Neuroimaging of Prayer: Questions of Validity

AQ: 1

Kevin L. Ladd, Cara A. Cook, Kaitlyn M. Foreman, and Erik A. Ritter
Indiana University South Bend

Studies investigating the brain in relation to religious experiences via neuroimaging tools have increased considerably. Most assume without verification that religious experience (e.g., prayer) while inside an imaging machine is the same as in normal settings. Addressing the validity of this assumption, we utilized a mock fMRI to compare self-reported typical prayer experience and 3 experimental conditions (silent room, initial fMRI, and acclimated fMRI). Forty-two individuals participated. In multiple aspects the "typical" and silent room conditions were indistinguishable; however, typical and fMRI conditions differed significantly. In sum, it was not clear what previous studies measured. These findings highlight the need for imaging research exploring religious experiences to include thorough debriefing protocols to disambiguate interpretations and facilitate meta-analytic efforts.

AQ: 2

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Since developing imaging techniques, investigators have refined the tools to explore questions such as consciousness (Cacioppo, Berntson, & Nusbaum, 2008) and religious experiences (Cahn & Polich, 2006). We focused on the latter, with regard to theistic prayer, setting aside nonreferential compassion meditation studies (Lutz, Dunne, & Davidson, 2007), except where linked to prayer practices. In particular, we addressed the question of the extent to which imaging tools may or may not be well-suited to investigations of prayer, given the identified character of these tools as **AQ: 3** physical (Ravicz & Melcher, 2001) and subjective stressors **AQ: 4** (Muehlhan, Lueken, Wittchen, & Kirschbaum, 2011). Here, we highlighted some of the better known studies in this area as examples of the various challenges.

Imaging and Prayer

Newberg, Pourdehnad, Alavi, and d'Aquili (2003) used single-photon emission computerized tomography (SPECT) to investigate **AQ: 5** "centering prayer" among Franciscan nuns. Results suggested that the praying activated regions associated with attention (prefrontal cortex) and language (inferior parietal area). Again using SPECT, Newberg, Wintering, Morgan, and Waldman (2006) mapped activation during glossolalia (speaking in tongues form of prayer), finding that patterns differed from those of meditation; no

increases in the prefrontal cortex, superior parietal lobe, or the thalamus were observed during episodes of glossolalia. **AQ: 6**

Beauregard and Paquette (2006) had Carmelite nuns undergo an fMRI pocedure while either reliving a mystical experience or thinking about intense unification feelings. Compared to baseline, **AQ: 7** they saw increases in the caudate nucleus (love and happiness) and the insula (autonomic regulation). They also witnessed increased temporal lobe activity.

Various investigators have compared ritual and spontaneous **AQ: 8** prayers to secular activities. Azari et al. (2001) utilized PET while six religious and six nonreligious participants recited a Bible verse (the first verse of Psalm 23, a passage commonly used as a formalized prayer in the Christian tradition), nursery rhyme, or a set of phone card instructions. For religious participants, a Bible verse stimuli resulted in schema evocation regions (right dorsolateral prefrontal cortex) showing more activity than in brains of nonreligious participants. Religious participants in this context also showed more activation in zones responsible for bodily alertness (dorsomedial frontal cortex) than did nonreligious people (Azari et al., 2001).

Schjødt, Stødkilde-Jørgensen, Geertz, and Roepstorff (2008) **AQ: 9** looked at brain scans of participants improvising prayer, reciting the Lord's Prayer, reciting a well-known rhyme, making wishes to Santa, or counting backward from 100. They observed increases in caudate nucleus activity during recitation of the Lord's Prayer; less activity was seen during improvised prayer.

Schjoedt, Stødkilde-Jørgensen, Geertz, and Roepstorff (2009) looked at similar conditions, but with highly religious individuals. During improvised prayer the areas of the brain associated with the ability to take another person's perspective (e.g., theory of mind regions in the temporo-parietal junction, temporopolar region, left medial prefrontal cortex) displayed increased activity; this pattern was less robust during recitation of the Lord's Prayer.

Schjoedt and colleagues (2009) further reported that autobiographical memory (temporopolar area) was active during improvised prayer, speculating that people were attempting to recall what had taken place since the last time they prayed. The precu-

neus (self-referential thought) was active during both improvised prayer and wishing to Santa.

AQ: 10   Neubauera (2014) employed fMRI with people praying, expressing love or gratitude to a loved one, or imagining and naming animals. In the prayer and love conditions, the medial prefrontal cortex and posterior cingulate showed elevations above baseline, suggesting theory of mind connections. They also noted that prayer linked to more robust emotional arousal than did the love condition. These findings align with recent work demonstrating distinctions between praying and conversations (Ladd, Vreugdenhil, Ladd, & Cook, 2012).

Critical Issues

Prayer, as a form of spiritual discipline, was not developed and is not regularly practiced by most people as a form of experimentally manipulated independent variable to be given or withheld on the request of a scientist in search of empirical data. Although our focus here is on the specific context of imaging studies and prayer, there is, of course, this much larger issue of using prayer in any experimental protocol in which people are asked to produce prayer-on-demand. There are substantial individual differences with regard to when and how people engage in spontaneous prayer or in the use of formal, scripted prayers. Those differences do not exist in a vacuum, but rather are embedded in particular social contexts that include a range of other related spiritual practices, both private and corporate. In those contexts, when prayer-on-demand occurs, the intent is not oriented toward null hypothesis testing, but is, instead a declaration of personal faith. This means that researchers face the considerable challenge of creating a realistic research setting in which to allow people to pray (or not). At the front-end of protocols, this means allowance must be made for a considerable attrition rate because under the even best scenarios, it is likely that a number of people who would like to participate may find the experience too foreign and otherwise uncomfortable. At the back-end of protocols, debriefing sessions will be required to understand the ways in which the prayer-on-demand relates to the typical prayers of participants. These debriefing sessions also will allow for the exclusion from the analysis of those who attempted to pray during the protocol but found themselves unable to do so successfully. In the growing body of literature using prayer-on-demand designs, while some attention is being paid to debriefing (Bremner, Koole, & Bushman, 2011), the contents and outcomes of those sessions are not reliably detailed for readers. Other work duly reports inclusion criterion ("participants who reported being comfortable with prayer were invited"; Lambert, Fincham, Stillman, Graham, & Beach, 2010, p. 128), drop-out rates, and other excellent details of studies, however, those indexes are not able to assess the realism of the protocols and the degree to which people felt that their prayer activities were authentic. The interpretation of results in prayer-on-demand studies, whether significant or nonsignificant, depends heavily on the experience of the participant.

An additional challenge centers on how to identify the nature of the behavior under investigation. *Prayer* is variously operationalized as the recitation or reading of a text, spontaneous thinking, or trying to sense a divine presence. These divergent definitions capture significantly different aspects of the prayer act. Using familiar texts, for instance, places prayer into a communal context whereas spontaneous praying is more individualized. Those individualized prayers are, in turn, divergent in their content and the extent to which that content is more affective, cognitive, or behaviorally oriented may well shift cortical activation patterns. Analyses that do not take into consideration these and other nuances associated with the multidimensional nature of prayer run the risk of suppressing interesting information by averaging across participants (Ladd & Spilka, 2006).

With more specific reference to imaging and prayer studies, some findings clearly overlap (e.g., prefrontal cortex activation) and are arguably associated with basic thinking processes. Other patterns are unique to individual studies and may be either sample or methodology specific. What the entire group of studies contributes is not immediately clear (Ladd, 2012). In her recent review, Maselko (2013) characterized the available findings as "somewhat strained" (p. 216), noting problems of overinterpretation. A similar situation exists for imaging studies beyond the present context of prayer (Lieberman, Merkman, & Wager, 2009; Vul, Harris, AQ: 11 Winkielman, & Pasher, 2009).

Despite the differences in operationalizations of prayer, imaging techniques, or post hoc reasoning that characterize many discussion sections, the studies share a critical and largely unexamined assumption: Religious experiences in imaging and daily contexts are equivalent. The extent to which this assumption is accurate is the extent to which the measurements are valid; without validity, arguments about activation patterns are moot.

This is not to suggest that there will ever be perfect correspondence between laboratory and "real world" conditions. By definition lab-based studies are artificial to some extent because they explicitly control the variables under investigation; this is true of any experimental study, not just those related to prayer or those involving imaging procedures. The question here is not on whether absolutely all peripheral details are in perfect alignment, but whether the contexts are sufficiently similar so as to allow people to at least approximate natural prayer behavior. As one example, the types of prayer investigated are often "spontaneous," personal prayers. In daily experience, this way of praying is, by definition, unplanned and not of an extended duration. Most fMRI contexts, however, rely on block designs that require alternation of "prayer" and "nonprayer" in close succession. This "start–stop–start–stop" series of trials does not align neatly with typical practice and may be so intrusive as to unduly restrict the ability of participants to feel that they are able to actually engage in prayer consistently during the experiment, even if they are trying to do so. One outcome of this potential difficulty for participants is a compromised data set where the prayer data includes both actual praying behavior and attempted prayer behavior. The unintended mixing of these levels of measurement obviously makes any interpretation of findings challenging.

Prayer, fMRI, and Context

Some studies have attempted to make the fMRI less novel by providing recordings of fMRI sounds to participants before the study (Lazar et al., 2000). The extent to which this acclimation process succeeded is not clear. Regardless, that approach could not address the physical sensations of imaging.

Beauregard and Paquette (2006) compared baseline and "mystical experience" activation. But without a comparison of mystical

experience and typical (i.e., nonexperimental, actually lived) contexts, researchers may simply be recording activation patterns associated with what participants may self-report as attempts to engage or recall a mystical experience. The extent to which a perceived attempted prayer is equivalent to an actual prayer is a theologically complex issue beyond the scope of this paper. With regard to prayer, Ladd and Spilka (2006) noted that there was often a significant divergence between official theological positions and "lived" theology. For our purpose, we focus on the self-reported nature of the individual's experience.

At a minimum, evaluating participants' abilities to engage in the assigned prayer activity should be standard practice (Ladd, 2012). Schjoedt and colleagues (2009) asked participants how similar praying in the fMRI machine was to other situations, reporting that experiences were comparable to typical praying. It is counterintuitive that wearing ear protection inside a 60-cm tube with 110 dB of ambient noise would be similar to typical prayer practice. It may be that participants meant that they attempted to pray in a way consistent with nonexperimentally driven prayer or that the content of their prayer was similar to typical prayer.

Neubauera (2014) is among the few researchers who reported a thorough debriefing following a scanning/prayer protocol. Among other questions, participants indicated if they did or did not feel the presence of God during their attempts to pray while being scanned: 57% did (43% did not) feel the presence of God during each of the trials. This is critical because for the participants (charismatic Pentecostals), experiencing the presence of God is a hallmark of the practice of prayer. In short, although people were attempting to pray as requested, they only reported about chance levels of succeeding at that task consistently throughout the study.

Validity Checking

Readers are confronted with findings that raise more questions than are dispelled. Although many questions exist about the usefulness of imaging in the context of studying religion (Ladd, 2012; Schjoedt, 2009), one of the most basic is very simple. To what extent are people truly able to pray inside a scanner? The present work used a within-subjects design to investigate typical (i.e., self-reported reflections) prayer experiences in comparison to a silent room (SR) and an fMRI context to address notions of validity.

We predicted that the fundamental content of the prayers would be relatively consistent across all settings (retrospective and experimental) because people would carry with them the same concerns (Hypothesis 1; H1) regardless of context. This content stability should be matched with an affective stability of prayer experience (H2); people will emotionally react to similar prayer content in a stable fashion. As an additional means of demonstrating the stability of people across conditions, we anticipated that people would maintain a constant sense of their relationship with the God to whom they were praying (H3: Closeness to God will be perceived as consistent across experimental conditions). In sum, people will engage in personally relevant prayers and their sense of God will remain at a constant level throughout the experiment.

The three predictions are in favor of the null hypothesis but we include them because, if supported, they will show that, in terms of the current operationalization of prayer, people are attempting to do the same type of praying across contexts. Any differences

observed in the ability to experience prayer would therefore not be due to the nature of the prayer per se, but to the context in which the prayer is attempted.

Although the three predictions are critical to demonstrate because they address how people are trying to engage the target activity, of primary importance is to understand the extent to which people felt that their attempts to pray actually meet with success. If they try very hard to pray, but do not feel as though they are able to pray in a relatively normal fashion, the fMRI data would not reflect actual prayer, but more likely, attempted prayer. These two states are ostensibly different at many levels, not only in fMRI settings, but more generally in experiments that include prayer-on-demand designs.

We hypothesized additional differences between the SR and fMRI settings that speak to the questionable validity of fMRI as a prayer context. For instance, it is more common for people to sit physically upright rather than recline during prayers, so we anticipated that in the SR, the chair would be preferred to the flat surface (H4); this speaks to the potential confound of simple physical positioning within the fMRI setting. We further believe that because fMRI procedures are typically associated with ill-health related medical treatments, (H5) immediate state positive affect will be lower than typical (i.e., outside the experimental condition) in the fMRI conditions and (H6) immediate state negative affect will be higher than typical levels in the fMRI conditions. This affective shift can make the attempt to pray in the fMRI a difficult event.

We also expect that (H7) participants will spend more time in typical prayer sessions than in the fMRI conditions. This, we believe, reflects both the artificiality of praying in any sort of experimental context and the heighted challenge of praying within the fMRI bore in particular.

Because the fMRI is a novel situation, especially in comparison to the SR condition, we think prayer will be rated as less natural in the fMRI than in the SR (H8), and prayer will be rated as (H9) less comfortable in the fMRI than in the SR.

Overall, we believe the earlier difficulties cited with fMRI contexts will lead to participants rating prayer as less successful in the fMRI than in the SR (H10). If, in fact, participants report that their fMRI prayer attempts are not very successful, this will cause us to reconsider the interpretation of a considerable portion of the prayer-fMRI literature.

Method

Participants

There were 42 participants (67.6% women) who participated in this Internal Review Board approved study. Twenty-eight were psychology students who received extra credit points; others were recruited through word of mouth from congregations. The average age of participants was 24.81 years (range: 18–51 years). The majority were never married (75.7%) and White (83.8%). They classified themselves with regard to religious affiliation as other (32.4%), Catholic (29.7%), none (13.5%), Protestant (10.8%), agnostic (10.8%), and atheist (2.7%). Those who reported never praying (3) were excluded from further analysis, resulting in a total of 39 participants with data available for analysis. Remaining participants self-rated their overall spiritual health as 3.97 based on a scale ranging from 1 (*poor*) to 6

(*excellent*), with 50% attending a religious service at least once per month (30.8% attended once per week or more). On average, the individuals began praying at 4.85 years of age ($SD = 2.29$) and reported a typical prayer length of 3.90 min.

Materials

Replica fMRI.   We constructed a full-scale slightly modified replica of the exterior of a Siemens Trio Magentom Unit (60-cm bore) including a head matrix coil, two head wedges, and a leg cushion. JBL Eon 518S and 515 speakers (Harman, Stamford, CT) inside the replica shell reproduced sounds of a high resolution 3T scan at 110 decibels. Peltor NEXT Nitro (3M Personal Safety Division, St. Paul, MN) earplugs were worn by participants. Such mock fMRI units are commonly employed in research and training sessions as well as being used to familiarize patients with imaging procedures (Neubauer, 2014). The nonoperational status renders the machine less intimidating and hence allows participants to engage the experience with lower levels of anxiety.

Silent room.   A 2′ high, flat 4′ × 6′ table and an upholstered club chair were used for the silent condition of the study. These were positioned side by side with equal access to both.

Testing area.   A single large room in a quiet building was partitioned into two areas of 20′ × 20′ each. An 8′ × 8′ area enclosed a table and chair for participants to complete initial materials.

Scales.   In addition to general questions about the participant's prayer life (e.g., How often do you pray?; How long is your typical prayer?), the survey measured the content of prayers (Ladd & Spilka, 2002, 2006) using a 6-point Likert scale ranging from 1 (*never use during prayer*) to 6 (*always use during prayer*) with 28 words and phrases people use during prayer via eight scales (examination, tears, petition, rest, intercession, radical, suffering, sacrament). Cronbach's alpha reliabilities for the prayer scales exceeded .70 in all cases.

The affect associated with prayer experiences was reported using the Prayer Feelings measure (Ladd et al., 2007). This tool presents single items of six "basic" emotions (happiness, surprise, disgust, sadness, fear, anger). A 6-point Likert scale ranging from 1 (*never feel during prayer*) to 6 (*always feel during prayer*) is used to indicate the extent to which they experienced each emotion while praying.

Current emotions were obtained in relation to each condition using the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988). Five items capture positive and five capture negative emotions. Participants were explicitly requested to focus on their immediate emotional state, using a 6-point Likert scale ranging from 1 (*not at all or very slightly*) to 6 (*extremely*).

Key questions asked after each condition assessed the participant's subjective experience: (1) Right now, I feel very close to God. (2) This experience was very similar to my regular prayer experience. (3) I think most people would be comfortable praying in this sort of atmosphere. (4) I was able to focus on truly praying. Participants responded using a Likert scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*) for each of these items.

Sporadic missing or incomplete data were excluded from analysis on a case-by-case basis.

Design

As a comparison condition, participants responded to the various scales with regard to their typical experiences. They completed this segment prior to encountering any of the experimental conditions, so the answers (with the exception of the "current emotions" scale) represent retrospective data. Following this initial answering of questions, participants experienced a repeated-measures design with three experimental conditions: (1) a silent room, (2) initial exposure to being inside the fMRI, (3) an extended period of acclimation to being inside the fMRI. Experimental Conditions 1 and 2 were counterbalanced, but Condition 3 necessarily always followed Condition 2.

Procedure

Potential participants were informed that this research project was about how people prayed in different settings. On agreement to participate, they completed consent forms, provided demographic information and responded to questions outlining their typical prayer content and affect as well as their general closeness to God. Researchers then taught participants how to operate a small pushbutton remote control capable of turning on and off a light located in the researcher's work station. Researchers next randomly assigned the participants to a beginning condition (mock fMRI or SR).

Reminder instructions were given to participants prior to each of the three experimental conditions. They were reminded that the study was about how people pray in different situations and were told that they could pray about any topic for as long as they desired. When they were finished praying, they could notify the researcher by using the remote control to active the signal light.

Following each condition, participants responded to the scales described above with specific reference to their experience during the immediately preceding condition. Participants had a 2-min break of silence between conditions. After completing all conditions and the survey segments, participants were thanked and dismissed.

Mock fMRI.   To increase realism associated with the medical context in which most fMRI encounters occur, researchers wore white lab coats and participants silently read a safety checklist used for real fMRI sessions. They were informed that the fMRI unit was nonoperational but would realistically mimic the experience of being inside an operational unit. Next, participants removed any metal objects (e.g., jewelry, glasses), placing them in a locker before entering the fMRI room.

Participants inserted earplugs and then reclined on the fMRI sliding table. Researchers then positioned the head coil, two head wedges, and leg cushion. Using a laptop, researchers activated the scanning sounds at 110 dB and then slid the participant into the fMRI bore. Participants prayed in the fMRI as long as they desired, notifying the researcher when they finished by pressing the remote control button.

Acclimation fMRI.   After the 2-min break, participants began an acclimation session. This session consisted of alternating being inside and outside of the fMRI (2 min inside; 1 min outside; 2 min in; 1 min out; 5 min in; 1 min out). During the "inside" portions, the researchers activated the scanning sounds; sounds were discontinued when the participant was outside. Participants were instructed to think about a recent pleasant conversation with a

friend during the acclimation session. This series was followed by a final participant controlled period inside during which time participants were instructed to spend as long as they desired in prayer, notifying the researcher of their completion using the pushbutton remote.

Silent room. Participants chose between lying on a low, flat table or sitting in a club type chair. They spent as long as they wanted in prayer, using the remote control to signal their completion.

Results

Prayer Content

We evaluated (H1) participants' engagement of different prayer contents (eight Prayer Thoughts scales) during typical (retrospective) praying in relation to the three experimental conditions (SR, fMRI, acclimated fMRI). A significant main effect of condition emerged, $F_{omnibus}(3, 102) = 35.25$, $p < .001$, $\eta^2 = .51$. Prayers contained more content during typical experiences ($M = 3.14$, $SD = 0.62$) than during experimental conditions (SR: $M = 2.45$, $SD = 0.64$; initial fMRI: $M = 2.29$, $SD = 0.66$; acclimated fMRI: $M = 2.33$, $SD = 0.66$); $F_{contrasts}(1, 34) > 41.56$, $p < .001$, $\eta^2 > .55$. The experimental conditions did not differ significantly from each other, supporting H1.

This difference was not due to a simple uniformity of approaches to prayer. There was a main effect of the eight Prayer Thoughts scales, indicating that people in the sample prayed about a wide variety of different content, $F_{omnibus}(7, 238) = 21.51$, $p < .001$, $\eta^2 = .39$, consistent with previous work (Ladd & Spilka, 2002, 2006).

An interaction effect between conditions and prayer content was present, $F_{omnibus}(21, 714) = 3.32$, $p < .001$, $\eta^2 = .09$. The differences observed were between the typical (retrospective) condition and the experimental conditions rather than among experimental conditions. In no case did any of the experimental conditions elicit greater amounts of any variety of prayer than was retrospectively reported as typical by the participants.

Prayer Affect

We tested the degree to which typical (retrospective) prayer affect aligned with the experimental conditions affect. Using single item indexes of six basic emotions, a main effect was evident, $F_{omnibus}(3, 111) = 21.08$, $p < .001$, $\eta^2 = .36$. Typical affect levels ($M = 2.65$, $SD = 0.80$) were significantly greater than those experienced during experimental conditions (SR: $M = 1.81$, $SD = 0.55$; initial fMRI: $M = 2.01$, $SD = 0.62$; acclimated fMRI: $M = 1.83$, $SD = 0.63$); $F_{contrasts}(1, 37) > 23.91$, $p < .001$, $\eta^2 > .39$. The experimental conditions muted affective experience.

A main effect of prayer affect was present, $F_{omnibus}(5, 185) = 28.76$, $p < .001$, $\eta^2 = .44$. Positive emotions were generally stronger than negative emotions in agreement with previous reports that basic emotions were not evenly represented during prayer (Ladd et al., 2007).

An interaction effect existed between conditions and prayer affect, $F_{omnibus}(15, 555) = 5.73$, $p < .001$, $\eta^2 = .13$. Affective experiences were uniformly higher in typical (retrospective) set-

tings; attempting to pray in an experimental context elicited less emotionality than was typical for the participants.

We hypothesized a consistency of prayer affect across conditions (H2). This hypothesis was partially supported. The earlier findings suggest a consistency of prayer affect within experimental conditions, however, being under observation while praying appears to lower the affective experience.

Closeness to God

In support of H3, when participants reported how close they felt to God, ratings did not differ significantly across experimental conditions, $F_{omnibus}(2, 38) = 1.25$, $p = .30$, $\eta^2 = .06$. The overall mean (3.56) fell at the response scale midpoint (3.5) signifying a modest sense of experienced closeness to God throughout the experiment.

Prayer Position

Supporting H4, participants almost unanimously chose to sit in the chair (97%) as opposed to lying on the table in the SR condition. Lying flat on one's back was not a preferred way to engage in prayer.

Current State Affect

A significant change in positive affect was observed, $F_{omnibus}(3, 108) = 4.34$, $p = .006$, $\eta^2 = .11$. Participants began the study with a positive affect at the scale midpoint ($M = 3.53$, $SD = 1.00$). This was not significantly different than the positive affect during the SR condition ($M = 3.30$, $SD = 1.19$), however, during the fMRI conditions, the positive affect decreased significantly below that score (initial fMRI $M = 3.11$, $SD = 1.05$; acclimated fMRI $M = 3.01$, $SD = 1.02$); $F_{contrasts}(1, 36) > 9.73$, $p < .003$, $\eta^2 > .23$. This offers support for H5.

Negative affect also changed significantly across the study, $F_{omnibus}(3, 108) = 4.99$, $p = .003$, $\eta^2 = .12$. The initial level was quite low ($M = 1.82$, $SD = 0.67$), decreasing significantly in the SR condition ($M = 1.61$, $SD = 0.70$), then increasing during the initial fMRI experience ($M = 2.12$, $SD = 0.95$), and was equivalent to the ratings in the acclimated fMRI setting ($M = 1.74$, $SD = 0.83$); $F_{contrasts}(1, 36) > 4.29$, $p < .04$, $\eta^2 > .11$. This finding aligns with H6, although it is important to keep in mind that at no point did the means cross the scale midpoint. The results do not suggest that the initial fMRI context evoked strongly negative reactions, but rather that the initial fMRI context was simply more negative than the typical and SR ratings.

Prayer Duration

We measured the time (in seconds) that people spontaneously spent praying to compare this to their self-reported typical prayer duration. A significant difference was observed when comparing their self-reported typical prayer duration ($M = 234.51$, $SD = 280.86$) and prayer time in the three experimental conditions: SR ($M = 162.47$, $SD = 139.53$), the initial fMRI experience ($M = 129.95$, $SD = 145.12$), and postacclimation fMRI ($M = 157.55$, $SD = 165.59$); $F_{omnibus}(3, 111) = 3.26$, $p = .02$, $\eta^2 = .08$. The typical (retrospective) condition did not differ significantly from either the SR or acclimated fMRI conditions, however, the typical

condition was significantly greater than the initial fMRI condition ($F_{contrast}$ = 5.82, ps < .02, η^2s > .14). People approximated their typical prayer duration, except during the initial fMRI exposure. This offers partial support for H7.

Prayer

When indicating how similar the prayer experience was to their normal prayer experience, participants rated the SR significantly higher (M = 4.20, SD = 1.67) than the fMRI both initially (M = 2.25, SD = 2.02) and after acclimation (M = 1.85, SD = 1.50); $F_{omnibus}$(2, 38) = 20.68, p < .001, η^2 = .52; $F_{contrasts}$(1, 19) > 17.42, ps <.001, η^2s > .48. This supports H8, with the SR ratings falling above the scale midpoint of 3.5 while the fMRI ratings were below the scale midpoint.

When estimating if they thought other people would be comfortable praying in the same sort of atmosphere, participants rated the SR (M = 4.25, SD = 1.65) significantly higher than they did the fMRI both before acclimation (M = 1.80, SD = 1.20) and after (M = 2.00, SD = 1.45); $F_{omnibus}$(2, 38) = 28.53, p < .001, η^2 = .60; $F_{contrasts}$(1, 19) > 29.26, ps <.001, η^2s > .61. This supports H9, with the SR ratings falling above the scale midpoint of 3.5 while the fMRI ratings were below the scale midpoint.

Finally, when asked if they were able to truly focus on praying, participants rated the SR (M = 3.65, SD = 1.69) significantly higher than the fMRI both before acclimation (M = 2.41, SD = 1.54) and after (M = 2.47, SD = 1.32); $F_{omnibus}$(2, 32) = 7.73, p = .002, η^2 = .33; $F_{contrasts}$(1, 16) > 7.46, ps <.01, η^2s > .32. The SR mean was above the objective mean (3.5), while the fMRI condition means were below that level indicating that in the silent condition, participants were more able to focus on praying but they were not as successful in achieving that same sort of focus during the fMRI conditions. Although this aligns with H10, it is also important to keep in mind that the SR mean was not exceptionally positive, having just crossed the scale midpoint. As with other of the findings reported, the data do not demonstrate that the SR condition was perfectly conducive to engaging in prayer, only that it was significantly better than the fMRI alternative. Again, attempting to engage in prayer-on-demand is apparently a challenging task even under favorable conditions.

Discussion

People tried to pray in ways similar to their retrospective typical practices regarding content, but their success was muted. This general suppression of prayer content across experimental conditions shows that praying during experiments is not necessarily the same as normal prayer. As we noted in the introduction, this prayer-on-demand challenge is not limited to imaging studies, but pervades experimental prayer research in general. We believe that the following findings, while highlighting an imaging and prayer research context, point out the broad need for additional caution in the methodology and interpretation of experimental prayer studies.

As with content, prayer emotionality generally was suppressed within the experimental context. The effect sizes here were quite robust and we anticipate that this represents a situation not limited to fMRI settings but rather is likely to be common to prayer-on-demand protocols in other contexts; being watched by a scientist while praying changes the emotional experience.

With regard to both content and affect of prayer, it is also possible that the retrospective nature of the typical ratings were artificially inflated. Especially with regard to the prayer affect, Thomas and Diener (1990) demonstrated the uneven nature of emotional recall. Even more challenging, Winkielman and Berridge (2004) provided a review of how unconscious processes can skew emotional experiences. Noting that the content recalled retrospectively and the content reported in each of the experimental conditions revealed no significant differences, provides us with some confidence in the stable nature of the retrospective reports, however, the content and the affect associated with prayer are separable so our confidence is not absolute.

The effects of being under observation appear to have been limited in this study to the particular event of praying during the research protocol. This is demonstrated by the fact that participants did not report any significant differences with regard to their general feelings of closeness to God. As with other domains of research, the levels of measurement are important to consider because global measures of specific behaviors may provide inaccurate information.

Our hypothesis that participants would prefer to pray while sitting in a chair versus lying on a hard table was confirmed; people do not consider lying on a hard, flat surface a desirable prayer position. As expected, participants spent longer periods in prayer during the silent condition than during the initial fMRI condition; this timing difference was ameliorated following acclimation to the fMRI context. Although people can learn to endure fMRI conditions, those conditions are not initially embraced. Even if the person ultimately can make the physical adjustment to being inside the fMRI, this does not speak to the individual's unique mental and spiritual experiences of prayer in that context. As shown for psychology in general (Gallagher, 2005) and religion in particular (Coakley, 1997), embodiment's influence on mental processes is considerable and not always personally identifiable. Previous work has shown this to be explicitly the case with fMRI contexts (Muehlhan et al., 2011; Ravicz & Melcher, 2001) and the extent of those effects with regard to prayer research are not documented.

In answer to our central question (Do people think they can effectively pray on demand in an fMRI), as expected, participants found the experience of the silent room significantly more like their typical experience and were able to focus more on praying than during the fMRI (before or after acclimation). This suggests that even though participants may become somewhat acclimated to being inside the fMRI physically, most of them were still not able to engage in prayer in a way that is similar to their typical manner. It is important to keep in mind that although the fMRI averages were significantly lower than the SR average regarding the ability to focus on praying, the SR average itself was not exceptionally high, just crossing over the objective mean into the *agree* portion of the scale. This again speaks to the clear challenge of asking people to pray on demand in an experimental context. Even a condition that was judged relatively similar to typical settings did not evoke strong prayer experiences. In this protocol, in an attempt to maximize individual comfort and to explore the naturally occurring breadth of prayer content, we did not seek to direct the topics of prayer in any fashion. Other studies (Schjoedt et al., 2009) have provided more specific prayer stimuli that might pro-

mote more effective focusing of effort, although simultaneously intensifying the prayer-on-demand characteristics of the protocol.

To the best of our knowledge, this is one of the first experimental studies to place an emphasis on the question of one's perceived ability to pray in different contexts; far more studies explore perceived efficacy of prayers (either for known or unknown recipients or for practitioners as a personal coping strategy). Essentially, people are asked to what extent their prayers helped as opposed to if they were able to pray at all. Yet in a review of the religious coping literature (Gall & Guirguis-Younger, 2013), it is clear that there are substantial numbers of religious people who do not use prayer when coping with significant events. These people may find themselves unable to pray, or actively choose not to pray because they feel abandoned by God (Pargament, Koenig, & Perez, 2000) or are angry at God (Exline, 2013; Exline, Prince-Paul, Root, & Peereboom, 2013). The present study highlights the necessity of better understanding the prayer experience of individual participants, whether in imaging protocols or otherwise, such as in the area of prayer and coping. For instance, in addition to asking if people employed prayer as a coping strategy, the question can be asked: To what extent did you attempt to pray and find yourself unable to do so? Although we failed to obtain this information in the present study, it would have provided an important baseline to determine the extent to which success in praying under experimental conditions was better or worse than in typical settings.

Limitations

This study included introductory psychology students and people active in various Christian denominations. These people were not experts in the sense of having devoted their lives to the pursuit of prayer as was the case in some of the studies cited earlier. In many cases, restricting an investigation to expert practitioners introduces a variety of potential confounds. For instance, a sample of monks or nuns is highly self-selective and the nature of their lifestyle and social relations is not necessarily comparable to the typical individual. Likewise, studying only the prayers of highly religious individuals provides information about a narrow range of the population. This is further complicated when the highly religious people are recruited from within a heavily secular context, such as is the case with several of the European studies. Self-identifying as very religious in a nonreligious setting creates a very particular cultural experience that, by definition, is marginalizing.

In contrast, the present study's data speak to a common level of experience. Thinking about prayer at this practical level, rather than as a specialized practice, emphasizes that prayers are not inherently linked to a practitioner's status or level of practice; accessibility to prayer cuts across categories (Ladd & McIntosh, 2008). Given this "equal access" availability of prayer and the repeated-measures design employed, issues such as social desirability are unlikely to have played a role in the findings.

The Christian nature of the sample may represent a limitation. Our expectation is that because the major faith traditions share a large amount of practice and content in common with regard to prayer that the fMRI context represents a situation that is uniformly atypical. Attempting to pray on demand while wearing auditory protection, and lying inside a 60-cm tube is not a typical prayer situation. We would expect the findings in the present paper to be replicable across traditions.

The typical prayer experiences were retrospectively self-reported by participants and are susceptible to all of the vagaries associated with that methodology. It may be that these longer term retrospective reports were systematically different than the instantaneous short-term retrospective reports obtained during the experimental conditions. Any potential influence of this difference in the immediacy of measurement is limited to comparisons of the typical to experimental conditions and generally speaks to questions about prayer-on-demand designs. If comparisons to the typical are removed from consideration, this circumscribes the level of measurement issue. In that situation, the fundamental relations between the silent and fMRI conditions persist, so the basic findings of the study remain stable.

In an attempt to mimic fMRI procedures, researchers wore white lab coats during the fMRI portion of the present protocol. Previous studies have not reported this level of detail concerning their investigations, so we followed local conventions. Some anonymous reviewers, however, indicated that they do not, in fact, wear such garb during their investigations, suggesting that our use of the coats unduly emphasized a medical context. The use (or not) of lab coats is an area of difference across fMRI research protocols that clearly has slipped under the reporting radar, contributing another layer of challenge for those wishing to replicate or evaluate the existing studies. We are not able to empirically determine the extent to which the use of the coats in the present confounded the present results, however, researchers in future protocols may wish to provide more explicit contextual details to parse out such potential effects.

Implications

Current fMRI technology may be overly invasive for prayer research. Prayer-on-demand in any experimental context is odd for practitioners and the fMRI context exacerbates that problem, at least over a silent room setting. At a minimum, future fMRI, as well as other prayer-on-demand studies could employ quick manipulation checks or more thorough debriefing methods. The simple step of evaluating the extent to which participants were able to comply with the prayer instructions would not add to the cost of the experiments but would speak to the critical factor of validity.

As an alternative, the fMRI potentially could be used to study [AQ: 24] prayer indirectly by emphasizing words and phrases associated with distinct prayers (Ladd & Spilka, 2002, 2006; Spilka & Ladd, 2013). This type of protocol would call for participants to think about the language used during different types of prayer. In other words, people would not be attempting to pray per se, but instead would be concentrating on constellations of words and phrases typically used in the context of praying. Results could help us better understand the extent to which the typical linguistic contents of prayers arouse distinct activation patterns. Knowing how the prayer related language functioned in and of itself would then allow for the formulation of hypotheses about the extent to which various contexts (e.g., attempting to pray; attempting to avoid praying) influenced these baseline activations.

Another option is to use visual presentation of distinct physical positions used during prayer (Ladd, Cook, Foreman, Ritter, & Cora, 2015), asking participants to imagine themselves adopting these bodily postures for the purpose of prayer. These approaches

avoid the artificiality of experimental-prayer-on-demand while presenting testable hypotheses (as opposed to post hoc reasoning).

An additional line of research could focus explicitly on exploring any differences in activation patterns between people who report actually praying and those who report trying to pray without consistent success. This would be closely linked to research involving potential differences in neural responses depending on whether the prayer stimuli are provided by the researchers or are self-generated. Cued and self-initiated thinking are known to activate discrete systems (Ciaramidaro, Becchio, Colle, Bara, & Walter, 2014; Gilbert, Gollwitzer, Cohen, Burgess, & Oettingen, 2009), so parsing out these effects can deepen our understanding.

Advances in fMRI (e.g., open structure) also are changing the extent to which the procedure may or may not be perceived as restrictive in a physical sense. Although this change will not address the problems inherent in block design protocols (start–stop–start praying), it represents a step in the direction of greater validity and realism for participants.

In sum, we believe that as designs and methods are tightened and definitions are sharpened, fMRI studies may provide better understanding of relations between brain activation patterns and the ancient prayer practices.

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