



Supplementary Materials for
Analytic Thinking Promotes Religious Disbelief

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Published 27 April 2012, *Science* **336**, 493 (2012)
DOI: 10.1126/science.1215647

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Supporting Online Material

Across all studies except Study 4, participants were University of British Columbia undergraduates. While student samples are typically homogenous (26) this was a religiously and ethnically diverse population, covering the whole spectrum of religious belief from atheists to deeply committed believers (Table S1). All reported effects remain significant when treating gender as a covariate, and gender did not significantly interact with any of our priming manipulations. In addition, across studies religious affiliation (comparing two of our largest available subgroups: Christians vs. all other religious affiliations) did not moderate any effects. Thus we do not discuss gender or religious affiliation further.

Study 1

We measured analytic thinking with the Cognitive Reflection Task (6), which contains three problems that require participants to analytically override an intuitive, yet incorrect, response in order to obtain a correct response. This task was designed to specifically measure analytic (System 2) processing because an intuitive reading of each problem invites a quick and easy, yet incorrect, response. Furthermore, the computational demands of each question are minimal. Frederick (6) explains: “The three items on the CRT are ‘easy’ in the sense that their solution is easily understood when explained, yet reaching the correct answer often requires the suppression of an erroneous answer that springs ‘impulsively’ to mind.” Furthermore, experimental manipulations known to induce analytic processing reliably improve performance on the task (18). Thus, the total number of correct answers provides a measure of the degree to which participants are analytically overriding flawed intuitions in reasoning. Next, participants completed three separate measures of religious belief. First, participants completed the widely used ten item ($\alpha = .90$) intrinsic religiosity (21) scale ($M = 33.07$, $SD = 14.39$). Then, they

completed a new intuitive religious belief scale ($\alpha = .80$; $M = 21.83$, $SD = 7.57$). Finally, they completed a three item belief in supernatural agents scale ($\alpha = .91$; $M = 11.63$, $SD = 5.97$).

Study 2

Pilot Study

To assess whether the visual priming procedure triggered analytic thinking, we performed a pilot test in which participants were randomly assigned to look at either pictures of *The Thinker* ($N = 20$) or pictures of *Discobolus* ($N = 20$), exactly as in the main study. After viewing the pictures, participants completed a 4-item syllogistic reasoning task that measures analytic overriding of intuitive tendencies (35, 36). The task consisted of arguments with conclusions having an intuitive plausibility that clashed with the logical structure of the argument. Participants were asked to evaluate the validity of the arguments (i.e., whether the conclusion follows logically from the premises). Two items included logically valid arguments with intuitively implausible conclusions (e.g., Premise 1: All things that are made of plants are good for the health. Premise 2: All cigarettes are things that are made of plants. Conclusion: All cigarettes are good for the health.) and two items included logically invalid arguments with intuitively plausible conclusions (e.g., Premise 1: All animals which feed their young are mammals. Premise 2: All birds are not mammals. Conclusion: All birds feed their young.). The degree to which participants attended to the logical structure of the argument while ignoring conclusion plausibility served as the dependent measure assessing analytic processing. As predicted, participants randomly assigned to the *Thinker* condition were significantly more likely to override intuitions and produce responses consistent with the logic of the arguments ($M = 3.50$, $SD = .69$) than were participants in the control condition ($M = 2.60$, $SD = 1.27$), $t(29.23) = 2.78$, $p = .009$ (equality of variances not assumed).

Main Study

All participants completed the experiment on a computer, and received fully automated instructions. Participants were randomly assigned to view four (slightly different) pictures of either *The Thinker* or of *Discobolus*. All participants received instructions to look at each picture for 30 seconds before moving on to the next portion of the experiment. After viewing the pictures, participants were redirected to an ostensibly separate task in which they were asked to report demographic information, including a single face-valid measure of belief in God. Participants rated their belief in God from 0 (God definitely does not exist) to 100 (God definitely exists). In a post-experiment debriefing, only 5 participants (all in the *Thinker* condition) expressed suspicion and were therefore omitted from all analyses.

Study 3

Pilot Study

We conducted a separate pilot study to ensure that the priming procedure actually elicited analytic processing. Participants were randomly assigned to complete either the Analytic prime ($N=39$) or the Control prime ($N=40$) before answering a question often used to assess analytic versus intuitive processing (*19*) (the so-called Moses Illusion: “How many of each kind of animal did Moses take on the Ark?”). Participants were significantly more likely to give the correct answer (e.g., “Moses didn’t have an Ark”) in the Analytic condition (26%) than in the Control condition (5%), $\chi^2=6.53, p=.01$.

Main Study

All participants completed the experiment on a computer, and received fully automated instructions. After providing consent, participants were informed that they would be participating in a number of distinct and unrelated “mini-studies” presented in random order. In fact,

participants always completed a priming task, followed by a measure of religious belief, followed by distracter tasks and demographic information. We primed participants using a standard sentence unscrambling paradigm (22). All participants began the study with a “verbal fluency” task in which they were given ten sets of five words. For each set, participants had to drop one word and rearrange the remaining words to form a phrase (e.g., dog away deli ran the → the dog ran away). In the Analytic condition, five of these words sets contained target prime words related to analytic reasoning (*analyze, reason, ponder, think, rational*). In the Control condition, words were unrelated to any coherent concept. After completing the priming manipulation, participants completed the belief in supernatural agents ($\alpha = .93$) measure from Study 1. In a post-experiment debriefing, 5 participants (2 in the Analytic condition, 3 in the Control condition) expressed suspicion and were therefore omitted from analyses.

All participants also completed a prescreening demographic questionnaire at the start of the term, several weeks prior to the experiment, including an item in which participants rated (from 1-7) their agreement with the statement “I believe in God.” Participants in the present study spanned the entire spectrum of belief on this item, with substantial variability (Range: 1-7, $M = 4.31$, $SD = 2.11$). Pre-experiment belief in God did not differ between priming conditions ($p = .97$), but it was strongly non-normally distributed (Kolmogorov-Smirnov $p < .001$). We therefore separated participants into three groups (Low Belief = 1 or 2 on initial belief in God, $N = 25$; Medium Belief = 3, 4, or 5 on initial belief in God, $N = 37$; High Belief = 6 or 7 on initial belief in God, $N = 31$). We then performed a 2 (condition: Control vs. Analytic Thinking) by 3 (pre-experiment belief: High vs. Medium vs. Low) ANOVA on belief in supernatural agent ratings. As hypothesized, this analysis revealed a significant main effect of condition, $F(1, 87) = 4.51$, $p = .04$, $\eta_p^2 = .05$, and a marginal effect of pre-experiment belief, $F(2, 87) = 2.73$, $p = .07$,

$\eta_p^2 = .06$; however, there was no interaction between these variables, $F(2, 87) = .42, p = .66, \eta_p^2 = .01$. Alternative analyses treating pre-experiment belief in God as a continuous, rather than categorical, variable similarly reveal significant main effects of condition, $\beta = -.22, p = .03$, and pre-experiment belief, $\beta = .22, p = .03$, but no significant interaction between these two variables, $\beta = -.04, p = .64$.

Study 4

Participants in Study 5 hailed from 36 different states representing all major geographic regions of the US mainland. Ages ranged from 18-69. In addition to the demographics reported in Table S1, these participants represented disparate educational and income levels. Education: 15% high school or equivalent, 38% some college or university, 35% completed college or university, 13% postgraduate degree. Income: 19% < \$10K, 15% \$10K-20K, 19% \$20K-30K, 13% \$30K-40K, 8% \$40K-50K, 8% \$50K-60K, 17% > \$60K.

The experimental procedure was identical to that used in Study 4. No participants indicated suspicion during a post-experiment debriefing. Most participants guessed that the priming task was instead used to ensure English language proficiency.

Study 5

Pilot Study

An independent sample ($N = 153$) rated the Disfluent font (*sample*) as more difficult to read than the Control font (**sample**), $t(140.58) = 10.97, p < .001$.

Main Study

In a series of studies, Alter and colleagues (18) demonstrated that meta-cognitive experiences of disfluency function as alarms to trigger analytic thinking strategies. Of particular interest for the present study, disfluency can be manipulated in very subtle ways, such as by

merely presenting participants questions in a difficult-to-read font. In this paradigm, participants are randomly assigned to either of two conditions in which they answer identical questions and perform identical tasks. In the control condition, participants are given the questionnaires in a typical, easy-to-read font. Essentially, a participant in the control condition fills out a questionnaire that is more-or-less identical in form to any other questionnaire they have filled out. In the experimental condition, participants complete identical measures that are merely presented in a font that is more difficult to read. In a post-experiment debriefing, no participants expressed suspicion.

As in Study 4, participants completed a pre-screening belief in God item weeks before completing the main experiment. Participants in the present study spanned the entire spectrum of belief on this item, with substantial variability (Range: 1-7, $M = 4.29$, $SD = 2.08$). Pre-experiment belief in God was again non-normally distributed (Kolmogorov-Smirnov $p < .001$). We therefore separated participants into three groups (Low Belief = 1 or 2 on initial belief in God, $N = 51$; Medium Belief = 3, 4, or 5 on initial belief in God, $N = 67$; High Belief = 6 or 7 on initial belief in God, $N = 61$). We then performed a 2 (condition: Control vs. Disfluency) by 3 (pre-experiment belief: High vs. Medium vs. Low) ANOVA on belief in supernatural agent ratings. As hypothesized, this analysis revealed significant main effects of condition, $F(1, 175) = 4.01$, $p = .047$, $\eta_p^2 = .02$, and pre-experiment belief, $F(2, 175) = 137.98$, $p < .001$, $\eta_p^2 = .61$; however, there was no hint of any interaction between these variables, $F(1, 175) = .05$, $p = .96$, $\eta_p^2 = .001$. Alternative analyses treating pre-experiment belief in God as a continuous, rather than categorical, variable similarly reveal significant main effects of condition, $\beta = -.10$, $p = .02$, and pre-experiment belief, $\beta = .79$, $p < .001$, but no significant interaction between these two variables, $\beta = .02$, $p = .65$.

Additional Tests of Alternative Explanations

In addition to measuring religious belief, we also included a separate measure that is conceptually distinct from religion in order to test whether methodological artifacts introduced by the disfluency manipulation might have affected participants' responses. For example, participants might simply be less likely to endorse any statements presented in disfluent fonts. To assess this possibility, participants also completed a standard five-item satisfaction with life scale (37) in which questions were presented in a Likert format identical to that used for the religious belief questionnaire. Scores on this scale did not significantly differ between the two experimental conditions, $t(177) = .10, p = .92$.

We also considered the possibility that the disfluency manipulation might have introduced a negativity bias that would have weakened endorsements of religious beliefs that are positively-valenced. If true, then participants in the disfluent condition should rate lower belief in positively-valenced supernatural agents (God and angels) and higher belief in negatively valenced supernatural agents (the devil), relative to participants in the control condition. To the contrary, participants rated lower belief in all three supernatural agent items in the disfluent font condition than in the control condition, God: $M_{Control} = 4.36, SD_{Control} = 2.07, M_{Disfluent} = 3.76, SD_{Disfluent} = 2.00$, angels: $M_{Control} = 4.06, SD_{Control} = 2.14, M_{Disfluent} = 3.51, SD_{Disfluent} = 1.97$, the devil: $M_{Control} = 3.74, SD_{Control} = 2.15, M_{Disfluent} = 3.13, SD_{Disfluent} = 2.00$.

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Table S1. Participant Demographics. Note: -- denotes categories that were not included as options in a given study.

	Study 1	Study 2	Study 3	Study 4	Study 5
Mean Age	20.22	20.40	20.15	33.14	20.40
Gender					
Female	68%	71%	78%	74%	70%
Male	32%	29%	22%	26%	30%
Religion					
Christian	33%	33%	33%	56%	31%
None	28%	25%	27%	8%	29%
Agnostic	11%	10%	12%	10%	11%
Buddhist	4%	8%	5%	2%	8%
Atheist	11%	7%	8%	16%	9%
Sikh	3%	5%	5%	--	2%
Other	6%	4%	3%	3%	5%
Muslim	2%	4%	3%	0%	5%
Jewish	2%	2%	3%	4%	2%
Ethnicity					
East Asian	50%	47%	48%	8%	62%
White/Caucasian	30%	34%	28%	75%	24%
South Asian	12%	15%	16%	3%	12%
Mixed/Other	8%	4%	8%	2%	2%
Hispanic	--	--	--	6%	--
African Am.	--	--	--	7%	--

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