Why Hast Thou Forsaken Me?

Investigating the effects of analytic thinking and self-efficacy on religiosity

Abstract

If religiosity is divine and transcends earthly experiences, are there interventions that can modulate it? An emerging body of literature suggests that primes to elicit analytic thinking can significantly reduce belief in God. However, these findings have come into question due to diverging evidence in both successful and unsuccessful replications. We explore this inconsistency by contributing our own replication to further investigate this relationship. Moreover, to our knowledge, we conduct the first experiment to directly test whether manipulating self-efficacy can significantly influence self-reported religious beliefs. Using a 2x2 factorial design, we conduct a between-subjects randomized controlled experiment on Amazon Mechanical Turk. Drawing upon well-established models of System I/II thinking, Compensatory Control and social cognitive theories, we hypothesized that (1) analytic thinking reduces belief in God and (2) lowered self-efficacy increases religiosity. However, our results suggest that neither cognitive priming nor self-efficacy significantly influences religiosity. We consider our null findings in the context of our design constraints, sample heterogeneity and limited statistical power. We conclude by offering avenues for future research and discussing the policy implications of cognitive or self-efficacy based interventions to reduce maladaptive social behaviors such as religious discord or criminality.

Keywords: Self-efficacy, analytic, religion, beliefs, God, prime

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Total word count: 5333

I. Introduction

Religion is an integral part of civilization, and has a substantial impact on culture and human behavior. Although religious belief has been associated with positive outcomes such as higher well-being (Carlucci et al., 2015), life satisfaction (Bergan & McConatha, 2001) and prosociality (Billingsley et al., 2018), it also correlates with prejudice (Altemeyer & Hunsberger, 1992), hostility (Koopmans, 2015), and even armed conflict (Cornell, 2005). With significant implications at both the individual and societal level, there has been growing interest in psychological literature regarding the formation of religious beliefs and interventions that can modulate them.

The dichotomy between intuitive and analytic processes is a central tenet in contemporary behavioral science (Frederick, 2005). There is general agreement that deeply held abstract beliefs such as religiosity lie primarily in the domain of intuitive cognition (Barrett, 2000). Using this paradigm, Gervais & Norenzayan (2012) found that priming participants to think analytically significantly reduces self-reported belief in God. However, replication attempts have yielded conflicting results. While Yilmaz et al. (2016) successfully replicated the original findings, Sanchez et al.'s (2017) MTurk replication found no significant difference.¹

One potential explanation for these conflicting findings is that religiosity is not determined by a single factor. Indeed, belief in God is a function of distinct constructs such as culture (Dennett, 2006), emotional state (Kim-Prieto & Diener, 2009), thinking style (Kim-Prieto & Diener, 2009), locus of control (Kay et al., 2009), and even self-efficacy (Toburen & Meier, 2010). However, the exact mechanism through which these variables influence religiosity remains understudied. For instance, while the relationship between locus of control² and religiosity is well-established via Compensatory Control Theory (Kay et al., 2009), few experiments have explored how the related concept of self-efficacy affects belief in God.

¹ Gervais & Norenzayan (2012) found that both visual and analytic primes reduce belief in God. Yilmaz et al.'s (2016) successful replication used a written prime, while Sanchez et al. (2017) used a visual prime and failed to replicate.

² The degree to which people believe they internally have control over outcomes in their lives.

To provide clarity to the present literature, we conducted an online MTurk replication of the original study by Gervais & Norenzayan (2012), using the visual priming replication materials created by Sanchez et al. (2017). In addition, we added two new treatment groups that incorporate an impossible-to-solve anagram task as a manipulation to lower self-efficacy. Using a self-report scale, our experiment tested the effect of analytic thinking style and self-efficacy reduction on belief in God.

We find little evidence that analytic thinking or self-efficacy, either alone or in combination, significantly affect religious beliefs. However, we interpret our findings in the context of our limited sample size and experimental constraints. We also discuss potential areas for further research emerging from our exploratory analysis. Given the multidimensionality of religiosity, addressing further research questions could have widespread implications on policy and social behavior (Bloom & Arikan, 2012). We therefore hope to contribute to the growing body of work that investigates cognitive and behavioral influences on religion, one of the most sacred and personal of human institutions.

II. Literature Review

Here, we review the literature on religion and discuss how belief in God is espoused through social, emotional, and cognitive mechanisms. We evaluate pre-existing work to identify gaps in the literature as directions for future investigation. We pay particular attention to thinking style, and self-efficacy, and how such modulators of religiosity have been operationalized, manipulated, and measured in previous research.

Religion

Religion refers to "human beings' relation to that which they regard as holy, sacred, absolute, spiritual, divine, or worthy of special reverence" (Britannica). There is general agreement that religiosity is at least partly a result of social influence. Evidence is strong that belief in God is formed through the process of religious socialization, in which consciousness is built through significant others such as parents, teachers and peers (Cornwall, 1987).

However, there is less agreement on the cognitive correlates of religiosity. A common theory is that belief in God functions as an internal coping mechanism; indeed, empirical evidence supports this assertion. For instance, a national survey shortly after the 9/11 attacks found that a majority of Americans turned to God for solace and support (Schuster et al., 2001). Another study by Kesselring et al. (1986) found that most Egyptian patients with cancer reported that they believe that God will help with their disease. Similarly, between 39% and 51% of HIV/AIDS and cancer patients reported drawing on their religion to cope with their illnesses (Tarakeshwar et al., 2006; Trevino et al., 2010). Religion as a coping mechanism thus appears to be a robust cross-cultural phenomenon.

These findings are well-aligned with Compensatory Control Theory, a model of how belief in an interventionist God serves as a coping mechanism to deal with the anxiety caused by uncontrollable life events (Kay et al., 2009). Compensatory Control Theory suggests that when people deal with difficult situations, their locus of control shifts externally, which causes a feeling of helplessness. Kay et al. (2009) experimentally demonstrated that when threatened with such loss of control, people become more superstitious, defend strong political institutions, and endorse beliefs in an omnipotent higher power.

A challenge in any study measuring belief in God is how to operationalize such deeply held beliefs. While measuring religiosity through proxies such as prosocial behavior (Batara et al., 2016) and fMRIs (Kapogiannis et al., 2014) have recently gained ground, conventional self-report measures remain the simplest way to operationalize religiosity. For example, Kay et al. (2009) used a simple Likert scale, while Gervais & Norenzayan (2012) asked participants to rate belief in God on a scale of 0-100. While self-report measures are flawed, they provide the most parsimonious method of studying interventions that may modulate religiosity.

Analytic Thinking

When cognitive resources are available, System II thinking (slow, deliberate, logical) can often override System I (emotional, instinctive, involuntary) and introduce a completely new cognitive style (Fellner, 2004). Research shows that analytic thinkers score higher than intuitive thinkers on a variety of cognitive measures (Frederick, 2005). This connection between analytic thinking and religious disbelief might explain why atheists and agnostics tend to be less dogmatic and more likely to adopt scientific reasoning than religious believers (Beit-Hallahmi, 2007; Zuckerman, 2009). Given these implications, much research has been conducted on interventions to elicit particular thinking styles, with priming emerging as a common manipulation method used in experiments. For instance, in a series of pilot studies, Gervais & Norenzayan (2012) established that priming participants by having them view certain artwork or complete verbal tasks could increase scores on syllogistic or cognitive reflection tests, well-established measures of analytic thinking style.

However, a contradicting body of literature has recently questioned the System I/II distinction altogether. Krajbich et al. (2015) argue that evidence for the dichotomy is weak. In the context of religiosity, this raises questions as to whether priming interventions could influence self-reported belief in God. While Gervais & Norenzayan (2012) concluded that analytic thinking promotes religious disbelief, we note their lack of statistical power³ and the existence of both successful (Yilmaz et al., 2016) and unsuccessful (Sanchez et al., 2017) replications.

While conventional theories lead us to hypothesize that analytic thinking promotes religious disbelief, the discrepancy in the literature indicates the value of replications to further probe this phenomenon. Hence, one research question we ask is: *Does analytic thinking increase religious disbelief*?

³ We ran a two-tailed Wilcoxon rank-sum post-hoc test on G*Power. Their effect size was d = 0.59 and sample sizes of 31 and 26 for the neutral and analytic thinking respectively. At the 0.05 error probability their study achieved 58% power, making it underpowered.

Self-efficacy

Self-efficacy refers to an individual's belief in his or her capacity to complete a particular task (Bandura, 1977). It is associated with athletic success (Wurtele, 1986), workplace performance (Lunenburg, 2011), and health-related behaviors (Luszczynska & Schwarzer, 2005). Given the benefits of high self-efficacy, its relationship with religion is a promising domain of study. Previous research has indicated that religious participation is associated with self-concepts, such as self-esteem and self-efficacy (Ellison 1993; Krause 1995; Schieman et al. 2003). Moreover, religion can help individuals experience a sense of control and mastery over life events (Pargament et al., 2000).

There also appears to be a correlation between belief in God and self-efficacy measures such as persistence (Nie, 2019; Fatima et al. 2018). For instance, Ellison & Levin (1998) found that religious involvement increases one's self-esteem and self-efficacy, while Toburen & Meier (2010) concluded that religious individuals have higher task self-efficacy when given impossible anagrams to solve. However, few studies have investigated the other direction. In particular, to our knowledge there have been no experiments that directly used self-efficacy interventions to modulate belief in God.

Thus, we seek to contribute to present literature by considering the importance of emotional thinking. Research reveals that emotions can sway religious beliefs (Kim-Prieto & Diener, 2009). Thus, one might ask: how does lowered self-efficacy, and the associated feelings of frustration and helplessness, influence religioisity? Based on Kay et al.'s (2009) Compensatory Control Theory discussed earlier, we expect that lowering self-efficacy would cause a feeling of helplessness and thus shift the locus of control outwards. It should therefore follow that such manipulation would result in increased religious belief as individuals cope by holding onto a higher power. This hypothesis is further supported by Trix & Frazer (1998), who posit that people turn to religion when things are out of their control.

Nonetheless, reliably manipulating self-efficacy remains a challenge for experimenters. One paradigm used is the impossible anagram task, developed by Smith et al. (2006). Pilot studies

provide evidence that self-efficacy is reduced when individuals are given an extremely challenging task such as anagrams that have no correct solution. However, this paradigm has primarily been used as a measure as opposed to a manipulation. For example, Toburen & Meier (2010) used the time participants spent solving the anagrams before giving up as a proxy measure, with longer time spent indicative of higher persistence and self-efficacy.

We therefore distinguish ourselves from previous contributions by setting out to test if a reduction in self-efficacy impacts how strongly one believes in God. We ask: *Does lowered self-efficacy increase religious belief*? We hope that using the impossible anagram task before measuring belief in God could provide useful insights into the interaction between emotions, self-concept and deeply held cognitive beliefs.

Moreover, our research questions in general could have widespread implications for policy and social behavior. Our findings can inform the design of self-efficacy-based interventions to reduce discord associated with religious extremism, and help policymakers draw connections between economic strife, unemployment and self-efficacy in non-secular countries. Ultimately, we hope to lend to the large body of research that aims to connect religious behaviors with potential policy implications (Bloom & Arikan, 2012).

III. Hypotheses

Given the existing research outlined in our Literature Review, we assert the following hypotheses:

H1: Participants exposed to the analytic prime will show decreased religious beliefs.

H2: Participants given the impossible-to-complete anagram task will have increased religious beliefs.

The experimental investigation and analyses put forth in this paper can be subdivided into several steps that build upon each other across the three subsequent sections. Our Methods section outlines the details of the study design, participant recruitment, and analyses plan. Following which, the Results & Analysis section demonstrates our primary findings. Finally, the Discussion closes with an evaluation of our findings including limitations and implications of our study.

IV. Methods

Two hundred and eighty-three participants (mean age = 37.7 years; 54% male, 46% female) completed this study. We recruited participants by posting 283 HITs on Amazon Mechanical Turk. To answer our research questions, we used a between-subjects, 2x2 factorial experimental design to assess the effect of individual treatments and their interactions. Our four conditions are displayed below.



Figure 1: Experimental Conditions

Measures

Analytic Thinking Prime

Participants were randomly assigned to view four images⁴ of artwork depicting a reflective thinking pose (The Thinker) or control artwork matched for surface characteristics in color and posture (Discobolus of Myron). A pilot test conducted by Gervais & Norenzayan (2012) revealed that this novel priming procedure significantly improved performance on a syllogistic reasoning task that measures analytic tendencies. In the present study, we anticipated that this visual prime triggers analytic thinking, therefore promoting religious disbelief.

⁴ Please see Appendix A

Self-Efficacy Manipulation

Manipulating self-efficacy in a research setting poses challenges, but it has been done successfully in multiple studies (McAuley & Blissmer, 2000; McAuley et al., 1999). One way to manipulate self-efficacy is by presenting subjects with a task that they will be unable to complete, as conducted by Smith et al. (2006). We proposed a version of their original impossible-to-solve anagram task⁵ because of its compatibility with our study's online format. We gave participants three anagrams, of which only the first one was solvable. Participants had one minute to complete the task and were automatically directed to the next page of the Qualtrics survey afterwards.

Consistent with the use of the task as a method to undermine self-efficacy, we informed participants that anagram tasks are a measure of verbal intelligence (Toburen & Meier, 2010). We used the same anagrams and character strings used in the original study by Smith et al. (2006). However, we reduced the length of the manipulation to account for practical considerations related to the study's online format as well as time and funding constraints.

Outcome Variable

Our main outcome variable was belief in God. This was measured by using a self-report questionnaire in which participants were asked: "*How strongly do you believe in God (from 0-100)? To clarify, if you are certain that God does not exist, please put "0" and if you are certain that God does exist, then put "100"*. Participants typed their numerical answer into a provided box, and our Qualtrics survey validated responses so that only values from 0 to 100 were recorded. Participants received an error message if they input values outside that range.

While we recognized the limitations of using self-report and non-incentive compatible measures, we utilized this question to remain consistent with both the original study by Gervais & Norenzayan (2012) and the replication by Sanchez et al. (2017). This allowed us to directly

⁵ Consistent with the observations of Smith et al. (2006) and Toburen & Meier (2010), our pre-test feedback revealed that users were, in fact, frustrated by being unable to successfully complete this task.

compare our results, conduct robustness checks, and draw preliminary conclusions regarding the effectiveness or lack thereof of our analytic prime and self-efficacy manipulations.

Experimental Design

After providing informed consent⁶ and going through the cover story⁷, participants were randomly assigned into one of the four treatment groups. To manipulate thinking style, we utilized the same visual priming paradigm used by Gervais & Norenzayan (2012) and Sanchez et al. (2017). We replicated the Neutral Prime + Baseline Self-efficacy (Neutral Prime) and the Analytic Prime + Baseline Self-efficacy (Analytic Prime) groups. For our two novel groups, Neutral Prime + Lowered Self-efficacy (Neutral Prime + Lowered SE) and Analytic Prime + Lowered Self-efficacy (Analytic Prime + Lowered SE), we incorporated a version of the impossible-to-solve anagram task developed by Smith et al. (2006) to lower self-efficacy, as discussed earlier.

In all conditions, the outcome variable was the magnitude of self-reported religious belief, on a scale of 0-100⁸. After reporting their belief in God, participants completed attention checks⁹ and a demographic questionnaire¹⁰. Their responses were used to inform our exclusion criteria and conduct regression analysis.

⁶ Please see Appendix C

⁷ Please see Appendix D

⁸ Please see Appendix E

⁹ Please see Appendix F

¹⁰ Please see Appendix G



A diagram of our experimental flow is presented in the figure below:

Figure 2: Summary of Experimental Flow

Sample: Descriptive Statistics & Power

This experiment was pre-registered on <u>aspredicted.org</u> and implemented using a Qualtrics survey, which was distributed via MTurk with a total of 283 participants. Each participant was paid \$0.50 for completing this survey based on an hourly rate of \$6.00 and average completion time of 6.8 minutes. A breakdown of participants included in the analysis by condition is displayed in Figure 3 below.



Figure 3: Sample of participants¹¹

¹¹ We had 66 participants that we could exclude due to failure (1) attention check or (2) the English proficiency criterion. However, we pre-registered that we would first run the analysis with all the data from participants who have completed the study, and another analysis with our exclusion criteria applied to determine if the results we get from both would vary. Given that the results from both the analyses were similar (see Appendix H), our sample is the complete dataset including participants that failed the attention and English proficiency checks. Please see Appendix I for the break-up of participants.

According to a two-tailed A priori Wilcoxon rank-sum test run on G*Power using our pre-test data, our study would have required 232 observations per condition to achieve 80% statistical power.¹² This was based on an effect size of d = 0.267 in our pretest data collection. Due to budgetary constraints, we were able to collect only 283 observations in total, prior to data exclusions.

Descriptive statistics (i.e. gender composition and age) of participants who were included in our primary analyses are shown in Table 1 below:

	Neutral Prime	Neutral Prime + Lowered SE	Analytic Prime	Analytic Prime + Lowered SE
Gender: Male	46	38	35	34
Gender: Female	32	25	38	35
Mean: Age	39.12	35.87	39.19	37.16
Total participants	78	63	73	69

Table 1: Gender and age composition by condition

V. Results & Analysis

We did not have missing data as our Qualtrics experiment was coded to force responses in all items. Therefore, the raw data we collected from MTurk consisted only of participants who fully completed our experiment.

We conducted analysis on data from all participants (n = 283) and another analysis excluding those who failed either of our attention checks or did not report sufficient English ability (n = 217). We conducted primary Wilcoxon rank-sum tests on both sets of data and found insignificant results throughout¹³. Following our pre-registration plan, we proceeded with the rest of our analysis using the full dataset (n = 283).

¹² Please see Appendix B

¹³ Please see Appendix H

Primary Analyses

To test our hypothesis on the effect of analytic priming, we pooled the two neutral groups and the two analytic groups. Similarly, to test our hypothesis on the effect of self-efficacy, we pooled the two baseline groups and the two lowered self-efficacy groups. We then conducted Wilcoxon rank-sum tests for our between-subjects design. We performed non-parametric tests as our limited sample size made it difficult to satisfy the normality assumption. We used a two-tailed version of the test, as the conflicting literature regarding both our hypotheses implies that effects may be observed in either direction.

As seen in Figure 4, at an $\alpha = 0.05$ level, we fail to conclude that analytic thinking reduces belief in God (p = 0.21). Table 2 shows the sample size, mean belief in God (0-100), and standard deviation for the pooled analytic and neutral thinking groups.



Figure 4: Box-plots comparing the pooled analytic thinking groups vs. pooled neutral thinking groups. Red lines indicate mean Belief in God (0-100).

	Neutral Primes	Analytic Primes
Sample size	141	142
Mean Belief in God (0-100)	77.09	70.61
SD	32.63	35.90

Table 2: Summary Statistics of DV: Belief in God (0-100) in the pooled neutral and pooled analytic prime groups.

As seen in Figure 5, we also fail to conclude that self-efficacy increases belief in God (p = 0.55). Table 3 shows the sample size, mean belief in God (0-100), and standard deviation for the pooled baseline and lowered self-efficacy groups. In summary, the overall effects of both our interventions on our primary outcome variable, religious belief, are statistically indistinguishable from zero.



Figure 5: Box-plots comparing the pooled baseline self-efficacy groups vs. pooled lowered self-efficacy groups. Red lines indicate mean Belief in God (0.100).

	Baseline Self-Efficacy	Lowered Self-Efficacy
Sample size	151	132
Mean Belief in God (0-100)	75.16	72.33
SD	34.03	34.90

Table 3: Summary Statistics of DV: Belief in God (0-100) in the pooled baseline and pooled lowered self-efficacy groups.

As pre-registered, we also conducted pairwise comparisons between our four groups individually, using Wilcoxon rank-sum tests. As seen in Figure 6 below, we did not observe a statistically significant effect as a result of the comparisons, which was consistent with tests conducted on the pooled groups. Table 4 shows descriptive statistics for each group.



Figure 6: Box-plots of pairwise comparisons between the Neutral Prime, Analytic Prime, Neutral Prime + Lowered SE, and Analytic Prime + Lowered SE groups. Red lines indicate mean Belief in God (0-100).

	Neutral Prime	Neutral Prime + Lowered SE	Analytic Prime	Analytic Prime + Lowered SE
Sample Size	78	63	73	69
Mean Belief in God (0-100)	79.73	73.83	70.27	70.97
SD	31.4	34.06	36.21	35.84

Table 4: Summary Statistics of DV: Belief in God (0-100) by condition.

Interaction Effects

Although we did not have specific hypotheses regarding interactions, we remained consistent with our pre-registration and tested for interaction effects. We ran a regression to investigate whether the effect of self-efficacy differs depending on the type of visual prime used, or vice versa. As seen in Figure 7, our regression confirmed that at an $\alpha = 0.05$ level, neither thinking style nor self-efficacy had a significant main effect, which is consistent with the Wilcox rank-sum tests conducted above. Moreover, there was no significant interaction between the two manipulations.

Interaction Table	
	DV: Belief in God
	Religiosity
Analytic	
Lowered Self-Efficacy	-5.905 (5.822)
Interaction	6.602 (8.197)
Constant	79.731*** (3.892)
Observations R2 Adjusted R2 Residual Std. Error F Statistic	283 0.013 0.002 34.370 (df = 279) 1.186 (df = 3; 279)
Note:	*p<0.1; **p<0.05; ***p<0.01

Figure 7: Interaction table showing the main and interaction effects of visual priming and self-efficacy on DV: Belief in God (0-100). Standard errors in parentheses.

To check for robustness, we performed an OLS regression on the entire dataset (n = 283). We first constructed a simple linear regression with treatment group as the sole explanatory variable, using the following equation (Model 1):

$$\mathbf{B} = \mathbf{b}_0 + \mathbf{b}_1 \mathbf{x}_1 + \mathbf{b}_2 \mathbf{x}_2 + \mathbf{b}_3 \mathbf{x}_3$$

Where

B = Self-reported belief in God (0-100)

 b_0 = Predicted belief in God in control condition (Neutral Prime)

 b_{1-3} = coefficient terms

 x_1 = dummy variable equal to 1 if Neutral Prime + Lowered SE condition, and 0 if not

 x_2 = dummy variable equal to 1 if Analytic Prime, and 0 if not

 x_3 = dummy variable equal to 1 if Analytic Prime + Lowered SE condition, and 0 if not

We also constructed a multiple linear regression (Model 2) to account for possible sample heterogeneity based on four demographic characteristics we collected: age, gender, ethnicity, and religion. The equation for Model 2 is as follows:

$$\mathbf{B} = \mathbf{b}_0 + \mathbf{b}_1 \mathbf{x}_1 + \mathbf{b}_2 \mathbf{x}_2 + \mathbf{b}_3 \mathbf{x}_3 + \mathbf{b}_c \mathbf{x}_c$$

Where

B = Self-reported belief in God (0-100)

 b_0 = Predicted belief in God in control condition (Neutral Prime)

 $b_x = \text{coefficient terms}$

 x_c = vector of variables controlled for (age, gender, ethnicity, religion)

Given that our sample is skewed towards certain demographics (54% male, 84% white, 83% Christian)¹⁴, we coded gender, ethnicity and religion using dummy variables to convert these explanatory variables into binaries (Male = 1, non-Male = 0; White = 1, non-White = 0; Christian = 1, non-Christian = 0).

¹⁴ Please see Appendix I

	DV: Belief in God			
	Rel	igiosity		
	(1)	(2)		
Neutral + Lowered SE	-5.905 (5.822)	-5.857 (4.681)		
Analytic	-9.457* (5.597)	-13.489*** (4.503)		
Analytic + Lowered SE	= -8.760 (5.680)	-7.283 (4.563)		
Age		0.155 (0.147)		
Gender (Male)		-1.336 (3.301)		
Ethnicity (White)		-3.981 (4.528)		
Religion (Christian)		56.303*** (4.447)		
Constant	79.731*** (3.892)	31.677*** (8.371)		
Observations R2 Adjusted R2 Residual Std. Error F Statistic	283 0.013 0.002 34.370 (df = 279) 1.186 (df = 3; 279)	283 0.378 0.362 27.475 (df = 275) 23.882*** (df = 7; 275)		
Note:	*p<	======================================		

OLS Regression

Figure 8: OLS Regression Comparing Belief in God across all four conditions, with Neutral Prime as the Control group (Constant). Dependent variable was self-reported belief in God (0-100). Standard errors in parentheses.

Model 1 shows differences between our three treatment groups. Consistent with our pooled Wilcoxon rank-sum tests and our pairwise comparisons, no significant differences in belief in God were observed in Model 1 at an $\alpha = 0.05$ significance level.

However, when age, gender, ethnicity, and religion were controlled for in Model 2, we found that the Analytic Prime group showed significantly lower belief in God (p = 0.003), with religion being a significant predictor at an $\alpha = 0.05$ significance level. This inconsistency between the insignificant findings in our pairwise comparisons and the significant result in Model 2 suggests potential sample heterogeneity.

Although the findings of Model 2 suggest that analytic thinking promotes religious disbelief, we interpret this result cautiously. Our experiment was underpowered, meaning that our sample size is not sufficiently large to determine the effect of thinking style on religiosity. Furthermore, Model 2 suggests that being Christian is a significant predictor of increased religious beliefs, implying that our mean comparisons may have been confounded by sample heterogeneity. Visualizations in Appendix J illustrate that the effect of thinking style on belief in God is significant for Christians but insignificant for non-Christians¹⁵. We elucidate these implications in our Discussion section.

Reliability of Data

As calculated by a two-tailed post-hoc Wilcoxon rank-sum test, we achieved 34.0% power when comparing results between (H1) Neutral and Analytic Priming conditions, and 10.3% power when comparing results between (H2) Baseline SE and Lowered SE conditions. The small sample size contributed to our study being underpowered. In order to achieve 80% power at a significance level of 0.05, based on a two-tailed a priori Wilcoxon rank-sum using the same data, we would have had to recruit 924 and 4,880 participants per treatment to test H1 and H2, respectively. A detailed overview on the statistical power with relative G*Power calculations, analyses, and figures can be found in Appendix B.

VI. Limitations

Certain limitations in our study could have undermined the validity of our findings. These limitations include a lack of statistical power, unequal sample sizes, and imperfect construct validity of the dependent variable.

¹⁵ We did not pre-register breaking down the analysis to separate Christians from non-Christians. However, given the highly significant effect detected in Model 2, we report these findings in Appendix J and leave the interpretation as potential avenues of investigation in future research. We thank Dr. Dimant for his helpful guidance in our exploratory analysis.

First, our experiment was underpowered due to challenges surrounding participant recruitment and incentivization. Based on the results of our pre-test, we needed 232 participants per condition to achieve 80% statistical power. However, we were only able to collect 283 observations in total, corresponding to a statistical power of 34% and 10% for H1 and H2, respectively.¹⁶ This lack of power undermines the likelihood of detecting a true effect and drawing substantive conclusions about the effect of analytic thinking and lowered self-efficacy on religiosity. We recommend that replication attempts recruit more participants by either securing sufficient funds or shortening the length of the experiment to be able to collect more observations.

Second, we observed differential exclusion which contributed to uneven sample sizes across our four conditions.¹⁷ While we conducted our analyses using the entire data set, the fact that participants in the anagram conditions were more likely to fail the attention checks could be for three possible reasons. These include: the check was not worded clearly enough, participants were not able to recall minute details such as the number of words they had to decode, or the time given for the task was insufficient. Moreover, as participants in the anagram conditions naturally took more time, their ability to recall may have been influenced by temporal effects, a well-documented phenomenon in research (Scwartz, 2005). Future replications should thus explore more appropriate attention checks.

Third, in an effort to design an experiment that is more generalizable, our exclusion criteria were less strict than those of Gervais & Norenzayan (2012) and Sanchez et al. (2017). For example, we did not exclude participants who had non-US IP addresses, took a prolonged duration to complete the experiment, or were able to correctly guess the study hypothesis. However, we are aware that IP addresses may serve as a proxy for varied geographical or cultural backgrounds, and so excluding these demographics may have helped replicate the original study more closely.

Fourth, we note that participants on MTurk might be different from the general population (Chandler et al., 2019). Analytic priming might be more effective in higher education contexts,

¹⁶ Please see Appendix B

¹⁷ Please see Appendix I, Table 1.5

such as the Canadian university that Gervais & Norenzayan (2012) used in pilot studies. In fact, while university students show increased scores in syllogistic reasoning tasks, larger studies on wider populations found that priming had little effect on Cognitive Reflection Test performance (Deppe et al., 2015). Moreover, variations in context might have interfered with our replication. Gervais & Norenzayan (2012) conducted their study in-person, while we implemented our research online. It is possible that the use of the Thinker image to prime analytic thinking might not work as effectively in a virtual setting, which consequently could have threatened the construct validity of our independent variable.

Finally, we also acknowledge the potential limitation in using self-report ratings to measure the dependent variable of religiosity. While we try to closely replicate the methods in the original studies, we recognize that religiosity is a complex construct that cannot be fully captured by a 0-100 scale measure.¹⁸ Indeed, visualizations of our data indicate clusterings around 0 and 100 in self-reported beliefs in God, implying that religiosity might be a binary rather than a spectrum concept.¹⁹ Reliable and cross-culturally valid psychometric approaches to measuring religiosity are rare. However, future studies could further investigate the potential binary nature of religious belief or develop more comprehensive scales that take into account multiple dimensions of religiosity (Maiello, 2007). We also recommend measuring not just self-reported belief but also other correlates of religiosity, such as cheating behavior or prosociality (Benjamin et al., 2016).

VI. Discussion

We hypothesized that analytic thinking would reduce belief in God, while lowered self-efficacy would increase it. While our data displays null results, this does not necessarily indicate that our interventions are ineffective. Although the underpowered nature of our study makes it challenging to draw conclusions, we nonetheless contribute to the existing literature as our findings raise notable routes for future investigation. Our analyses reveal the importance of resolving the literature conflict surrounding dual process theory, and developing frameworks to successfully operationalize thinking style and self-efficacy manipulations.

¹⁸ We received qualitative participant feedback regarding the difficulty in being able to self-report belief in God across such a broad scale, however we retained the measure to stay true to the replication. Question in Appendix E.

¹⁹ Please see Figure 5 and Figure 6

One noteworthy observation in our exploratory analysis was the highly significant impact of analytic priming when Christianity is controlled for.²⁰ This is in line with the results of both Gervais & Norenzayan's (2012) original experiment and Yilmaz et al.'s (2016) successful replication. While this could be due to statistical noise or sample heterogeneity, a similarly convincing explanation is that analytic primes are context-dependent and work differently on distinct religious groups. Benjamin et al. (2016) argue that in terms of correlates of religion such as prosociality, there are significant differences not only between Christians and non-Christians but also among Christians of different denominations.²¹ This raises the possibility that the effect of analytic thinking on belief in God depends on which social group an individual belongs to. Therefore, studying the interplay between religious socialization and deeply held cognitive beliefs can be a fruitful area for future investigations.

Our experiment also highlights the challenges of manipulating self-efficacy. Bandura (1977) notes that self-efficacy can either be task-specific or general, which means that simple interventions such as impossible anagram tasks may not be effective in altering deeply held convictions such as belief in a higher power. There is evidence to suggest that the impossible anagram paradigm only alters task-specific self-efficacy (Smith et al., 2006). The influence of general self-efficacy on religiosity thus remains to be studied. However, because general self-efficacy is a stable trait, we note that conducting an experimental manipulation would prove challenging. Moreover, the exact relationship between locus of control and self-efficacy that motivated our initial hypothesis remains a contested topic. While Peterson & Stunkard (1992) have characterized locus of control and self-efficacy as cognates, Bandura (1992) strongly disagrees and argues that the two concepts have little in common. With such diverging views on self-efficacy, its exact influence on religiosity and relationship with Kay et al.'s (2009) Compensatory Control Theory pose novel research questions.

Finally, another potential explanation for our results is the conflicting literature regarding the validity of the System I/System II theory. Recent studies have cast doubt on whether analytic priming fits within the dual process framework (Krajbich et al, 2015). One way to distinguish

²⁰ Please see Appendix J

²¹ Such a Protestant vs. Catholic

between intuitive and deliberative choices is to examine relative reaction times (RT), based on the logic that intuitive processes can be executed more quickly than deliberative processes. In recent years several researchers have used this relationship to infer the intuitive nature of fast decisions. Krajbich et al. (2015) question the validity of this reverse inference as reaction times are often a function of decision complexity. Furthermore, several studies have demonstrated that System I and System II work in tandem and not as separate entities. Peters et al. (2006) also found that over time, the consistent and effective use of System I reasoning calibrates and makes System II processing more effective, which in turn promotes better logical reasoning and creates a feedback loop. Thus, the null results in our study might have been due to the fact that analytic priming may not have any real effect on behavior. Further evidence for this interpretation is provided by the failed MTurk replication conducted by Sanchez et al. (2017) and a study by Deppe et al. (2015), which found that visual primes have little to no effect on thinking style. Further replications are therefore required to settle whether analytic primes affect religious beliefs despite the strong motivations and evidence presented by Gervais & Norenzayan (2012). In particular, we suggest probing different manipulations such as written or implicit primes in addition to visual ones to identify and elicit the most effective priming effect.

Implications

Our research may be extended to pursue the practical implications of addressing religious extremism. We shed light on questions that might inform governments in reducing violent acts associated with religious bigotry, hate crimes, and terrorism. For example, can a simple intervention that involves training analytic thinking reduce religious fanaticism? Might boosting a person's self efficacy expand their religious acceptance? Though our study is yet to provide conclusive evidence that can guide an immediate intervention, our endeavors contribute to the continuum of evolving scientific research. Future study will continue to be needed to concretize the theories on how analytic thinking and self-efficacy might affect religiosity.

It is worth noting that the null results of our study might also steer researchers in other fruitful avenues of examination. For instance, what other constructs could affect religiousness? How might we tailor interventions to each religious group? Understanding religiosity from different

facets and perspectives will help policy and decision makers leverage the positive effects associated with it, and mitigate its detrimental consequences.

Conclusion

We intended to replicate the effect of analytic thinking on self-reported religious beliefs found by Gervais & Norenzayan (2012) and propose self-efficacy as a potential mechanism to influence self-reported religious belief. Our MTurk study yielded null results in both hypotheses. Due to a lack of statistical power, our findings are inconclusive. Further research is thus needed to settle the discrepancy in the literature regarding the link between analytic thinking, self-efficacy and religiousness, especially among different religious populations.

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Appendix A: Measures









Analytic Prime Images



Neutral Prime Images

YNCFA

PADUS



VAOFEA

Anagram Task From Self-Efficacy Manipulation



Appendix B: G-Power Calculations

Post Hoc Hypothesis 1



Post Hoc Hypothesis 2



A Priori Hypothesis 1



A Priori Hypothesis 2

Appendix C: Informed Consent

You are invited to participate in our study. Our study is about factors that contribute to beliefs. In total, participation should take less than 10 minutes. If you decide to participate, we will ask that you answer questions about your beliefs and attitudes. We will also ask you to provide demographic information. We will not ask for your name or any information that will make you identifiable.

There is minimal risk involved with this study; no more than experienced in everyday life. Participation in this study is completely voluntary and you can leave the study at any point you wish. If you withdraw from the study before completing it, your data will be discarded.

If you have any questions about this research, please contact acacioa@upenn.edu or edimant@upenn.edu.

I have read and understood the above consent form and desire of my own free will to participate in this study.

○ Yes

🔿 No

Thank you for participating in our research!

There are two different mini-studies that you will complete. To randomize the order, we ask that you select any one of the options below, and this will determine which mini-study you complete first. The options have no text associated with them to help make the choice random.

Choose one of the options below to select your first mini-study:

\bigcirc			
0			

Appendix E: Dependent Variable, Self-Reported Belief in God

How strongly do you believe in God (from 0-100)? To clarify, if you are certain that God does not exist, please put "0" and if you are certain that God does exist, then put "100"

Appendix F: Attention Checks

Think back to the mini-study in which you viewed 4 images.

Now try to remember which of the images below match the ones you saw in the first portion of the study.

Check each image that you saw (and only those images).

You may need scroll to the right to see all the images for this question.



Visual Prime attention check

How many anagrams in total were you asked to solve?

○ 2○ 3	01			
○ 3	○ 2			
	○ 3			

Anagram attention check

>>

Appendix G: Demographic Questionnaire

In terms of religion, how do you classify yourself?

O Christian			
O Buddhist			
🔘 Sikh			
O Muslim			
) Jewish			
Agnostic			
Athiest			
() Other			
			>>
What is your gender?			
O Male			
) Female			
			>>

Which of the following best describes your ethnicity?	
American Indian or Alaska Native	
Black or African American	
East Asian	
Hispanic or Latino	
Native Hawaiian or Pacific Islander	
South Asian	
White/Caucasian	
Other	
	>>
Which of these best describes you?	
O English is my first and primary language.	
O English is not my first and primary language.	

>>

Appendix H: Wilcoxon Rank-Sum Test Results for (1) complete data set and (2) data set with exclusion criteria applied

Wilcoxon rank sum test with continuity correction

```
data: Religiosity by ThinkingStyle
W = 9184.5, p-value = 0.2143
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
-1.0000108229 0.0000364474
sample estimates:
difference in location
-8.245175e-05
```

Table 1.1: Wilcoxon rank sum test showing that the effects of the neutral and analytic primes on DV: Belief in God (0-100) are not significantly different in the complete data set (n = 283).

Wilcoxon rank sum test with continuity correction

```
data: Religiosity by SelfEfficacy
W = 10360, p-value = 0.5527
alternative hypothesis: true location shift is not equal to 0
95 percent confidence interval:
-3.725316e-06 4.703679e-06
sample estimates:
difference in location
7.564737e-05
```

Table 1.2: Wilcoxon rank sum test showing that the effects of baseline and lowered self-efficacy on DV: Belief in God (0-100) are not significantly different in the complete data set (n = 283).

Wilcoxon rank sum test with continuity correction

Table 1.3: Wilcoxon rank sum test showing that the effects of the neutral and analytic primes on DV: Belief in God (0-100) are not significantly different in the data set with exclusions applied (n = 217).

Wilcoxon rank sum test with continuity correction

Table 1.4: Wilcoxon rank sum test showing that the effects of baseline and lowered self-efficacy on DV: Belief in God (0-100) are not significantly different in the data set with exclusions applied (n = 217).

	Neutral Prime	Neutral Prime + Lo	wered SE	Analytic Prime	Analyti	ic Prime + L	owered SE
Mean: Age	39.	12	35.87	39.19			37.16
		Table 1.1: Avera	ige age by Co	ondition			
	Neutral Prime	Neutral Prime + Lowered SE	Analytic Prime	Analytic Prime Lowered SE	+	Total	Percent
Male	46	38		35	34	153	54%
Female	32	25		38	35	130	46%

Appendix I: Demographic Breakdown by Condition

Table 1.2 Gender by Condition

63

78

73

69

283

100%

Female

Total

	Neutral Prime	Neutral Prime + Lowered SE	Analytic Prime	Analytic Prime + Lowered SE	Total	Percent (Rounded)
American Indian or Alaska Native	1	2	2	2	7	2%
Black or African American	4	4	6	3	17	6%
East Asian	1	3	1	1	6	2%
Hispanic or Latino	4	3	3	4	14	5%
South Asian	1	0	0	0	1	0%
White/Caucasian	67	51	61	59	238	84%
Other	0	0	0	0	0	0%
Total	78	63	73	69	n = 283	100%

Table 1.3: Ethnicity by Condition

	Neutral Prime	Ne + I	utral Prime Lowered SE	Analytic Prime	Analytic Prime + Lowered SE	Total	Percent (Rounded)
Atheist		4	3	5	4	16	6%
Agnostic		3	5	2	5	15	5 5%
Buddhist		1	1	0	2	2	4 1%
Christian	6	4	52	65	55	236	83%
Jewish		2	0	0	1	3	3 1%
Muslim		0	1	0	1	2	2 1%
Other		4	1	1	1	7	2%
Total	7	8	63	73	69	n = 283	3 100%

Table 1.4: Religious Affiliation by Condition

	Neutral Prime	Neutral Prime + Low SE	Analytic Prime	Analytic Prime + Low SE
Sample Size	78	73	63	69
Exclusion Criteria:				
Failure of visual attention check	12	10	6	13
Failure of anagram attention check	-	17	-	17
Low English proficiency	1	-	-	1
Total Excluded	13	27	6	21
Total	65	46	57	48

Table 1.5: Exclusion Criteria by Condition



Appendix J: Comparing the Effect of Analytic Thinking on Religiosity between Christians and non-Christians.

Figure J1: Box-plots showing the effect of thinking style on DV: Belief in God (0-100) for Christians. Red bars indicate means. Difference is significant based on a t-test (p = 0.02).



Figure J2: Box-plots showing the effect of thinking style on DV: Belief in God (0-100) for non-Christians. Red bars indicate means. Difference is insignificant based on a t-test (p = 0.42).

Appendix K: Pre-registration

Our experiment has been pre-registered on https://aspredicted.org/. A link to a pdf copy of the public pre-registration is available here: <u>https://aspredicted.org/xn2t3.pdf</u>

Appendix L: Individual Contributions

AJ Acacio: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Visualization, Writing (Original Draft), Writing (Review and Editing)
Simone Arora: Conceptualization, Methodology, Investigation, Writing (Original Draft), Writing (Review and Editing)
Patrick Faga: Conceptualization, Methodology, Investigation, Writing (Original Draft), Writing (Review and Editing), Validation
Isha Jain: Conceptualization, Methodology, Investigation, Writing (Original Draft), Writing (Review and Editing), Validation
Dung Pham: Formal Analysis, Visualization, Validation, Writing (Review and Editing)
Cory Winkler: Methodology, Writing(Original Draft), Formal Analysis, Visualization, Data Curation, Data Analysis, Validation
Dr. Dimant: Funding Acquisition, Mentorship, Supervision
Sabrina Arias: Mentorship, Supervision
Alessandro Tacconelli: Mentorship, Supervision

Appendix M: Updates Based on Pretest

Based on our pretest, we updated the final survey to incorporate the following changes:

- 1. We removed the question related to whether participants were born and raised in the USA or had immigrated to the USA due to the lack of relevance for our study and to reduce the number of exclusions we applied.
- 2. We reframed the English language proficiency question from whether English was their first and primary language to whether their English language abilities are at least at a high school level in order to make it broader.
- 3. We removed the part that described our study as a series of mini-studies because we received verbal feedback that it confuses participants.
- 4. We reframed the anagram attention check from: *How many anagrams were you asked to solve?* to *How many anagrams in total were you asked to solve?* due to participant feedback.