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Functional Magnetic Resonance Imaging as Experienced by Stroke Survivors

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Abstract

Functional magnetic resonance imaging (fMRI), a noninvasive technique that measures brain activation, has been increasingly used in the past decade, particularly among older adults. Use of fMRI in research with stroke survivors in recent years has substantially contributed to researchers' understanding of the pathophysiology of stroke sequelae. However, despite the increasing popularity and use of fMRI, little is known about the patient experience of fMRI under research circumstances. The current research brief reports the findings of a pilot study undertaken to understand stroke survivors' experiences with fMRI under research circumstances. Nine ischemic stroke patients underwent two MRI sessions, each of which lasted 1.5 hours and included several fMRI tasks. Patients were asked about their experiences and to share any advice. All participants reported that they did not feel claustrophobic; in addition, the importance of educating participants about fMRI was a universal theme that emerged. Knowledge of participant experiences may help with enrollment strategies for fMRI studies and improve research outcomes related to the fMRI experience.

Functional magnetic resonance imaging (fMRI) is a technique that measures changes in the concentration of oxygenated versus deoxygenated hemoglobin in the blood. When a brain area is more active, it consumes more oxygen, which changes the ratio of oxygenated to deoxygenated hemoglobin. This change in ratio is the basis for the blood oxygen level dependent signal used in fMRI (Ogawa & Lee, 1990). The purpose of fMRI is to examine areas of activation when patients are asked to perform certain tasks.

In the past decade, researchers have increasingly used fMRI to answer questions about mechanisms underlying psychological phenomena, such as how individuals make decisions or respond emotionally to stimuli. In a literature review, Aue, Lavelle, and Cacioppo (2009) articulated the following reasons for the increasing usage of fMRI in research:

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- Advances in the fMRI technique in the past decade have made fMRI data more reliable and accurate.
- The noninvasive nature and relative safety of the technique, as compared with other neuroimaging techniques, has made it more attractive for both investigators and participants.
- fMRI allows continuous collection and analysis of data, which is suitable for longitudinal studies.
- fMRI provides objective biological markers, potentially adding validity and reliability to the subjective psychosocial instruments that are used in biobehavioral research.

Despite these advantages, fMRI technology has some potential drawbacks for participants to consider. For example, excellent fMRI data acquisition requires considerable effort on the part of participants to remain motionless during the procedure. Participants must be able to tolerate loud noises and feel comfortable in a confined space. Therefore, on the surface, fMRI may not seem to be the best approach for some patient populations, such as poststroke patients. Due to stroke impact, stroke survivors may have difficulty with remaining motionless for extended periods of time in a confined space, such as MRI scans. It is important to understand the experience of research participants with fMRI from the participant perspective to develop or revise protocols to make participants more comfortable in the scan. Two prior studies have reported patient experiences with MRI procedure under clinical conditions (MacKenzie, Sims, Owens, & Dixon, 1995; Nozzolillo et al., 1991). However, to the authors' knowledge, only one prior study has reported patient experiences of fMRI under research circumstances (Szameitat, Shen, & Sterr, 2009).

Several differences exist between fMRI for diagnostic and clinical purposes and fMRI used in research. In the case of clinical scans, patients have been directed by physicians to undergo the procedure for diagnostic purposes; however, this motivation does not apply to volunteers in research studies. In addition, fMRI for research purposes may cause more discomfort to participants than clinical fMRI scans because of the use of a different imaging parameter characterized by high volume hammering noises (Szameitat et al., 2009). Furthermore, in clinical scans, patients are typically not required to perform any tasks, whereas in the research fMRI scans, participants are usually asked to complete a task while in the scan to stimulate certain parts of the brain, thus allowing researchers to examine activities in those areas. Finally, research scans often last much longer than most clinical scans.

Szameitat et al. (2009) studied the perspectives of 77 neurologically healthy individuals and 22 older adult stroke survivors undergoing fMRI using a 3 Tesla MRI scanner. They found that the majority of participants in both groups (87% and 77%, respectively) rated the experience of fMRI as comfortable. Discomfort felt by participants was related to scanning noise, the need to remain still during the procedure, and occasional feelings of dizziness.

To further advance the valuable knowledge obtained from the Szameitat et al. (2009) study, the current study aimed to obtain three types of information from participants:(a) a

qualitative description of their experiences using a broad, open-ended question; (b) advice for other potential research participants; and (c) advice for researchers for enhancing recruitment, as stroke researchers have cited the recruitment and retention of stroke survivors as challenging tasks (Hadidi, Buckwalter, Lindquist, & Rangen, 2012; Mapstone, Elbourne, & Roberts, 2007; Watson & Torgerson, 2006). To the authors' knowledge, these aims have not been addressed in the literature.

METHOD

Design

The current study was conducted in the context of a parent longitudinal study that examined the impact of problem solving therapy (PST) on brain circuitry in poststroke patients. The fMRI and treatment results of the study will be reported separately; the purpose of the current study is to examine patient experiences.

The authors recruited a sample of 10 ischemic stroke survivors and randomized participants to a treatment or control group. Five experimental participants received six consecutive weekly sessions of PST to reduce depressive symptoms, whereas participants in the attention control group ($n = 5$) received six consecutive stroke education sessions based on an educational booklet developed for the purpose of the current study. Participants were recruited from an outpatient rehabilitation clinic setting. Inclusion criteria were (a) ischemic stroke within the past 3 months to 2 years; (b) age 55 or older; (c) Mini-Cog score of 3; and (d) safe to undergo fMRI (i.e., no metal implants). The Mini-Cog is a valid (Borson, Scanlan, Chen, & Ganguli, 2003) and reliable instrument used to assess mental status of older adults. It has a reported sensitivity of 76% to 99% and specificity of 89% to 93%, with a 95% confidence interval (Carolann Doerflinger, 2007).

Although all participants had undergone fMRI at the time of stroke, none had participated in fMRI for research purposes before the current study. For the study, each participant underwent two scanning sessions—one at baseline and one after completing either PST or educational sessions.

The current study was reviewed and approved by the Institutional Review Board (IRB) of the University of Minnesota. Participants received a \$100 gift card for participation in the study.

Procedure

Neuroimaging procedures were conducted on a Siemens 3 Tesla Tim Trio scanner at the Center for Magnetic Resonance Research (CMRR) at the University of Minnesota. At the beginning of the study, all participants provided informed consent and completed a safety screen. At that time, they were informed about the procedure and what would be expected of them. Participants were given clear instructions on performing the tasks and were reminded just before the procedure as well. Upon arrival to the CMRR, another safety screen was administered, and participants were asked to remove jewelry and any other metal objects incompatible with fMRI. The principal investigator (PI; N.N.H.) re-explained the procedure and what to expect during testing. Participants were directed to the MRI suite, where they

were given earplugs to lower the noise level and headphones to be able to hear the test administrators. The 32-channel head coil and visual apparatus for viewing the screen for the fMRI task were adjusted. An array head coil was placed with a mirror for the visual aid of participants. The mirror was used to present stimuli (e.g., faces with emotions) during task-based fMRI scans. Participants were asked to lie supine; their legs were supported with a leg rest to make lying on their backs more comfortable, and they were provided blankets if they felt cold.

All participants were given an emergency button to use in cases of feeling discomfort or claustrophobia. After the PI ensured participant safety and comfort, participants were also instructed on how to use the box to respond to tasks given to them during the procedure. The response box is a fiber optic, handheld device connected via electronic interface with a three-button response option. Prior to the procedure, participants were provided with instructions on how to use the device to respond to questions posed for them via computer interface. The scanning protocol included a high-resolution, T1-weighted anatomical scan; a 6-minute, resting state fMRI scan; and three fMRI scans, which included tasks. Between each sequence, the examiner (L.M.J.H.) spoke with participants by way of a microphone and speaker system installed within the magnet room. This communication was to ensure that participants were comfortable and to provide instructions for upcoming sequences. The entire scan procedure lasted 1 to 1.5 hours.

For all of the scans, participants were asked to lie as still as possible. For the resting state fMRI, participants were asked, in addition to lying still, to close their eyes and “not think of any thoughts, letting go of thoughts as they come into the mind” For the task-based fMRI scans, participants were asked to view images projected onto a screen at the back of the scanner. One task-based sequence acquired neuroimaging data while participants passively viewed emotional faces and symbols (Ekman & Friesen, 1979). Participants were asked to push a button whenever an “o” appeared on the screen to ensure they remained attentive throughout the task. A second task-based sequence required participants to match emotional faces using the same button box (Hariri, Tessitore, Mattay, Fera, & Weinberger, 2002).

As noted previously, all participants underwent two neuroimaging sessions—one at baseline and one post intervention. Following the second neuroimaging visit, participants were interviewed by either the PI or research assistant (RA; E.M.) using the investigator-developed structured interview to examine participant experience and advice. Both the PI and RA followed the same protocol for conducting interviews. The interviewers asked the questions verbally of each patient individually in a private room. Participant responses were audiorecorded verbatim.

Structured Interview

Face validity was established for the structured interview, which was developed by the PI by consulting experts in the field. The interview questions were as follows:

- Please describe your experience of undergoing fMRI.
- What advice do you have for research participants who will be undergoing fMRI?

- What is your advice to researchers who wish to recruit participants undergoing fMRI?

Nine stroke survivors completed the interview following their last fMRI. The interviews lasted 10 to 15 minutes each and took place immediately after the second scanning session in private rooms at the CMRR. All interviews were conducted in individual one-on-one meetings. One participant did not attend the interview because of a scheduling conflict.

Data Analysis

Two research team members (N.N.H., E.M.) independently read the recorded responses to open-ended questions and extracted, labeled, and hand-coded themes from the data. After coding the content, the two researchers identified themes (Table). If disagreements existed, the researchers discussed discrepancies until they reached consensus. They came to 100% consensus on the themes in their analysis of data. One research team coder (N.N.H.) was doctorally prepared and was an experienced researcher who trained the RA in coding qualitative research records.

RESULTS

Of the nine participants, five were men and four were women, 60% were married, and 30% were employed. All participants were White and had completed some college education. The average age of participants was 66 (range = 52 to 78, $SD = 7.89$ years). For all participants except one, the ischemic stroke was a first-time event. None of the participants had experienced a research fMRI prior to the study. No significant differences existed between treatment and control group participants on any demographic variables.

Regarding Question 1 about participant experience with fMRI, all participants expressed that they did not feel claustrophobic during the scan. They also denied having experienced any other discomfort. One participant said that the experience was very positive: "I am usually very claustrophobic in MRI and have had a few done, but this one was different. The mirror and picture and the depth helped with [the] feeling of openness and less claustrophobia."

All patients evaluated the experience as positive. They reported that they had felt "secure and comfortable." They said that staff made them comfortable and warm if they needed a blanket.

Two individuals expressed having some difficulty with the audio portion, as they could not hear instructions clearly. The same two participants expressed frustration about not having enough time to match emotions of faces on the screen. One expressed concern that the head coil did not accommodate individuals wearing glasses, and one participant indicated that communicating with the researchers could have been clearer and that the overhead made it hard for him to see the image.

A positive sense of making a contribution to research was one theme that emerged after speaking with four participants. One participant said, "The testing is very valuable. [I] looked forward to the experience and found it very interesting." Another participant said, "[I] wanted to be of assistance to others having stroke, which is why I decided to

participate.” Furthermore, she suggested that researchers “tell [potential participants] that without your participation, the knowledge will not progress.”

Regarding Question 2 on advice for research participants, three participants noted that having an open and positive mind about the experience would help. One advised, “Go in with an open mind. It usually doesn’t last that long if you relax.” She went on to offer that “if you think negatively right away, that’s how you will experience it.” Regarding noise, participants noted that earplugs were helpful. One participant suggested blocking plenty of time to ensure that participants did not worry about needing to be somewhere after the procedure. She also suggested avoiding taking any medications that impact cognition prior to the procedure.

In response to Question 3 regarding advice for researchers, the theme of education came up eight times across participants. Three participants suggested that education was the key to helping future participants. One participant suggested that an orientation film could be meaningful, whereas another suggested an orientation film as well as taking participants on a tour of the building and the machine prior to the procedure. Emphasizing the safety aspect of fMRI in education was suggested by five participants as a recommendation to researchers to enhance recruitment. One individual suggested that researchers should “explain what the fMRI is and that there is no radiation.” Another suggested that future participants be informed in advance about the noise and vibrations experienced in the scan.

DISCUSSION

fMRI is a tool that provides researchers with potentially valuable answers to the mechanism of action of treatments on certain behavioral and psychological interventions and outcomes (i.e., fMRI is a technique used to map brain activity). Despite the fact that fMRI is a safe technology for individuals without contraindications (e.g., a metal implant), the authors’ experience in the recruitment process taught them that some patients, prior to receiving education about fMRI, have an aversion to the idea of fMRI. Few studies have explored the perception and experience of patients undergoing the procedure.

The results of the small current pilot study demonstrate that all participants expressed comfort and did not feel claustrophobic. Feelings of claustrophobia have been cited as one of the most common reasons for premature scan abortions in clinical trials (Eshed, Althoff, Hamm, & Hermann, 2007). However, in the current study, an absence of claustrophobic feelings was most common. One participant indicated that despite having felt claustrophobic in the MRI scanner in a previous experience, her experience with the current study was different. This finding was also supported by the Szameitat et al. study (2009), in which only one of 70 healthy participants expressed claustrophobia. The result of the current study may be partially explained by the fact that all participants had undergone MRI scanning for diagnostic purposes and were familiar with the procedure. In addition, participants were asked to perform certain tasks while in the MRI scanner (related to the fMRI), and therefore, distraction may have been a helpful strategy. Furthermore, one participant noted that having a mirror overhead and being able to see the computer screen made the space appear open and lessened the feeling of claustrophobia.

Another important theme emerging from the current study was the eagerness of study participants to contribute to research. Participants wanted to help other stroke survivors, which was an important factor in their willingness to participate. This sense of altruism or the feelings that one has done a good deed by contributing to research has been supported by other studies (Hadidi, Lindquist, Treat-Jacobson, & Swanson, 2013; Kiecolt-Glaser et al., 2003; Schwartz, Meisenhelder, Ma, & Reed, 2003).

Finally, the importance of education about fMRI (i.e., how it works, safety considerations, and what to expect) was a strong theme that emerged throughout the interviews across all participants. Several researchers have concluded that adequate education and providing information to patients prior to diagnostic procedure and MRI are essential (MacKenzie et al, 1995; Thorp, Owens, Whitehouse, & Dewey, 1990). In a randomized controlled trial by Grey, Price, and Mathews (2000), 29 patients in the experimental group received the following interventions: (a) a booklet containing information about the scanning procedures, (b) advice on cognitive strategies for anxiety reduction, (c) a visit to the control room before scanning, (d) a visible clock during scanning, and (e) adjustment of music volume. The intervention group reported much less anxiety than the control group, thus supporting the result of the current study, in which the majority of participants expressed the need for education prior to fMRI.

Once participants are informed about what to expect in the scanner, the authors believe that their tolerance of the procedure will be enhanced.

IMPLICATIONS FOR RESEARCH

The findings from the current pilot study have several implications for researchers. First, to improve enrollment strategies, it is imperative that study participants are informed about the procedure, which includes ensuring they understand what to expect in the scanner (e.g., noise, vibrations, time), as well as clearly communicating task expectations and emphasizing safety aspects of the fMRI procedure. A tour of the MRI facility unit (i.e., control room and scanner) may be helpful in reducing anxiety. Second, it is important to emphasize the contribution of participants to research and, ultimately, clinical practice, thus leading to improved patient care. Finally, certain factors, such as the fit of the array head coil for patients requiring prescription glasses and environmental temperature for patient comfort, should be considered. These measures will contribute to better data acquisition as well as enhanced recruitment and retention of participants in fMRI studies.

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TABLEThemes Identified by Open-Ended Questions and Representative Responses ($N = 9$)

Theme	Representative Response
No feelings of claustrophobia, discomfort, or pain	"I am usually very claustrophobic in MRI and have had a few done, but this one was different. The mirror and picture and the depth helped with [the] feeling of openness and less claustrophobia."
Contribution to research	"[I] wanted to be of assistance to others having stroke, which is why I decided to participate."
Open mindedness and positivity	"Go in with an open mind. It usually doesn't last that long if you relax."
Education about fMRI and its safety	"Explain what the fMRI is and that there is no radiation."

Note. fMRI = functional magnetic resonance imaging.