel comfortable (or not) entering the scanner.

### Exiting the Scanner

One of the most concerning findings was that three fMRI and four MEG participants did not feel confident that they could exit the scanner in an emergency, a further three MEG participants were unsure. Generic scanning procedures include explicit guidance on what to do should there be an emergency but this finding from our study suggests this may be inadequate. These concerns contrast with participants' reports of feeling safe and raise questions about the level of information given to participants in advance of the scan. This limitation could again be addressed by the virtual tour; a demonstration of all the necessary steps to initially alert the experimenter and then to actually exit the scanner may alleviate this lack of confidence.

### Function of the scan

Probably the most intriguing aspect of participating in an fMRI experiment, as reported in the interviews, was being able to see a picture of one's own brain. Also apparent was that participating in research prompted less anxiety than was expected prior to a clinical fMRI scan to investigate a medical condition. It is possible then that the anxiety, and side-effects, reported in this study are minor, *relative* to the perceptions of patients attending for a medical scan. In one sense, this study acts as a control where emotional and physical reactions to the scan equipment and experience can be investigated without the potential confound of ill health. This finding suggests the need for a similar study with clinical patients to review the consenting process when applied to a medical scan in order to reduce anxiety and ensure best practice. The research by Grey

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et al. (2000) suggests that some patients are anxious about attending MRI procedures but Grey et al. acknowledge that it is unclear which elements of the procedure reduce or increase anxiety. Thus, more in-depth data collection, potentially using interviews, is needed to explore anxiety among clinical populations.

A related concern is the procedure for referring participants to appropriate health services if a potential condition is identified during the research process. Several participants acknowledged the potential identification of a medical problem as a risk when consenting to participate in neuroimaging research. Potential participants need to be made aware that there is a slight chance that brain scanning could identify a problem currently unknown to them. Subsequently, they need to know the precise procedures for referral before consenting to the experiment. This could be easily dealt with by providing clear information about what would happen in the unlikely event that a medical condition was discovered.

### Implications and Future Directions

This study has highlighted several implications for neuroimaging research practice, outlined above, which may further prepare potential participants for the scanning experience and therefore reduce anxiety. One avenue for future research is to implement a validated measure of anxiety such as the State-Trait Anxiety Inventory (STAI: Spielberger, 1983) which would provide baseline anxiety levels and therefore rule out the possibility that participants reporting anxiety are not just generally more anxious than participants not reporting anxiety.

An in-depth debrief of all neuroimaging participants, which addresses both physical and psychological comfort, should be considered a generic part of best practice

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in neuroimaging research. This may be particularly important with participants who come for their first scan; if they are anxious or have perceived side-effects after the scan, and have not had the opportunity to discuss these concerns, they may have misconceptions about scanning procedures and be unlikely to participate in future research.

A more detailed inquiry into the reasons for the negative emotions felt by participants, including anxiety, fear and nervousness, is required to enable researchers to design screening and consenting procedures which minimize these feelings. Further research is already underway which involves interviewing participants before and after the scan to ascertain the nature of their expectations and experiences of the scanning procedure from beginning to end. This is something which could then be transferred to a clinical setting with a view to designing interventions which better prepare patients for their brain scan. The recommendations above will be combined with future research findings to inform evidence-based guidelines for neuroimaging research practice.

In conclusion, this study has confirmed that current procedures for fMRI and MEG scanning experiments are appropriate and that participants feel safe when inside the scanner. However, a number of improvements to procedures have been indicated to further reduce anxiety and discomfort. These results highlight the utility of asking participants about their experience of neuroimaging procedures as a way to identify concerns of which researchers are not aware. Future research is needed to build on these findings in order to both sustain the rigour of neuroimaging procedures and to ensure participants' welfare.

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