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The effects of prayer on attention resource availability and attention bias

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Abstract

Two experiments were used to measure the effects of prayer, contemplation, or a control activity on attention resource capacity and attention bias. Results from a dual-task test in Experiment 1 indicated that allowing participants to pray about an issue in their lives improved subsequent task performance, but only for individuals who score highly on a measure of religiosity. Experiment 2 suggested that praying about a problem can bias attention in a word-search task. Similar effects were not observed for control activities. Thus, at least for people most likely to engage in religious behavior, praying about a problem appeared to liberate cognitive resources that are presumably otherwise consumed by worry and rumination, leaving individuals better able to process other information, and additionally to bias attention to favor detection of problem-relevant information. These effects suggest one cognitive process (attention) that may underlie how people come to perceive answers to prayers.

The 2012 Pew Research Center's Forum for Religion and Public Life indicated that over 80% of the world's population is religiously affiliated, with 74% identified with Buddhism, Christianity, Hinduism, Islam, or Judaism (pewforum.org, 8/29/2013). Within all of these large religions, and perhaps others, prayer is a significant component of the religious experience. In the 2014 Pew Forum U.S. Religious Landscape Survey, 55% of more than 35,000 respondents indicated that they prayed daily, and an additional 21% responded that they prayed weekly or monthly. Only 23% of Americans reported they seldom or never prayed. This practice of prayer reflects the pluralistic nature of the United States as these participants represented many religious traditions, and hints at the prevalence of prayer by people around the globe. Whereas attendance of religious services has declined in the last two decades (Marty, 2009), the prominence of individual prayer experience in American society has remained constant, suggesting that prayer offers benefits to individuals separate from other religious practices (pewforum.org, 2/17/2010), at least in the U.S. and very likely worldwide.

More than just an aspect of religious behavior, prayer is also a personal, cognitive and social experience. Prayer involves and is related to a wide range of cognitive processes, including perception, language and inner speech, affect, self-concept, memory, decision-making, planning, and social cognition. Individuals may pray to seek guidance before making

important decisions about which they are uncertain, to find comfort when faced with circumstances that are distressing or stressful, or to alleviate loneliness through communication with the divine. Indeed, the 2016 Pew Research Center's data show that, among highly religious individuals, 86% rely on prayer when making a decision—a larger percentage even than relying on one's own research in making the decision (pewforum.org, 04/12/2016). Many individuals believe that such prayers are answered, but it remains unclear how individuals perceive answers to prayers that seek divine direction in the face of response uncertainty (e.g., what medical treatment should I select, or what college should I attend?). To understand how people perceive the answers to these kinds of prayers, it seems important to understand both the cognitive processes that are involved in prayer and also how cognitive processes are affected by prayer. There has been considerable attention to the former issue in recent years, as summarized below; however, relatively few studies have directly examined the effects of prayer on cognition. The present study was designed to examine effects of prayer on attention—the selection of information for processing and response—as one potential cognitive construct involved in the perception of answers to prayer. That is, it seems reasonable to suppose that praying about a problem or decision might alter attention so as to increase the probability of perceiving problem-relevant information, or to alter the mental effort expended invested into a decision.

Prayer

Prayer has been studied since psychology's early days as a discipline (e.g., Caulkins, 1911; Strong, 1909), and throughout that history researchers have recognized the complex, multidimensional nature of prayer (e.g., Heiler, 1932; Hood, Morris & Watson, 1987; Ladd & Spilka, 2002, 2005, 2006; Spilka, Hood, Hunsberger, & Gorsuch, 2003). There has been much less agreement on the exact number and nature of these dimensions, which have for example been described in four types (colloquial, petitional, ritual and meditative; Paloma & Gallup, 1991; see also Paloma & Pendleton, 1989) and in over 100 categories (Richards & Hildebrand, 1990). Spilka and Ladd's (2013) state-of-the-literature review of the psychology of prayer provides a wonderful summary of what is known about the multidimensionality of prayer, its expression across the lifespan, its effects on health and well-being, the effects of intercessory prayer, and related topics. It also framed the cognitive perspective on prayer, summarizing what is known about prayer and cognition but also serving to highlight the gaps in this literature.

For example, Ladd and Spilka's own research (e.g., 2002, 2006) has addressed the multidimensionality problem by examining the language used in various prayer types. Building on Foster's (1992) theory of the directionality of prayer, Ladd and Spilka found that prayers serve to establish cognitive connections with the divine (upward-directed), with other humans (outward-directed), or with oneself (inward-directed). This link between prayer and self-concept is reminiscent of the many studies of prayer and personality (reviewed by Ladd & Spilka, 2013).

The number of studies (like the present one) on the cognitive effects of prayer is much smaller. Childs (1983) had suggested a relation between prayer, inner speech, and self-regulation; however, Schneider's (2004) research found no link between prayer, inner

speech, and self-efficacy. That same year, Wiegand (2004) tested the efficacy of prayer to reduce anxiety and cognitive interference. She found that, although participants who prayed (specifically, who read a prayer passage) scored lower in anxiety, performance on cognitive tasks decreased, whereas participants not asked to pray showed no performance decline.

Schjoedt, Stodkilde-Jorgensen, Geertz, and Roepstorff (2009) used fMRI to identify patterns of neural activation in Christians during personalized, improvised prayer versus rote repetition of institutionalized prayer. They found that religious individuals engaging in improvised prayer activated areas known for social cognition, as well as areas associated with the dopaminergic reward system.

Luhrmann, Nusbaum, and Thisted (2013) studied the effect on cognition of practicing kataphatic prayer. They reported increased vividness in visual imagery along with other cognitive processes, including increases in the focus of attention, as a result of the practice of this imagination-based prayer. The authors concluded—as the other studies reviewed above suggest—that prayer does influence cognition. The present study was also designed along these lines, to identify effects of prayer on attention capacity and selection biases.

Most relevant to the present research, Friese and collaborators (Friese, Schweizer, Arnoux, Sutter & Wänke, 2014; Friese & Wänke, 2014) studied the effects of prayer on cognitive control, and specifically on the protective or restorative effect that prayer appears to have on cognitive resources that are consumed in taxing mental activities. Participants were asked continuously to report the contents of consciousness for a period of time. One group of participants was further instructed to suppress one specific thought (e.g., a white bear) during this interval. Both activities (the detailed reporting of conscious thoughts and particularly the effortful suppression of a specific thought) were expected to deplete mental energy, an effect that has been shown to result in reduced capacity for self-control (e.g., Baumeister, Vohs & Tice, 2007; Hagger, Wood, Stiff, & Chatzisarantis, 2010; but see Lurquin et al., 2016 for contrary evidence, for example). The researchers administered a Stroop task to determine the effects of mental activity on subsequent cognitive control; however, either before or after the thought-reporting activity, participants engaged in a period either of free thought or of prayer. Stroop interference was significantly greater for the suppression group than the control group, but this effect was only observed when the experimental activity was free thought, not prayer. That is, is appears that prayer allowed participants to preserve or recover mental resources that were required for thought suppression.

Although not specific to the topic of prayer, similar effects have also been reported from studies of the effects of meditation on attention and cognitive control. Participants who were trained in a form of short-term mediation showed improved performance on the Attention Network Test and increased white matter within the anterior cingulated cortex, along with decreased levels of anxiety, depression, fatigue, and cortisol (Tang, Lu, et al., 2010; Tang, Ma, et al., 2007;).

Attention Capacity

These findings are easiest to understand with a framework like Kahneman's (1973) influential resource model, in which attention is conceived as a limited capacity-resource, similar to one or more (Wickens, 1980) pools of mental energy that can be allocated, expended, depleted. When attention is required for processing specific stimuli, individuals can allocate mental resources accordingly and flexibly. Thus, people can generally multi-task and perform multiple complex activities simultaneously (e.g., driving a car and talking on the phone). Attention resources may be divided and switched between concurrent tasks, but not always without cost. The capacity of attention resources is limited, such that as a task demands that the individual pay more attention (e.g., one focuses increasingly on the cell-phone conversation while driving), at some point the combined demands will reach the limits of capacity and performance on the concurrent task will suffer (e.g., one may fail to perceive and respond to the traffic signal).

Manipulations of the nature and priority of multiple concurrent task demands have been used to examine the capacity and allocation of attention. At any given time, performance on one or more tasks is an interactive function of attention resource capacity and the resource demands of each task or activity that is competing for this capacity. Mental workload, the amount of cognitive resources used to complete any task (e.g., Procter & Van Zandt, 1994; 2011), thus interacts with attention capacity to predict performance. If task workload exceeds available capacity, performance deteriorates (e.g., Eggemeier & Wilson, 1991; O'Donnell & Eggemeier, 1986), because fewer resources are available to process other information.

The present investigation was designed to elucidate whether and how prayer affects the capacity of attention resources. Based on the many findings from dual-task studies of attention, it seemed reasonable to suppose that prayer about a particular problem or concern would increase the allocation of attention to that problem, leaving fewer resources for other processing, as indicated for example by declines in performance concurrent or subsequent tasks. This prediction is similar to the findings reported by Schjoedt et al. (2013) and by Friese and collaborators (Friese et al., 2014; Friese & Wänke, 2014). In the Schjoedt et al. (2013) model, resource depletion during some emotional religious rituals compromise the executive functions of error monitoring, memory updating, and conflict resolution, thus creating gaps in attribution that make the individual more vulnerable to influence, particularly in the presence of a charismatic authority.

Conversely, one might predict that praying about a problem would temporarily release the individual from the cognitive workload associated with stress and worry about that decision or problem (e.g., by yielding responsibility for resolution to the divinity). If this were to occur, attention resources that might otherwise be consumed by worry and rumination would be liberated and remain available for allocation to concurrent and subsequent tasks. That is, prayer might have the effect of releasing attention from the problem, decision or issue, at least temporarily. This prediction, built on the assumption that there are resource costs associated with problem-related worry or stress (see Hasher & Zacks, 1979; Lazarus, 1999; Matthews & Campbell, 2010; Matthews et al., 2002; Matthews et al., 2006; Stawski,

Sliwinski & Smyth, 2006), would be validated by findings that concurrent or subsequent task performance improves following prayer about that problem, decision, or issue. So for the present study we hypothesized that prayer would alter attention-resource availability, and also predicted that self-reported stress would decline following prayer.

Attention Biases

Given that there are resources to allocate, how will they be allocated? That is, what determines the focus of attention—and pursuant to the present research, does prayer influence what stimuli are selected for attention? Numerous theorists (e.g., Norman & Shallice, 1980, 1986) have posited models in which selection is controlled by a combination of bottom-up (i.e., contention scheduled) and top-down (i.e., supervisory control) processes. That is, attention can be stimulus- or data-driven or can be directed conceptually or executively. Priming is a mechanism for attention bias, or the systematic prioritizing of some stimuli over other information. These effects can be general and transient (e.g., reading the word “bread” may facilitate the speed with which one processes subsequent instances of “bread” as well as related words like “butter”), or may be more stable and characteristic biases. For example, anxious individuals have been shown to hold attention biases toward threatening stimuli relative to neutral stimuli (Bar-Haim, et al., 2007; Mogg & Bradley, 1998). Eysenck, Derakshan, Santos, and Calvo (2007) explained this effect by proposing that anxiety impairs resource-demanding, top-down inhibition that would otherwise disengage attention from threatening stimuli that elicit automatic responses.

Nisbett (2003) and others have shown that attention can also be biased by cultural variables, with participants from Eastern cultures biased toward global patterns but Western participants more biased toward focal or local features of the same visual scenes. Colzato and collaborators (Colzato, van den Wildenberg, & Hommel, 2008) extended this finding, reporting differences in the magnitude of the attention bias toward local or global features as a function of religious beliefs. For example, Calvinists showed stronger local-attention bias whereas Catholics displayed a larger global-dominance effect, consistent with the individual-responsibility versus group-identity emphases (respectively) of these religious orientations (Colzato, Beest, et al., 2010). Colzato, Hommel, and Shapiro (2010) also found that, relative to Atheists, Dutch Calvinists have a relatively pronounced attentional blink, an empirical phenomenon in which a participant fails to perceive target stimuli that are presented while the participant’s attention is occupied by the processing of previous target stimuli. This difference was also interpreted as a chronic attentional bias for global perception that is strengthened by religious beliefs.

In the present study, we hypothesized that prayer would bias attention, not just to a global or local processing style, but toward the processing of particular stimuli. That is, we tested whether the act of prayer would prime the subsequent selection and processing of information related to the prayed-about issue or decision. It seemed reasonable that prayer might activate schemata relevant to the prayed-about topic, lowering the threshold for perceiving information relevant to the problem or solution.

Experiment 1: Effects of Prayer on Attention Resources

Method

Participants—Volunteers (N = 173, 122 females; age range 18 to 48 years; 44% self-identified as Black/African American, 27% as White/Caucasian, 15% as Asian, 8% in other categories; 6% identified as Hispanic/Latino/a in ethnicity) were recruited from an undergraduate psychology research pool at Georgia State University in Atlanta, Georgia, and were tested individually in private rooms to prevent distraction. During the sign-up procedure, participants were made aware of the potential request to pray during the study, and were given the choice to discontinue with the experiment at that, or any, time.

Apparatus and Measures—A battery of tasks and self-report instruments were administered, to which participants responded using the computer keyboard or mouse. Participants reported personal religious experience through the Religious Background and Behavior Scale (RBBS; Conners, Tonigan & Miller, 1996), a 13-question questionnaire primarily used to measure private religious and spiritual practices, including prayer. It has been shown to be high in test-retest reliability and internal consistency (r = .94 and Cronbach's alpha = .86).

To allow for an individual subjective interpretation of the instructions to pray, each participant of the prayer group completed a post-test questionnaire consisting of six open-ended questions allowing each participant to describe her/his prayer during the study (Appendix A). The written responses were coded independently by three researchers and were analyzed for themes.

Individual differences in attention skills were measured by five tasks chosen from the Assessment Software for Attention Profiles (ASAP; Washburn & Putney, 1998) battery, designed to provide measures of attention across component factors of attention focusing, shifting, and sustaining. Mean test-retest reliability of the full ASAP battery is .88 (Washburn & Putney, 1998). The Stroop task (Stroop, 1935) required participants to identify the color of sequentially presented words or characters, including congruous and incongruous color words (e.g., the word BLUE in blue or red, respectively). Two tasks required rapid identification of a letter (an E or an F) presented to the left or right of fixation. To facilitate identification, on some trials the location of the target letter was reliably indicated by a brief cue either in the location where the target would appear (Cue task) or in the opposite position from where the target would appear (Anti-saccade task, or Anti). A Visual Search task required participants to determine whether a target letter (F) was embedded in arrays of 10 to 70 Es, Ls, and Ts. A continuous performance task (CPT) required participants to make a stream of target/nontarget judgments across a 6-minute vigil, to provide a measure of sustained attention.

Each participant also completed a dual-task test to provide a measure of attention-resource capacity. This task combined the demands of the CPT task with a concurrent tone-detection task, which required the volunteer to press a key on the keyboard with the non-dominant hand whenever a tone sounded. Following the logic of hundreds of prior studies in which the dual-task paradigm was used, varying the difficulty of the primary task (i.e., the inter-

stimulus interval in the E/F judgment the task) was expected produce reciprocal disruptions of response latency to the secondary tone-detection task. Each participant completed 100 trials of this task, during which participants also responded to approximately 10 tone presentations.

To examine potential mediation of any relationship between prayer and attention by changes in arousal, stress, or anxiety states, participants completed the Dundee Stress State Questionnaire (DSSQ; Matthews et al., 2002) before and after the experimental manipulations. The DSSQ measures three fundamental stress-state dimensions: task engagement, distress, and worry. Internal consistency of factors ranges from .76 to .89, with a reliability range from .37 to .66.

Procedure—After consent was obtained, the participants completed the RBBS and then were randomly assigned to one of three conditions (word-search control, contemplation or prayer). Participants were then asked to identify one current area of concern in their lives from the following choices: health, academics, relationships, or finances. A computerized version of the DSSQ was administered, followed by the dual-task test of attention capacity. Each participant then completed the 10-minute experimental activity: One control group was asked to perform a paper-and-pencil word-search task (find the names of US cities, embedded in an array of 225 letters). The contemplation group was instructed to sit and think or ruminate about their area of concern for 10 minutes. Members of the prayer group were asked to pray, in whatever way each participant wished to define it, about the particular concern he/she had identified. Instructions for the participants were the following: “Please spend the next ten minutes in a comfortable position, and think or contemplate the current concern in your life that you indicated in the paperwork you filled out” or “Please spend the next ten minutes praying, however you personally define prayer, in whatever position you choose, about the current concern in your life that you indicated in the paperwork you filled out.” Following this prayer/contemplation/word-search activity, a post-activity administration of the dual-task test of attention capacity and the Cue, Anti, CPT, Stroop, and Search battery, followed by second DSSQ. Then the experimenter requested that prayer-group participants complete a questionnaire to describe their activity during the prayer. Participants were then debriefed and dismissed. All participants were tested with the experimenter present except during the prayer, ruminating, and control activity, during which time the experimenter left the room to allow the participant privacy.

Results

Prayer and Religiosity—Of the participants who were assigned to prayer condition, 92% reported directing their prayer to God, Allah, or a Higher Power. When asked whether they were distracted during prayer, 60% responded no, 17% said yes, and 23% chose not to answer. Among reasons for distractions, participants reported, “Things I need to do” and “Voices or Noises in the hallway” most frequently. On assuming physical position during prayer, 66% of participants reported bowing their heads, 67% reported closing eyes, and 40% indicated folding or clasping hands. Three individuals stated that they placed their head on the desk, three individuals looked up at the ceiling, and one individual assumed a Hindu yoga position. When asked what prayer meant to them, 97% of those who prayed described

prayer as a form of communication, using words like “telling God,” “talking to God,” “listening to divine power” or “asking God.” Twenty-two percent of participants indicated that they expected or requested resolution to their concerns.

Composite scores on the religiosity measure ranged from 9 to 55, M=26.5, with a standard deviation of 9.4. Religiosity did not vary as a function of gender, age, or race. (Indeed, no gender, age, or race effects were found on any dependent measure in this study.) Of the 173 participants, 46 participants indicated atheist or not religious to a question regarding religious identity, 27 participants indicated Islam as their religion, 61 participants indicated Christian, 6 participants indicated Catholic, 3 participants indicated Wiccan, and the remaining participants chose not to indicate their religious identity.

Dual-task test of attention capacity—Two composite variables (pre-test attention capacity and post-task attention capacity) were computed by combining primary-task and secondary-task response times for each test and each participant. The pre-task composite response times were then subtracted from post-task to yield a measure of the change in attention capacity as a function of the experimental activity[1]. A 3 (experimental condition) × 3 (religiosity, grouped into tertiles) between-groups analysis of variance was used to analyze the effect of prayer and religiosity on the response-time difference measure, with Helmert contrasts for all post-hoc comparisons. Main effects of experimental condition and religiosity were not found. However, a significant interaction between experimental condition and religiosity was observed, $F(4,164) = 3.27$, MSE =4.183, $p<.05$, $\eta^2 = .074$. For highly religious participants, those participants who prayed demonstrated a significantly greater decrease in composite response times (M = 811 ms, sd = 284 ms) than those who contemplated (M = 193 ms, sd = 325 ms) or completed the control activity (where response times actually increased by an average of 203 ms, sd = 269 ms), $p<.05$. There was no significant difference in change of mean response times between word-search and contemplation groups, $p=.471$, or between any conditions for groups in the low- and moderate-religiosity groups.

Similarly, for all participants who prayed, Helmert contrasts indicate that participants who were high in religiosity demonstrated a significantly greater decrease in response times from the pre-test to the post-test, compared to the medium- (increase of 213 ms, sd = 206 ms) and low-religiosity participants (decrease of 174 ms, sd = 489 ms), $p<.05$. These latter two groups did not differ significantly from one another ($p = .933$).

ASAP results—No significant main effects or interactions of experimental group or religiosity on the Cue, Anti, or Search tasks were observed. There was no significant effect of experimental condition or religiosity on CPT task response time; however, an Experimental Group × Religiosity interaction was observed, $F(4,159) = 3.048$, $MSE = .026$, $p<.05$, $\eta^2=.075$. For participants who scored high in religiosity, there was a significant difference between those who prayed (M = 473 ms, sd = 22 ms) and those who either

[1]This pattern of results for the composite “change in response time” measure is comparable to the effects observed when analyses were conducted on the primary-task and secondary-task response times separately. Mean response times for both the primary-task and secondary-task measures are displayed in Appendix B.

contemplated (M =555 ms, sd = 24 ms) or completed the word-search task (M =485 ms, sd = 21 ms), $p<.05$

For the Stroop task, accuracy differed significantly between the experimental groups, $F(2,89) = 4.116$, $MSE = .065$, $p<.05$, $\eta^2=.080$. Those participants who prayed were significantly more accurate in overall Stroop performance than participants who were assigned to contemplation or word-search task, $p<.01$. These results are depicted in Table 1. Response times did not show this effect. There was no effect of religiosity on Stroop accuracy or response time, and no further interaction.

All factors of the DSSQ except for hedonic tone significantly decreased from pre- to post-task tests: tension $t(169) = 6.03$, $p<.001$; energetic arousal $t(169) = 4.09$, $p<.001$; self-focus $t(169) = 6.46$, $p<.01$; hedonic tone $t(169) = 1.734$, $p = .084$. Means for DSSQ scores are shown in Table 2.

No significant differences in DSSQ scores (overall change scores, or by subscales) were observed between the experimental groups or religiosity group, $p > .05$. Further, no significant correlation was found between any subjective stress-state measure and the response-time measures from the dual-task attention-capacity test, and there was no evidence of significant mediation from the results of linear regression analyses (using the method of Baron & Kenny, 1986). Volunteers reported more stress early in testing than toward the end of their participation, but there is no indication that this effect impacts the primary questions being pursued here.

Discussion

As predicted, attention capacity was affected by prayer, but only for participants in the highest tertile of religiosity. Participants in this group showed an increase in attention resources, as evidenced by faster dual-task responses, after prayer versus before. This is the pattern of results would be expected if praying about a real-life problem served to free the individual from having to attend to the problem, at least for a short time, thus releasing attention resources that could otherwise be used for other processing. Because this effect was not seen for the other experimental or religiosity groups, alternative interpretations (e.g., practice or automaticity effects) are untenable. The effects of prayer on Stroop accuracy and CPT-task response time provide further support that prayer can alleviate cognitive load for the high-religiosity group. Because the Stroop task is a demanding, response-competition task that can be interpreted as a measure of executive attention (Kane & Engle, 2003), one would expect performance to vary as a function of attention resources. This replicates the results of Friese and collaborators (Friese et al., 2014; Friese and Wänke, 2014), albeit the effect was only seen in the present Stroop accuracy measure. The response competition in the CPT task is the battle to sustain attention against the habituation and boredom that characterizes vigilance decrements. Those individuals who prayed about their concerns performed better on these tasks compared to the participants in the contemplation or control groups. Although the Cue and Search tasks are also attention tests, they reflect the capacity to orient attention, and thus it seems reasonable that prayer-induced changes in attention capacity would not be reflected in these measures. The anti-saccade task also reflects attention shifting, but because it requires attention to be moved in the opposite direction of a

flashing cue, it is often used as a measure of executive attention (e.g., Ilkowski & Engle, 2010). Thus, it is somewhat surprising that attention-capacity changes did not also affect this task.

Although it seemed likely that the effect of prayer on attention tasks would be at least partially mediated by subjective stress states (i.e., that prayer would reduce self-reported stress, contributing to any effect of prayer on attention-task performance), no significant mediation was observed. Participants reported significantly less stress at the end of the study than at the beginning, but the magnitude of this effect did not vary by experimental group or religiosity. Thus, the observed effects of prayer may be interpreted as dependent upon attention resources and not as an artifact of stress state, at least as measured here.

Experiment 2: Effects of Prayer on Attention Biases

Method

Participants—Volunteers (N=83 for the lexical decision task; N=137 for the computerized word-search task; age range 18 to 23 years, mean=19.5 years; 67% of the participants were female; 27% identified as Black/African-American, 40% as White/Caucasian, 17% as Asian, and 16% as other racial groups) were recruited using Georgia State University undergraduate research pool.

Apparatus and Measures—The apparatus and the religiosity instrument was the same as was employed in Experiment 1. Participants completed two computerized tasks. In the Computerized Word-Search Task (not to be confused with the paper-and-pencil word-search activity performed by participants in the control group), participants searched a 225-letter array on the computer screen for words. The words embedded in this array were associated with the four concerns (health, academics, finances, relationships) and were either positive or negative in valence with respect to these concerns. For example, the words *doctor, hospital*, or *sickness* (consistent with the health schema) were hidden horizontally, vertically, or diagonally within an array of other letters, some forming words and others not words. Each participant searched the 225-letter array for 10 minutes and recorded any words he or she located, in whatever order they were identified.

In the Lexical-decision task, participants saw a sequence of letter strings and were required to identify whether each string formed an English word (e.g., MONEY) or was not a word (MINOY). The 50 words were selected from the four potential concern categories (academic, health, relationship, finances). The 50 nonwords were generated to match the lengths of the words, amount of syllables, and vowel to consonant ratio. Participants were instructed to respond as quickly and as accurately as possible. To identify any attention biases, accuracy and response times were recorded for each trial and compared between schema-consistent and inconsistent words in prayer, contemplation, and a control (the paper-and-pencil word-search activity) group.

Procedure—The procedures were the same as in Experiment 1 except the previous computer tasks (dual-task, Stroop, Cue, Anti, CPT, DSSQ) were replaced with the Lexical-decision task and the Computerized Word-search task.

Results

Lexical-Decision task—Participants were generally accurate in distinguishing words (M=83%) from nonwords (M=79%), and mean response times were faster for words (M = 638 ms) than nonwords (M = 848 ms). For all subsequent analysis, only response times from trials in which participants accurately identified the stimulus as a word were examined. A 3 (experimental condition) × 3 (religiosity, low, medium, and high) × 4 (concern) mixed ANOVA was used to test for any effect of prayer, religiosity, or concern on word response times. A significant interaction between experimental condition, religiosity, and concern on response times was found, $F(6,81) = 11.65$, MSE = 819391.45, $p < .001$, $\eta^2 = .46$. Post-hoc Helmert analyses indicated that participants who prayed demonstrated significantly lower response times (M=612 ms) than those who contemplated (775 ms) or performed the control task (661 ms), $p<.001$. There was also a significant difference in response times between the contemplation and control groups, $p<.001$. Furthermore, among all participants there were significant differences between religiosity groups, $p<.05$. Those individuals who scored high in religiosity (M=626 ms) responded quicker to word stimuli than those who self-identified as moderately religious (M=634 ms), $p<.001$. To probe these interactions further, the data from highly religious participants were examined separately. There was a significant interaction between concern type (relevance) and religiosity, $F(2,38)= 3.82$, MSE=345399.16, $p<.05$, $\eta^2=.25$.

Participants identified words associated with their chosen concern (M = 611 ms) more quickly than those words associated with other concerns (M = 623 ms). However, within each of the groups of concerns, neither experimental condition nor religiosity was determined to have significant effects ($p > .05$; see means in Table 3).

Computerized Word-Search Task. Participants found an average of 8.15 words in 10 minutes. Table 4 demonstrates means of relevant, irrelevant, positive, and negative of words found. To analyze the computerized word-search data, a 3 (experimental condition) × 2 (religiosity, using high and medium tertiles[2]) × 2 (relevance of words found) mixed analysis of variance (ANOVA) was performed on the first ten words found. No main effect of experimental group, religiosity, or word valence was observed. However, there was a significant interaction between experimental condition and religiosity on the number of concern-relevant words found, $F(4,154) = 4.103$, $MSE = 13.391$, $p<.01$, $\eta^2=.096$. Means for this interaction are shown in Table 5. Additional simple-level analyses indicated a significant effect of religiosity for participants assigned to the prayer condition, $F(2,78) = 4.559$, $MSE = 18.434$, $p<.05$, $\eta^2=.105$ but not in the contemplation or control condition. Post-hoc analyses demonstrated that among participants who prayed there was significant difference in the mean number of relevant words found between high religiosity (M=1.75) and those moderately religious (M=1.68), $p<.05$.

An additional analysis was run on the order of locating the words, using the placement of the first concern-relevant word located (i.e., how many words were found before the first concern-relevant word was reported) as the dependent variable. A significant difference of

[2]No low-religiosity participants were assigned to the prayer condition and tested on the computerized word-search task. Thus, the low-religiosity group was omitted from this analysis.

placement was observed between the prayer (M = 3.18) and contemplation [M = 5.29; $t(112)=2.11$, $p<.01$] and control [M = 5.16; $t(102)=2.10$, $p<.05$] conditions. That is, participants who prayed about a concern found a concern-relevant word about two items sooner than participants who contemplated about the concern or engaged the control activity for 10 minutes. The two contemplation and word-search groups did not significantly differ from one another, $p=.92$.

Discussion

It bears noting that, of all ways that these Experimental Condition × Religiosity × Concern Relevance analyses could have turned out for the two tasks, the few statistically significant effects that were observed were consistently in support of the conclusion that prayer can bias attention toward concern-relevant stimuli, at least under some conditions. These effects are admittedly subtle: relative to the other conditions, the prayer group produced overall faster lexical-decision times (an effect that likely reflects the attention-resource changes observed in Experiment 1) and located concern-relevant words earlier in the computerized word-search. However it should also be noted that there was reason to anticipate no differences between the conditions at all. Because the words in the lexical-decision and the computerized word-search tasks were themselves drawn from four concern categories, it seems likely that there was significant priming within the tasks (e.g., responding to the word *doctor* on an earlier lexical-decision trial or finding that word in the word-search task would be expected to prime *hospital* and other health-relevant words). Perhaps this is why there was a surprising absence of priming from 10 minutes of contemplation about a problem: any activation of concern-relevant concepts was masked by all of the within-task priming of the four concern categories. Nevertheless, even within this context there were significant effects of prayer on lexical decisions and word-search of concern-relevant words. An interaction between prayer and religiosity in the lexical decision task and the computerized word-search task suggested that those who engaged in prayer were more likely to identify stimuli relevant to their current concerns and do so at a quicker rate of response, but this effect was only significant if the individual self-reported as high in religiosity.

It was surprising that the effect of prayer (or any condition) did not appear differentially to affect whether positively or negatively stimuli are more readily perceived. Participants did not identify positive stimuli more quickly than negative stimuli in lexical decision, although a relationship was observed between the valence of words, prayer condition, and religiosity. However, there was no effect of valence in the word-search task. Thus, to the degree that prayer biases attention, it appears that the bias is as strong to problem-relevant (e.g., *flunk*) as to solution-relevant (e.g., *success*) information.

General Discussion

What does it mean for an individual to claim a prayer has been answered? Typically, it means that individual has perceived some form of resolution within the environment around her or him. Whereas it is beyond the scope of this study to speculate about any supernatural interventions, it is certainly within the purview of cognitive science to investigate how the individual perceives that resolution. As this study demonstrates, attention resource allocation

and attention biases may be two means by which prayer affects an individual's cognition, potentially supporting the subsequent perception of answers to the prayer. First, these data show prayer can affect, at least for highly religious individuals who are most likely to believe in the efficacy of prayer and are more practiced in the act of prayer, how much attention is available to process subsequent information or tasks. It seems possible that prayer affects attention resources by altering the chronic cognitive workload an individual carries, for instance that workload associated with thinking or worrying about everyday stresses and concerns—although no direct evidence for this interpretation is provided by the present study. A standard assumption of cognitive research is that participants are focused, as instructed, only on the cognitive tests being administered during a research study; but of course these volunteers do have lives outside the laboratory, and worries that do not necessarily end at the lab doors. These concerns about exams, relationships, finances, and major decisions may indeed be ignored briefly so as to allow participants to focus on task demands of an experiment, or they may continue to tax cognitive resources even during a research assessment (or a classroom test, or while driving a car, and so forth). For most studies of attention and performance, this chronic mental workload is not a problem because it presumably remains constant across the experimental session, and thus does not confound the experimental results. But the present results suggest that by temporarily relieving this workload through prayer, thus liberating attention resources that had been allocated (voluntarily or automatically/habitually) to concerns, a person can invest a greater amount of mental energy to the performance of everyday tasks, presumably including those related to the resolution of the problem. If prayer produces effects outside the laboratory as were observed in Experiment 1 here, then in the absence of concurrent experimental tasks, attention capacity may be enhanced and can be used to seek and to process solutions to current real-life concerns.

A slightly different interpretation of this same effect was offered by Friese et al. (2014) and Friese and Wänke (2014). They too showed effects of prayer on cognitive resources, but interpreted these effects as protective and restorative. In other words, they argued that prayer allowed individuals to recover from resource depletion from attention-demanding tasks, whereas we suggest that prayer reduces the amount of resource depletion from competing problem-related cognition.

The effects of dividing or sharing attention between simultaneous tasks are well established in psychology, with thousands of studies of how allocating mental effort to a primary task affects performance on a secondary concurrent task (e.g., Kahneman, 1973; Navon & Gopher, 1979; Pashler, 1993; Wickens, 2008). Baumeister and his collaborators (e.g., Baumeister et al., 2007) extended this well-established phenomenon further, contending that performance is not only compromised when concurrent-task demands exceed capacity, but also that a effortful mental operation can exhaust resources that will compromise performance (specifically, cognitive control) on subsequent tasks. The so-called strength model that underlies this phenomenon of ego-depletion has received empirical support (see, for example, the meta-analysis by Hagger et al., 2010). However, the robustness and replicability of this effect has been debated (e.g., Carter & McCullough, 2014; Hagger et al., in press; Lurquin et al., 2016). Further research is needed to clarify the exact conditions that produce ego-depletion—including the effects that Friese et al. (2014) and Friese and Wänke

(2014) interpret in this way—and to test validity of Baumeister's strength model that purports to account for such effects.

We interpret the present findings as consistent with dual-task, shared-attention effects that have been robustly reported. It seems likely that praying about a problem reduces the attention allocated to problem-related rumination, but only for those high-religiosity individuals who would be expected to believe that prayer is efficacious. We did not see evidence of across-the-sample benefits of prayer, as were reported in the Friese et al. (2014) and Friese and Wänke (2014) studies. Nevertheless, it is also possible that prayer does provide insulation or recovery from rumination-related resource depletion (although we wonder whether the Friese ego-depletion effects stem instead from general relaxation, given the absence of a control condition like our contemplation group). Indeed, the shared-attention and ego-depletion possibilities are not mutually exclusive, and future research should disambiguate any generic, meditation-like benefits of prayer from any effects that are specific to mental processing that is related to the prayed-about issue.

A step in this direction is provided by the results of Experiment 2, which show issue-specific attention effects. Not only does prayer appear to create attention capacity, but it may also bias the kinds of information that benefits from these resources. That is, prayer may affect the likelihood of attending to problem- and solution-relevant information in the surroundings, at least for high-religiosity participants under some conditions. The results of the Lexical Decision and computerized Word-search tasks indicate that individuals who are highly religious and pray may become biased to attend to information that is relevant to the topic of the prayer. In other words, high-religiosity people tend to find what they pray about in their environment. In future research, we intend to use psychophysiological measures (e.g., eye movements) as well as methods that do not introduce other potential sources of priming (e.g., semantic priming from other concern-relevant words) to explore this effect. Psychophysiological or neuroimaging techniques may also allow a direct test of the hypothesis that the effect of prayer on attention resources is mediated by a reduction in chronic mental workload.

The current study was designed to examine just two attention-related mechanisms for the effects of prayer. Certainly there are other cognitive processes that might also be affected by prayer, and that indeed might interact with the attention in the present tasks and measures. The goal for future investigations should be further to elucidate how the various components of cognition interact to allow individuals to know when prayers, particularly prayers for direction (e.g., "What should I do in this situation?"), have been answered, and thus how prayer affects decision making more broadly.

Like much of the cognitive literature on prayer, the present study is also admittedly limited by little inclusion of types of prayer from religious traditions other than Christianity or western, monotheistic traditions. This limitation is important for several reasons. First, the western monotheistic traditions reflect a typically anthropomorphized male version of a supreme being whereas religious traditions like Hinduism and Wicca may offer female interpretations of deity. If the model of prayer used is based on relationship, gender may influence an individual's experience of relationship in prayer. Furthermore, specific aspects

of prayer emphasized may vary in religious traditions, and thus the cognitive effects of prayer may vary by religious experience. Whereas a meditative, contemplative prayer experience is common in some Buddhist or Hindu traditions, it may be less commonly associated with Confucian or Islamic experience. These variations of prayer experience cause difficulty in measurement and description of prayer, and should be specifically studied in future empirical, cognitive investigations.

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Appendix A

Prayer Questionnaire

What does prayer mean to you?

What did you do when you prayed?

Did you feel distracted in any way while you prayed?

If so, what distracted you?

Did you assume any physical position while you prayed? If so, what did you do?

Did you direct your prayer at anyone or anything?

Do you expect any results from your prayer? If so, what?

Appendix B

Means for DualHoll Primary Task

Religiosity	experimental	PRE/POST	Mean (ms)	Std. Error (ms)	95% Confidence Interval	
					Lower Bound	Upper Bound
High	Contemplation	Pre	573	26	521	624
		post	521	29	464	578
	Pray	pre	683	23	638	728
		post	554	25	504	604
	Word-search	pre	541	22	498	584
		post	606	24	558	653
Med	Contemplation	pre	565	17	532	598
		post	583	18	547	620
	Pray	pre	565	18	530	600
		post	589	20	550	628
	Word-search	pre	594	19	557	631
		pre	554	21	512	595
Low	Contemplation	post	539	24	492	586
		pre	597	26	546	649
	Pray	pre	583	42	500	666
		post	513	47	421	605
	Word-search	pre	542	22	498	586
		post	508	25	460	557

Means for DualHoll Secondary/Concurrent Tone Task

Religiosity	experimental	PRE/POST	Mean (ms)	Std. Error (ms)	95% Confidence Interval	
					Lower	Upper
High	Contemplation	pre	1454	180	1098	1809
		post	1312	184	948	1676
	Pray	pre	1991	157	1681	2302
		post	1310	161	992	1628
	Word-search	pre	1362	149	1068	1655
		post	1500	152	1199	1801

Religiosity	experimental	PRE/POST	Mean (ms)	Std. Error (ms)	95% Confidence Interval	
					Lower	Upper
Med	Contemplation	pre	1351	115	1125	1578
		post	1559	117	1327	1791
	Pray	pre	1262	123	1020	1504
		post	1450	126	1202	1698
	Word-search	pre	1592	130	1336	1848
		post	1406	133	1143	1668
Low	Contemplation	pre	1018	162	698	1338
		post	1491	166	1163	1819
	Pray	pre	1353	290	781	1926
		post	1249	297	663	1836
	Word-search	pre	1684	153	1382	1986

Group Sizes for DualHoll Task

	Prayer	Contemplation	Word-search
High Religiosity	18	21	22
Medium Religiosity	20	27	18
Low Religiosity	15	14	18

Table 1

Means for Stroop accuracy (proportion correct) and response times (in msec.), with standard errors and confidence intervals

		Mean Accuracy	Mean Overall	Std. Error	95% Confidence Interval	
					Lower	Upper
Prayer	Congruent	.990	.955	.016	.958	1.021
	Incongruent	.923		.023	.877	.969
Contemplation	Congruent	.933	.905	.017	.900	.966
	Incongruent	.877		.024	.829	.925
Word-search	Congruent	.942	.899	.015	.913	.971
	Incongruent	.855		.021	.813	.898

Group	Stroop Condition	Mean RT	Overall Mean RT	Std. Error	95% Confidence Interval	
					Lower	Upper
Prayer	Congruent	813	914	44	725	900
	Incongruent	1016		57	902	1129
Contemplation	Congruent	807	938	48	712	902
	Incongruent	1068		62	945	1192
Word-search	Congruent	941	1022	42	858	1024
	Incongruent	1103		54	996	1210

N=89

Table 2

Mean DSSQ subscale scores, with standard deviation and standard error terms

DSSQ factor	Test	Mean	Std. Deviation	Std. Error Mean
Energetic/Arousal	Pre	18.27	3.933	.244
	Post	15.67	9.712	.603
Tension	Pre	24.29	4.539	.282
	Post	19.79	12.217	.759
Hedonic Tone	Pre	14.79	4.742	.295
	Post	13.73	8.959	.557
Self-Focus	Pre	16.36	3.638	.226
	Post	12.85	8.802	.547

Table 3

Mean response times in milliseconds, with standard errors and confidence intervals, for correct Lexical Decision “word” responses, as a function of experimental group and religiosity

Group	Religiosity	Relevance	Mean	Std. Error	95% Confidence Interval	
					Lower	Upper
Prayer	High	Non-relevant	600.000	60.061	479.032	720.968
		Relevant	545.514	70.071	404.383	686.645
	Medium	Non-relevant	695.021	56.181	581.866	808.177
		Relevant	577.350	65.546	445.334	709.366
	Low	Non-relevant	753.770	103.32	441.08	1034.71
		Relevant	718.499	100.76	468.96	1032.65
Contemplation	High	Non-relevant	625.669	60.061	504.700	746.637
		Relevant	667.446	70.071	526.315	808.577
	Medium	Non-relevant	599.083	79.453	439.057	759.108
		Relevant	671.715	92.696	485.016	858.414
	Low	Non-relevant	449.112	64.873	318.451	579.772
		Relevant	442.417	75.686	289.978	594.855
Word-search	High	Non-relevant	684.305	64.873	553.645	814.965
		Relevant	687.010	75.686	534.571	839.449
	Medium	Non-relevant	577.974	60.061	457.006	698.942
		Relevant	524.363	70.071	383.232	665.494
	Low	Non-relevant	590.562	56.181	477.407	703.718
		Relevant	686.515	65.546	554.499	818.531

Group sizes

	Finance	Relationship	Academics	Health
Contemplation	7	7	21	1
Prayer	7	5	19	5
Word-search	12	4	19	4
High	5	7	27	2
Medium	12	6	22	5

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Group sizes

	Finance	Relationship	Academics	Health
Low	9	3	10	3

Table 4

Mean number, range, and standard deviation of words found in the computerized Word-search task, as a function of relevance and valence.

	Possible	Minimum	Maximum	Mean	Std. Deviation
Relevant Words	8	0	4	1.57	1.088
Irrelevant words	24	0	10	6.58	2.624
Positive words	4	0	3	1.28	.951
Negative words	4	0	3	.29	.544

N=163

Table 5

Mean number of relevant words found within the first ten responses on the computerized Word-search task, with standard error and confidence intervals, as a function of experimental condition and religiosity.

Religiosity	Experimental Condition	Mean	Std. Error	95% Confidence Interval	
				Lower	Upper
High	Contemplation	1.615	.319	.985	2.246
	Prayer	1.750	.217	1.320	2.180
	Word-search	1.300	.364	.581	2.019
Medium	Contemplation	1.400	.257	.891	1.909
	Prayer	1.687	.166	1.359	2.016
	Word-search	1.278	.271	.742	1.814

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