

Running Head: ANALYTIC THINKING PREDICTS ENDORSEMENT OF EVOLUTION

**Override the controversy:**

**Analytic thinking predicts endorsement of evolution**

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**Abstract**

Despite overwhelming scientific consensus, popular opinions regarding evolution are starkly divided. In the USA, for example, nearly one in three adults espouse a literal and recent divine creation account of human origins. Plausibly, resistance to scientific conclusions regarding the origins of species—like much resistance to other scientific conclusions (Bloom & Weisberg, 2007)—gains support from reliably developing intuitions. Intuitions about essentialism, teleology, agency, and order may combine to make creationism potentially more cognitively attractive than evolutionary concepts. However, dual process approaches to cognition recognize that people can often analytically override their intuitions. Two large studies (total  $N = 1324$ ) found consistent evidence that a tendency to engage analytic thinking predicted endorsement of evolution, even controlling for relevant demographic, attitudinal, and religious variables. Meanwhile, exposure to religion predicted reduced endorsement of evolution. Cognitive style is one factor among many affecting opinions on the origin of species.

**Keywords:** evolution; creationism; dual process theories; supernatural beliefs; cognitive style

**Override the controversy:**

**Analytic thinking predicts endorsement of evolution**

*The highest stage in moral culture at which we can arrive, is when we recognise that we ought to control our thoughts.*

~ Charles Darwin, *The Descent of Man* (1871, p. 60)

Evolution is the foundational principle underlying modern biology (Dobzhansky, 1973). Evolutionary theory meets near-universal scientific acceptance, yet remains stubbornly controversial outside of scientific circles. For example, recent polls in the US reveal that one in three American adults believe that humans have existed in their present form since the beginning of time (Pew, 2013), a human era which 19% of Americans believe spans less than ten millennia (Gallup, 2014). Despite rapid technological and informational advances over the past 30 years, these rates have remained more-or-less stable. Although the USA is somewhat of an outlier among economically and educationally advanced nations when it comes to low acceptance of evolution, only a handful of countries on earth can boast 80% acceptance of evolution (Miller, Scott, & Okamoto, 2006). In the face of overwhelming scientific evidence supporting evolution, billions of people instead prefer various supernatural creation stories as explanations for the diversity of life on earth.

Why do so many reject evolution, and what factors might promote endorsement of evolution? Clearly, any answers to these questions will be complex and multifaceted. Attitudes towards evolution are affected by a slew of developmental (e.g., Evans, 2000), cultural learning and religious (e.g., Gervais, Willard, Norenzayan, & Henrich, 2011; Lawson & Worsnop, 1992; Rissler, Duncan, & Caruso, 2014), motivational (e.g., Rutjens, van der Pligt, & van Harreveld, 2010; Rutjens, van Harreveld, van der Pligt, Kreemers, & Noordewier, 2013), and educational

(e.g., Nehm, Kim, & Sheppard, 2009; Nehm & Schonfeld, 2007) factors. Nonetheless, the present studies explore the possibility that more basic differences in cognitive style may help explain divergent attitudes towards evolutionary theory.

### **Cognitive Style**

In Western traditions, there is a long history of viewing human psychology as ultimately divided between “passions” and “reason.” This dual emphasis on quick and often irresistible urges in competition with more effortful and rational thinking has been influential in psychology since at least William James (1890), who proposed two distinct systems for information processing. One system quickly and effortlessly provides intuitive, heuristic responses while the other system relies on effortful, rational processing.

In current dual process theories, these two modes of thinking have been dubbed System 1 and System 2 processing (see, e.g., Evans, 2003; Kahneman, 2011). System 1 relies on fast and frugal heuristics to yield quick, “good enough,” intuitive responses. On the other hand, System 2 relies on slower, more effortful, analytic processing. Although there is considerable debate regarding many details of the interplay between these two systems, dual process approaches have been quite successfully applied to numerous problems in psychology (see, e.g., Evans, 2003; Evans & Stanovich, 2013; Greene, et al., 2001; Kahneman, 2011; Petty & Cacioppo, 2012; Sloman, 2014; Thompson, 2013). Crucially, in many circumstances System 1 takes priority: it operates more quickly and with less effort than does System 2. However, given time, energy, and motivation, System 2 processing can be used to analytically inhibit or override the intuitive processing of System 1. That is, sometimes people can analytically override their intuitions.

Turning from cognitive style in general to endorsement of evolution in particular, how might cognitive style influence attitudes towards the origins of species? To foreshadow, many

recent lines of research suggest that, ultimately, evolutionary concepts may not be great fits for human (System 1) intuitions.

### **Intuitive Creationism and Analytic Evolution?**

Evolution is far from the only domain in which everyday beliefs depart from scientific understanding. Resistance to many scientific conclusions may stem not from a lack of knowledge, but rather from reliably developing intuitions that people have about the way the social and physical worlds work (Bloom & Weisberg, 2007). Regarding beliefs about evolution, cognitive style likely plays a somewhat complicated role, with both intuitions and analytic thinking differentially supporting both evolution and creationism (Evans & Lane, 2011). For example some intuitive processes might underpin concepts of change over time—concepts that are fundamental to evolution—while analytic thinking may be used to justify and elaborate creationist arguments.

On the whole, however, the operation of several interrelated psychological processes may make creationism, rather than evolution, intuitively compelling. For example, intuitive essentialism may give creationist beliefs an early head start in development. As young as 2 years old, children tend to view animal species as essential “kinds” with deep underlying characteristics that transcend superficial appearances (e.g., Gelman & Markman, 1987; Gelman & Wellman, 1991). This essentialist approach to animals persists into adulthood, at least intuitively, leading adults to endorse scientifically inaccurate statements (including statements about evolution) when cognitive resources are strained (e.g., Shtulman & Valcarcel, 2012). Crucially, these internal essences are viewed as eternal and immutable. Further, essentialism leads people to underappreciate individual variation within species—a key component of evolutionary processes. To the extent that people view animal species as fundamentally

unchanging and unchangeable, as well as homogenous and invariant, evolutionary concepts face an uphill cognitive battle. Indeed, adults who tend to endorse essentialism in biological concepts also tend to reason poorly about core concepts in evolutionary theory (Shtulman & Schulz, 2008). Many adults who purportedly endorse evolution tend to—thanks to the operation of early developing intuitions—nonetheless hold naïve and scientifically inaccurate conceptions of how evolution actually works (Shtulman, 2006).

Like essentialism, intuitions regarding purpose, function, and agency all support the development of creationist concepts at the expense of evolutionary thinking. From a young age, children view things in the world as existing for a reason; they view objects as serving functions (Kelemen, 2004). This promiscuous teleology persists into adulthood (Kelemen & Rossett, 2009), even among those with advanced scientific training (Kelemen, Rottman, & Seston, 2013). Further, functionally specialized features of animals (such as a zebra's stripes or a kangaroo's tail) are viewed as inherently characteristics of an animal's "kind," perhaps implying a deeper and more temporally stable essence of the animal (Lombrozo & Rehder, 2012; Ware & Gelman, 2014). If objects in the world, including living things, are intuitively imbued with function and purpose, it seems a small step to viewing them as intentionally designed by some external agent.

Natural theologian William Paley (1802) introduced an analogical argument for the existence of God based around the existence of apparent order in the natural and biological world. If one were walking on a beach and stumbled upon a complex object such as a watch, opined Paley, one would naturally and irresistibly infer the existence of a watchmaker. Does not the existence of even more complex living objects—aardvarks, acacias, ants, arbutus, and azaleas—similarly imply a Creator? In everyday experience, functionally complex and ordered objects do not spontaneously generate. Instead, they demand the existence of a designer. Given

that children and adults alike share the intuition that objects in the world, including living things, serve functions and exist for purposes, they may infer intentional agency behind intuited purpose. Consistent with this idea, children as young as 12 months old tend to expect intentional agents when they observe objects in a system exhibit increased, rather than decreased, order over time (Newman, Keil, Kuhlmeier, & Wynn, 2010). Infants are surprised if order spontaneously arises, but rather nonplussed if an agent is present while order arises. This suggests that if children and adults alike experience order and apparent purpose in the world without an agent apparent, they may simply—like Paley—infer the existence of an order-producing agent. As a result, intuitions regarding teleology, order, and agency may serve as initial stepping-stones for creationist beliefs, but stumbling blocks for endorsement of evolution.

Consistent with the above possibility, there is at least some evidence to suggest that in certain cultural contexts, children readily and intuitively adopt creationist conceptions of biology at a certain stage of development. In two sets of studies, Evans (2000; 2001) asked children of various ages (5-12 years old) in the American Midwest directly where new animal species come from. The youngest children gave nonsystematic responses, equally citing spontaneous generation, creationism, and evolution. Interestingly, however, children tended to show a spike in creationist beliefs during the middle years, before settling in to the same beliefs as their parents among the oldest cohort (Evans, 2001). Although these data certainly allow a large role for cultural learning (Gervais, et al., 2011), they are also consistent with the interpretation that early intuitions might favor creationism at a certain stage of development.

In sum, many scientific concepts are difficult for people to grasp intuitively (Bloom & Weisberg, 2007) while supernatural concepts may come more easily (e.g., McCauley, 2011). In the domain of evolution, many of the core concepts of evolutionary theory, including population-

level thinking, adaptation, and within-group variability, do not come easily (Shtulman, 2006). In contrast, reliably developing intuitions about essences, teleology, order, and agency all fit very well with creationist views. If System 1 had all the say, creationism might be universal.

However, recent evidence suggests that System 2 processing can also affect supernatural beliefs.

### **Cognitive Style and Supernatural Beliefs**

Many supernatural beliefs come easily to people, perhaps because they are supported by a variety of core intuitive processes (e.g., Atran & Norenzayan, 2004; Bloom, 2007; Gervais, 2013; McCauley, 2011; Norenzayan & Gervais, 2013; Willard & Norenzayan, 2013). As with creationism, reliably developing intuitions support the mental representation of supernatural agents, such as God. However, dual process approaches to cognition suggest that at times people are able to analytically inhibit or override their intuitions. What is the relationship between analytic thinking and belief in supernatural agents?

In 2012, three lab groups independently converged on essentially the same idea. If supernatural beliefs have intuitive support, and people can often analytically override intuitive inputs, then perhaps a tendency to engage in analytic thinking would be associated with lower levels of belief in supernatural agents. Consistent with this, all three groups found that performance on a classic task used to assess aptitude and motivation to engage analytic thinking (Frederick, 2005) consistently predicts lower levels of belief in gods (Gervais & Norenzayan, 2012; Pennycook, Cheyne, Seli, Koehler, & Fugelsang, 2012; Shenhav, Rand, & Greene, 2012). In support of a causal role for analytic thinking in reducing belief in gods, various experimental prods to engage analytic thinking similarly reduced self-reported religious belief (Gervais & Norenzayan, 2012; Shenhav, et al., 2012). Subsequent work in this area continues to deliver more nuanced interpretations of specific mechanisms (e.g., Pennycook, Cheyne, Barr, Koehler,

Fugelsang, 2014), but there is now convergent evidence that analytic thinking can reduce some supernatural beliefs. Indeed, the analytic thinking-religious disbelief link appears to be a relatively stable phenomenon, as it consistently appears across samples drawn from a dozen different countries and regions worldwide, ranging from Mauritius to Hong Kong to Singapore to Kentucky to Australia (Gervais, et al., manuscript in preparation). Analytic thinking tends to reduce at least some of the supernatural beliefs that are supported by various intuitions.

### **Present Research**

The fact that organisms have evolved, and continue to evolve, is scientifically speaking not controversial. Evolution by natural selection is among the most successful ideas in the history of ideas. Despite this, billions worldwide view it with suspicion and instead prefer supernatural creationist accounts of the origins of species. It is possible that reliably developing intuitions regarding essentialism, teleology, order, and agency converge to make creationism intuitively compelling and evolution a tougher sell. However, people are not blindly led by their intuitions, they can also engage in analytic thinking to (at least sometimes) inhibit or override their intuitions. In the domain of supernatural cognition, analytic thinking tends to reduce belief in supernatural agents. Combined, these various lines of research suggest, perhaps, that a tension between intuitions and analytic thinking may influence people's endorsement of evolution. Specifically, people who are more willing or able to engage analytic thinking might be more likely to endorse evolution than people who tend to trust their intuitions. If true, then measures of analytic thinking should predict greater endorsement of evolution. In the present paper, two large studies tested this core hypothesis.

In addition, these studies attempted to view analytic thinking and evolution within a broader cultural context. Supernatural belief and disbelief does not simply come down to a tug-

of-war between intuitions and analytic thinking: cultural learning is also a key component (e.g., Norenzayan & Gervais, 2013). While intuitions might make some supernatural concepts (including, it seems, creationism) compelling, they do not in isolation produce beliefs (e.g., Banerjee & Bloom, 2013; Gervais & Henrich, 2010; Gervais, et al., 2011). Indeed, supernatural beliefs may require cultural learners to observe people actually acting on them in order to foster belief in naïve learners. These actions are termed *credibility enhancing displays* (or CREDs, for short) of others' beliefs (Henrich, 2009). Credibility enhancing displays of religious faith have previously been linked to individual differences in supernatural beliefs (e.g., Gervais & Najle, revision invited; Lanman, 2012; Lanman & Buhrmester, under review). Plausibly, they also help bolster creationist beliefs.

Although intuitions might give creationism an advantage, cultural learning is probably also important (Gervais, et al., 2011). With this in mind, I also included measures of cultural learning of religion and religious CREDs to better situate any findings relating analytic thinking to endorsement of evolution within a more nuanced and multifaceted theoretical framework for understanding variability in supernatural beliefs (e.g., Norenzayan & Gervais, 2013). Thus, in addition to predicting an analytic thinking-endorsement of evolution link, I also hypothesized that measures of cultural exposure to religion would predict lower rates of evolution endorsement.

In sum, I tested the degree to which analytic thinking promotes endorsement of evolution. I tested this core hypothesis using two complementary measures of evolution endorsement, drawn from large-scale polls (Pew and Gallup measures, respectively). In addition, I evaluated the degree to which cultural exposure to religion predicts reduced endorsement of evolution. I

was able to test these hypotheses in two large samples of participants who show approximately the same evolution endorsement rates as the general public in the USA.

**Transparency statement.** All data and analysis code (R Core Team, 2012) will be posted on the author's website upon publication. I report how I determined my sample sizes, all relevant variables<sup>1</sup> included in the study, and all data exclusions.

### Study 1

Using a large undergraduate sample, Study 1 served as an initial test of the hypothesis that analytic thinking predicts increased acceptance of evolution.

#### Method

At the beginning of each semester, the University of Kentucky psychology subject pool administers a prescreening survey to all potential participants. Researchers can submit a handful of items for inclusion in the prescreening survey. This prescreen thus yields a large sample, but only limited opportunities for inclusion of items. All data for Study 1 were drawn from the prescreening survey administered during the fall semester of the 2014-2015 academic year.

**Participants.** To determine sample size, I simply accessed data from all participants who completed the prescreening measure. A total of 757 undergraduates (69% female,  $M_{age} = 18.75$ ,  $SD_{age} = 2.30$ ) completed both the first evolution question and all CRT items. By USA undergraduate standards, this was a fairly religious sample. More than three quarters (76.6%) reported a religious upbringing, and belief in God (rated from 1-7) was relatively high ( $M = 5.84$ ,  $SD = 1.85$ ,  $Mdn = 7$ ). Further, attitudes towards evolution closely mirrored recent (Pew, 2013) national estimates, as 29.5% (95% CI = [26.2%, 32.9%]) of participants endorsed a recent

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<sup>1</sup> The data were drawn from larger prescreening questionnaires in which multiple researchers could submit items. I had no access to the data for items included by other researchers. But, it should be acknowledged that all participants completed the measures from the present studies in the context of other, unrelated, measures.

creation of human beings (Pew national estimate: 30%). Overall, performance on the analytic thinking task (Frederick, 2005) was fairly low,  $M = .72$ ,  $SD = 1.05$ ,  $Mdn = 0$  out of 3 correct.

**Measures.** Participants completed two items assessing beliefs about evolution, a brief analytic thinking task, and a variety of religious and demographic items.

**Evolution.** I used evolution questions regularly used by Pew. First, participants answered one question asking “Which comes closer to your view?” with options “A. Humans and other living things have evolved over time” and “B. Humans and other living things have existed in their present form since the beginning of time.” Option B thus essentially signals endorsement of creationism. Following this item, participants answering A were given the choice of two options and asked to pick which comes closer to their view: “A. Humans and other living things have evolved due to natural processes such as natural selection” and “B. A supreme being guided the evolution of living things for the purpose of creating humans and other life in the form it exists today.” These options represent stances of naturalistic evolution and guided evolution, respectively.

**Analytic thinking.** To assess analytic thinking, I included the Cognitive Reflection Task (CRT: Frederick, 2005). This task includes three questions for which an incorrect answer impulsively springs to mind; this initial answer must be analytically overridden to reach a correct answer (e.g., “In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?” Intuitive answer = 24; Analytic answer = 47). I summed the number of analytically correct answers to form a composite analytic thinking measure.

**Religious and demographic questions.** Participants answered two religion questions. First, they rated their agreement with the statement “I believe in God” (from 1-7). Second, they

indicated whether or not they received a religious upbringing on a binary (yes, no) item. As demographics, participants indicated their sex/gender, age, and political beliefs (from 1- Very Liberal to 7- Very Conservative). Due to the abbreviated nature of the prescreen questionnaire, no additional demographic variables were included.

## Results

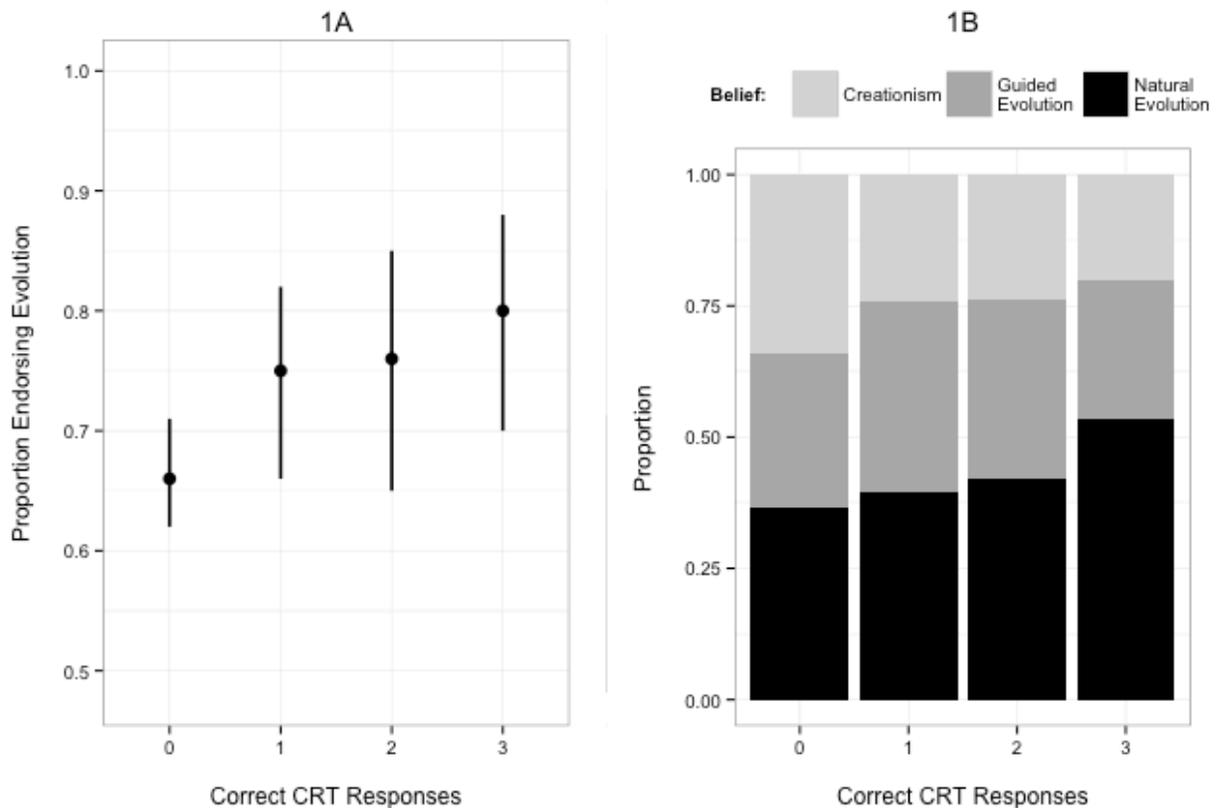
I utilized two slightly different analytic strategies, intended to map onto two distinct ways that large-scale polling companies (Pew and Gallup) query beliefs about evolution. First, I performed binary logistic analyses on the two evolution items. Next, I combined the two items to form a three-option (creationism, guided evolution, naturalistic evolution) evolution item and performed ordinal logistic regression.

**Binary analyses.** First, I examined patterns related to the first evolution item. In an initial binary logistic regression analysis, I predicted endorsement of evolution (vs. creationism) with analytic thinking. Each additional correct CRT response increased the odds of endorsing evolution by a factor (*Odds Ratio*, or *OR*) of 1.28, 95% CI [1.10, 1.52],  $z = 3.03$ ,  $p = .002$ , Figure 1A. Next, I included belief in God, religious upbringing, and political conservatism as additional covariates. In this second analysis, analytic thinking again emerged as a significant predictor (see Table 1). In sum, analytic thinking predicted greater endorsement of evolution. This effect was independent of current religiosity, religious upbringing, and political attitudes.

Next, I performed parallel analyses on the second evolution item (guided evolution coded 0, naturalistic evolution coded 1). Analytic thinking did not significantly predict endorsement of naturalistic evolution on its own,  $OR = 1.11$ , 95% CI [.95, 1.31],  $z = 1.28$ ,  $p = .2$ , or when including covariates (Table 1).

**Table 1.** Summary of binary logistic regression models for both evolution items

	<i>OR</i>	<i>LCI</i>	<i>UCI</i>	<i>z</i>	<i>p</i>
<b>Item 1, <i>df</i> = 680</b>					
Analytic	1.28	1.07	1.55	2.60	.009
Belief in God	.41	.30	.53	-6.36	< .001
Upbringing	.83	.49	1.37	-.73	.47
Conservatism	.89	.80	.98	-2.45	.01
<b>Item 2, <i>df</i> = 460</b>					
Analytic	1.07	.88	1.32	.69	.49
Belief in God	.52	.43	.60	-7.96	< .001
Upbringing	.37	.22	.64	-3.55	.0004
Conservatism	1.01	.89	1.14	.13	.90



*Figure 1.* Analytic thinking predicts greater endorsement of evolution. Panel A: Endorsement of evolution (vs. creationism) across CRT performance. Error bars represent 95% CI of the proportion. Panel B: Increasing CRT performance predicts a shift towards increasing endorsement of evolution.

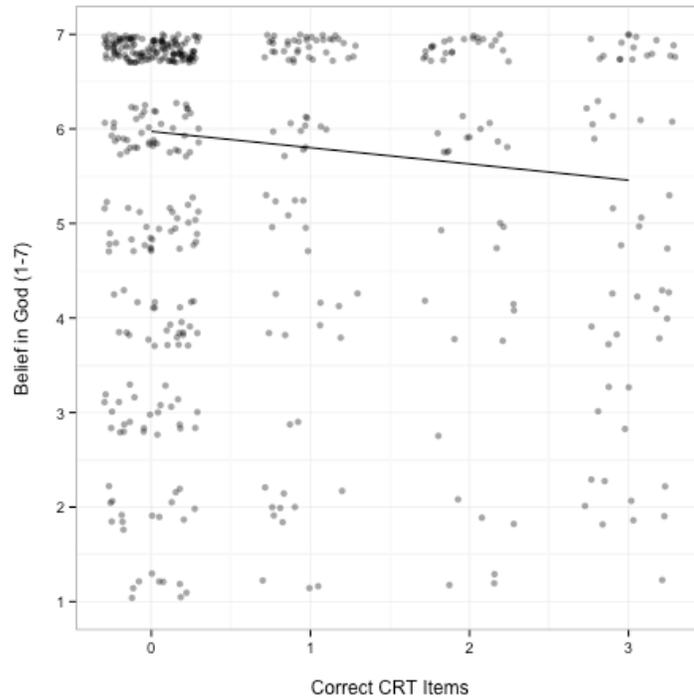
**Ordinal analyses.** Next, I combined the two evolution items into a single item reflecting three different views of evolution, ranging from stark creationism to stark evolutionism (creationism < guided evolution < naturalistic evolution). This enabled an ordinal logistic regression analysis. As with the binary analysis, I tested two separate models, one with analytic thinking predicting evolution beliefs in isolation, one also including covariates. On its own, analytic thinking predicted greater endorsement of evolution,  $b = .59$ , 95% CI [.09, .36],  $se = .09$ ,  $t = 6.45$ ,  $p = .0008$ , Figure 1B. When including covariates, analytic thinking again predicted greater endorsement of evolution,  $b = .21$ , 95% CI [.06, .37],  $se = .08$ ,  $t = 2.73$ ,  $p = .006^2$ . All covariates emerged as significant predictors (all  $ps < .03$ ). In support of the view that cultural exposure to religion reduces endorsement of evolution, participants reporting religious upbringings also reported lower endorsement of evolution,  $b = -.60$ , 95% CI [-1.03, -.17],  $se = .22$ ,  $t = -2.75$ ,  $p = .006$ .

**Additional analyses.** I conducted additional analyses to see if—consistent with previous research—analytic thinking predicted lower levels of religious belief in the present sample. Additionally, these analyses help to evaluate the potential effectiveness of using religious belief as a covariate in initial analyses, as it may have had insufficient variance to act as a meaningful control. However, a regression analyses found that analytic thinking predicted reduced religious belief,  $\beta = -.10$  [-.17, -.03],  $t(747) = 2.67$ ,  $p = .008$ , Figure 2. Identical inferences result from a bootstrapped regression model (10000 samples, percentile CI),  $\beta = -.10$  [-.18, -.02]. Although

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<sup>2</sup> In an exploratory analysis, I also repeated this analysis while also probing for a potential interaction between religious upbringing and analytic thinking on evolution endorsement. No such interaction was apparent,  $b = -.20$ ,  $p = .39$ .

both analytic thinking and religious belief had heavily skewed distributions, they were still meaningfully related.



*Figure 2.* Analytic thinking predicts reduced belief in God. Note: points in scatterplot are jittered to compensate for overplotting.

**Summary.** In Study 1, a large number of undergraduates with views on evolution approximating national trends completed measures of evolution endorsement, analytic thinking, religious belief, religious upbringing, and political affiliation. Regardless of whether evolution endorsement was treated as two distinct questions (one assessing evolution vs. creationism, the other teasing apart gradations of evolutionary belief), or as one single ordinal scale, analytic thinking predicted increased belief in evolution. Interestingly, analytic thinking did not predict attitudes regarding the natural versus supernatural forces guiding evolution. In addition to analytic thinking, both religious belief and political conservatism unsurprisingly predicted lower

endorsement of evolution. Finally, consistent with approaches that view cultural learning as an essential component of religious belief (e.g., Gervais, et al., 2011), religious upbringing and current belief in God generally predicted creationist beliefs. Broadly speaking, these findings support all major hypotheses.

## Study 2

Study 1 revealed a consistent pattern whereby individuals who are more prone and/or able to engage in analytic thinking to override their intuitions were more likely to endorse evolution, using a measure adapted from Pew polls. Further, both religious beliefs and upbringing predicted reduced acceptance of evolution. Study 2 replicated and extended Study 1 by 1) utilizing a different measure of evolution endorsement, and 2) utilizing a more refined measure of cultural exposure to religion.

## Method

As with Study 1, Study 2 relied upon the prescreening from the University of Kentucky psychology undergraduate subject pool. All data for Study 2 were drawn from the prescreening survey administered during the spring semester of the 2014-2015 academic year. I filtered the sample so that no participants in Study 2 previously participated in Study 1.

**Participants.** As with Study 1, I included all participants who completed the prescreening. A total of 567 undergraduates (416 female, 148 male, 2 other, 1 no response;  $M_{age} = 19.35$ ,  $SD_{age} = 3.08$ ) completed both the evolution question and all CRT items. Again, this was a fairly religious sample. Belief in God (rated from 0-100) was high ( $M = 79.10$ ,  $SD = 32.39$ ,  $Mdn = 100$ ). Attitudes towards evolution were similar to recent (Gallup, 2014) national estimates (creationism = 35% UK, 42% USA; guided evolution = 47% UK, 31% USA; naturalistic

evolution = 18% UK, 19% USA). Performance on the analytic thinking task (Frederick, 2005) was again fairly low,  $M = .78$ ,  $SD = 1.06$ ,  $Mdn = 0$  out of 3 correct.

**Measures.** Participants completed one item assessing beliefs about evolution, a brief analytic thinking task, and a variety of religious and demographic items.

**Evolution.** I used an evolution question regularly used by Gallup. Participants answered one question asking “Which of the following statements comes closest to your views on the origin and development of human beings?” with options “A. Human beings have developed over millions of years from less advanced forms of life, and God had no part in this process,” “B. Human beings have developed over millions of years from less advanced forms of life, but God guided this process,” and “C. God created human beings pretty much in their present form at one time within the last 10,000 years or so.” These options represent stances of naturalistic evolution, guided evolution, and creationism, respectively.

**Analytic thinking.** As in Study 1, I assessed analytic thinking with the CRT (Frederick, 2005).

**Religious and demographic questions.** Participants rated their degree of belief in God from 0-100. Next, they indicated their frequency of religious attendance, from “never” to “more than once per week.” For analyses, this item was coded ordinally (eight options were provided). To assess religious upbringing, I administered a validated seven-item scale ( $\alpha = .94$ ) of religious credibility enhancing displays (Lanman & Buhrmester, under review; sample item: “To what extent did your caregiver(s) make personal sacrifices to religion.” All items rated from “1- To no extent at all” to “7- To an extreme extent”).

## Results

I again utilized two slightly different analytic strategies, intended to map onto two distinct ways that large-scale polling companies (Pew and Gallup) query beliefs about evolution. First, I performed ordinal logistic regression on the three-choice evolution item. Next, I performed two separate binary logistic analyses meant to mimic the Pew-style evolution questions used in Study 1.

**Ordinal analyses.** On its own, analytic thinking predicted greater endorsement of evolution,  $b = .32$ , 95% CI [.17, .47],  $se = .08$ ,  $t = 4.18$ ,  $p = .00003$ , Figure 2A. When including belief in God, church attendance, and religious CREDEs as covariates, analytic thinking again predicted greater endorsement of evolution,  $b = .28$ , 95% CI [.10, .47],  $se = .09$ ,  $t = 2.99$ ,  $p = .003^3$ . All covariates emerged as at least marginal predictors (all  $ps < .052$ ). Consistent with secondary predictions, religious CREDEs predicted decreased endorsement of evolution,  $b = -.18$ , 95% CI [-.33, -.03],  $se = .08$ ,  $t = 2.32$ ,  $p = .02$ .

**Binary analyses.** First, I recoded the evolution item in a binary fashion (naturalistic or guided evolution = 1, creationism = 0). Each additional correct CRT response increased the odds of endorsing evolution of any sort by a factor (*OR*) of 1.33, 95% CI [1.12, 1.60],  $z = 3.21$ ,  $p = .001$ , Figure 2B. Next, I included belief in God, religious attendance, and religious CREDEs as additional covariates. Analytic thinking again emerged as a significant predictor (see Table 2). In sum, analytic thinking predicted greater endorsement of evolution. This effect was independent of current religious beliefs, religious attendance, and religious CREDEs.

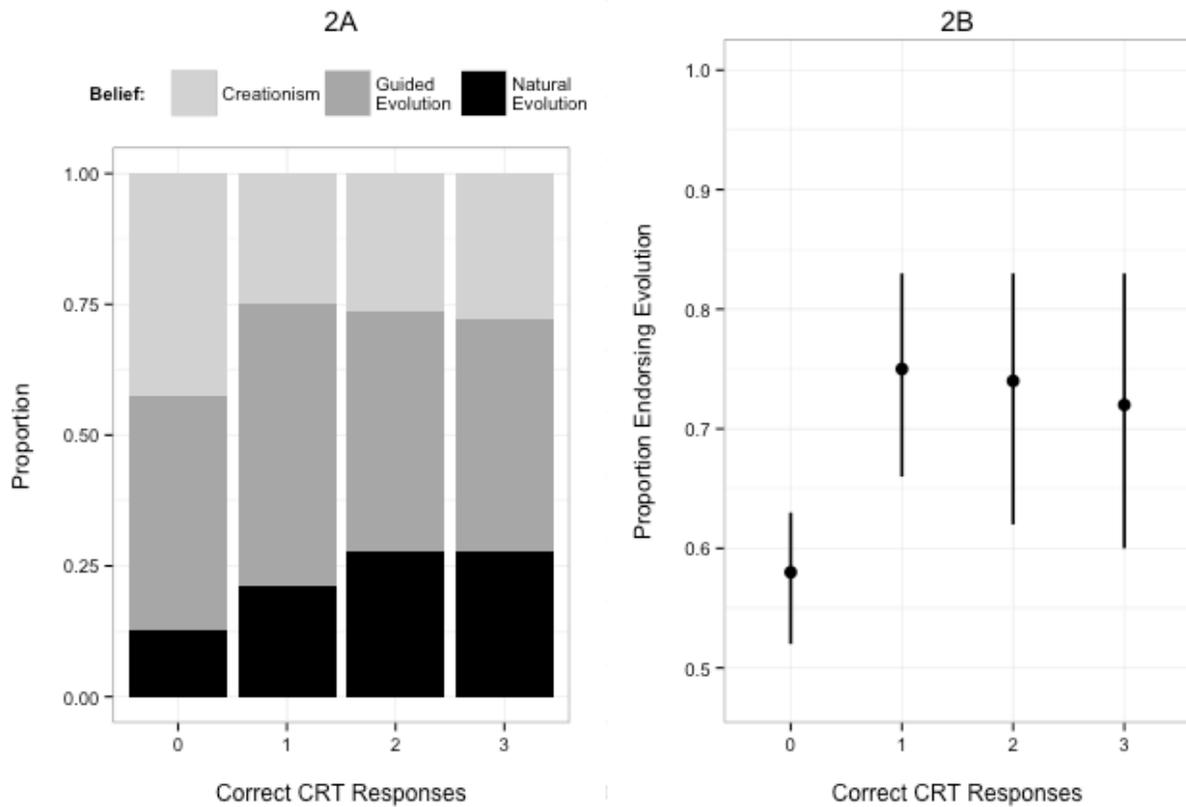
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<sup>3</sup> As in Study 1, I tested for an interaction between analytic thinking and religious CREDEs. No such interaction was apparent,  $b = -.08$ ,  $p = .23$ .

**Table 2.** Summary of binary logistic regression models for Study 2

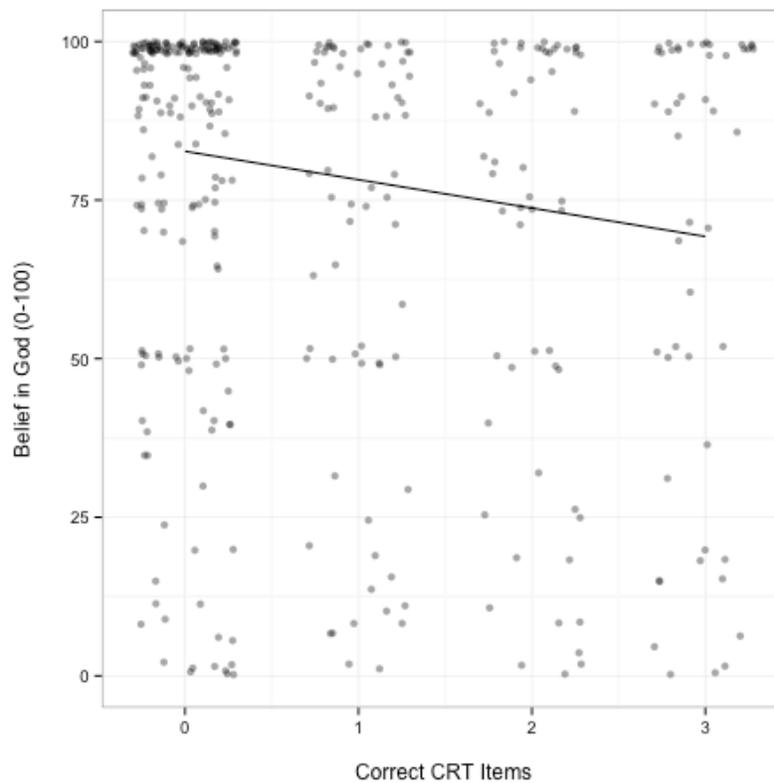
	<i>OR</i>	<i>LCI</i>	<i>UCI</i>	<i>z</i>	<i>p</i>
<b>Item 1, <i>df</i> = 517</b>					
Analytic	1.29	1.05	1.59	2.60	.009
Belief in God	.94	.92	.96	-6.36	< .001
CREDEs	.83	.70	.97	-.73	.47
Attendance	.91	.80	1.04	-2.45	.01
<b>Item 2, <i>df</i> = 329</b>					
Analytic	1.46	1.00	2.15	1.93	.053
Belief in God	.94	.92	.95	-7.60	< .001
CREDEs	.92	.67	1.29	-.48	.63
Attendance	.73	.54	.98	-2.08	.04

Next, I performed parallel analyses on the second evolution item (guided evolution coded 0, naturalistic evolution coded 1). In contrast to Study 1, analytic thinking significantly predicted endorsement of naturalistic evolution on its own,  $OR = 1.33$ , 95% CI [1.08, 1.64],  $z = 2.73$ ,  $p = .006$ , though only marginally when including covariates (Table 2).



*Figure 2.* Analytic thinking predicts greater endorsement of evolution. Panel A: Increasing CRT performance predicts a shift towards increasing endorsement of evolution. Panel B: Endorsement of evolution (vs. creationism) across CRT performance. Error bars represent 95% CI of the proportion.

**Additional analyses.** As in Study 1, I evaluated the relationship between analytic thinking and belief in God. A regression analyses found that, consistent with previous research, analytic thinking predicted reduced religious belief,  $\beta = -.15 [-.23, -.06]$ ,  $t(535) = 3.42$ ,  $p = .0007$ , Figure 4. A bootstrapped regression model (10000 samples, percentile CI) yielded identical inferences,  $\beta = -.15 [-.24, -.06]$ .



*Figure 4.* Analytic thinking predicts reduced belief in God. Note: points in scatterplot are jittered to compensate for overplotting.

**Summary.** Using a slightly different measure of evolution endorsement, Study 2 closely replicated the effects of Study 1. Again, analytic thinking predicted greater endorsement of evolution. This effect emerged in ordinal and binary analyses, although (as in Study 1) evidence was mixed regarding whether or not analytic thinking predicts different flavors of evolution endorsement (guided vs. naturalistic). In addition, a more nuanced measure of cultural learning of religion (religious CREDS) predicted reduced levels of evolution endorsement in the ordinal analyses, consistent with religious upbringing in Study 1.

### General Discussion

Though evolutionary theory underpins the biological sciences, it remains a popularly controversial topic. In the face of overwhelming scientific consensus, billions of people eschew

evolutionary theory in favor of supernatural creationist approaches to the origins of species. One factor (presumably among many) that may cognitively predispose people to adopt creationist beliefs is a reliance on a suite of reliably developing intuitions, including intuitions regarding essentialism, teleology, order, and agency. At the same time, dual-process approaches to reasoning suggest that people can often analytically inhibit or override their intuitions. Thus, I tested the primary hypothesis that performance on an analytic thinking task would predict greater endorsement of evolution. Further, this hypothesis was situated within a more nuanced multifactor framework that also suggests that cultural learning is instrumental to the development of supernatural beliefs. Thus, I also tested the secondary prediction that exposure to religion would predict reduced endorsement of evolution.

To test both primary and secondary hypotheses, I drew two large university samples that roughly approximated USA levels of evolution endorsement. Combined, evidence from both samples supported the primary hypothesis that analytic thinking predicts greater endorsement of evolution. This conclusion was supported using two distinct evolution endorsement questions, two distinct analytic strategies, and including a diverse range of additional covariates. At the same time, the data generally supported the secondary hypothesis that cultural exposure to religion (via current religiosity, religious upbringing, or childhood exposure to credibility enhancing displays of caregivers' religious faith) predicted lower rates of evolution endorsement in both samples. That said, this latter finding was less robust to different analytic strategies and inclusion of covariates. In sum, it appears that analytic thinking consistently predicts endorsement of evolution, but cultural exposure to religion tends—if anything—to predict reduced evolution endorsement.

### **Caveats & Clarifications**

The present studies relied on self-reported endorsement of evolution and creationism. Though a sensible first approach, it is possible that such self-reports in this domain only imperfectly represent underlying cognition (e.g., Shtulman & Valcarcel, 2012). People may explicitly endorse evolution, while holding numerous misconceptions about how it actually works (Evans, et al., 2010; Shtulman, 2006). Similarly, people may explicitly endorse creationism without being strongly convinced that it is true or viewing it as a belief of real-world import (Hill, 2014). Future research should continue to explore the degrees to which reported endorsement of various scientific concepts actually reflects conceptual and behavioral changes.

In addition, the present studies relied on relatively homogenous samples of USA undergraduates. Although overall rates of evolution endorsement roughly tracked national estimates, the present participants likely diverged sharply from national averages in several other domains. As the USA is somewhat of a worldwide outlier in attitudes towards evolution (e.g., Miller, et al., 2006), one should not hastily assume that the data gathered at a university in the Southern USA generalize easily across the globe (e.g., Henrich, Heine, & Norenzayan, 2010). That said, preliminary evidence suggests that at least some analytic thinking-supernatural disbelief relationships are not purely American phenomena (Gervais, et al., in prep). Finally, rather than merely asking whether the present effects would replicate elsewhere<sup>4</sup>, it may be more productive to hypothesize about the degree to which the predictive effect of analytic thinking on evolution endorsement might be meaningfully moderated by specific cultural contexts. Presumably, there would be relatively less need for people to analytically override creationist intuitions in cultural contexts that are comparatively devoid of cultural support for creationism.

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<sup>4</sup> Perhaps most obviously, the present effects will likely be tough to replicate in any sample that does not include many creationists (such as, for example, many university subject pools or MTurk).

Given that the present results come from Kentucky (home to both Answers in Genesis and the Creation Museum), it is plausible that the relationship between analytic thinking and evolution endorsement may be considerably weaker elsewhere, even in other regions within the USA.

The present results speak to a relationship between analytic thinking and endorsement of evolution. However, endorsement and understanding of evolution are distinct and dissociable phenomena (Shtulman, 2006). That is, many people believe in fundamentally inaccurate concepts of evolutionary change. Research on the relationship between endorsement and understanding of evolution reveals a mixed bag of results, with some studies finding no correlation between the two (Bishop & Anderson, 1990; Brem, Ranney, & Schindel, 2003; Demastes, Settlage, & Good, 1995; Lawson & Worsnop, 1992; Sinatra, Southerland, McConaughy, & Demastes, 2003), and others find moderate to strong correlations (Nadelson & Sinatra, 2009; Rutledge & Warden, 2000; Shtulman & Calabi, 2012). Regarding the present results, preliminary evidence suggests that analytic thinking might play an important moderating role, as analytic thinkers tend to show a more sophisticated understanding of many scientific concepts, including evolution (Shtulman & McCallum, 2014), and analytic thinkers may show greater increases in understanding of evolution after actually taking university classes on evolution (Shtulman, 2015).

### **Culture and the Convincingness of Creationist Intuitions?**

The potential cross-cultural (non)generalizability of the present effects highlights another potential concern and avenue for future research into the intuitive underpinnings of evolutionary and creationist beliefs worldwide. Extant evidence suggests that reliably developing intuitions may underlie creationist beliefs (Bloom & Weisberg, 2007), and that during development children come to favor creationist views regardless of some types of cultural inputs (Evans,

2001). This may suggest that intuitions exert a universal and strong influence on the development of attitudes towards evolution and creationism. While this view is widely discussed and cited, at least three lines of argument suggest that much more work is needed before strong conclusions can be reached regarding the degree to which intuitions actually strongly predispose people to become creationists.

First, a close examination of the most widely cited evidence for intuitive creationism reveals a potentially larger role for cultural learning than for underlying intuitions. A classic study (Evans, 2001) found a developmental spike in creationist attributions that was somewhat generalizable across one microcultural contrast. The study tested attributions about the origins of species in children in the American Midwest. Children were lumped into groups who attended 1) public school, or 2) either homeschool or fundamentalist religious school. Notably, children in both groups preferred creationist explanations for the origins of species at ages 8-10. Although the methods and results of this study are perfectly transparent, the study is nonetheless often cited for a claim that it cannot support: that children come to adopt creationist beliefs regardless of 1) cultural influence, or 2) parental evolution endorsement. Further, the results are also consistent with the possibility that a temporary spike in creationism was driven by differential cultural influences on evolutionary and creationist concepts in the Midwest at different stages of religious enculturation and education, rather than an inexorable pull of intuitions. Plausibly, early enculturation in this sample provides more discussion of religion than sophisticated mechanisms of biology (see Gervais, et al., 2011 for further discussion). To be perfectly clear, I am not claiming that these classic results (Evans, 2001) are in any way flawed, or that intuitions don't give creationist ideologies a head start; indeed, as the Introduction makes clear, I think this is precisely the case. Rather, the precise role of intuition—*contra* cultural learning—in the

development of evolutionary thinking has not yet faced the type of strong empirical test that could support a conclusion that, for example, children come to adopt creationist beliefs even if their parents are not creationists<sup>5</sup>. Such a test would require sampling from two highly dissimilar religious contexts, rather than children from the same community. Of note, nearly one in four children (24%) from the “nonfundamentalist” group in Evans (2001) actually attended fundamentalist churches. Nonetheless, they largely endorsed evolution by the time they entered middle school.

Second, the present results, in conjunction with previous research, present some ambiguity regarding the overall strength of influence that intuitions have on endorsement of evolution. On the one hand, many explicitly disavowed intuitions are still evident among adults (e.g., Kelemen, et al., 2013; Shtulman & Valcarcel, 2012). On the other hand, the present results suggest that it does not take a great deal of analytic thinking to overcome creationist intuitions. None of the three CRT items are computationally or conceptually difficult. They all require only grade school mathematical abilities. Yet, people who were able to answer at least one item correctly were 20% more likely to endorse evolution than were the (60% of) participants who failed to answer any correct. Thus, simultaneously some creationism-supporting intuitions can survive even rigorous scientific training (Kelemen, et al., 2013) while even a modicum of analytic processing is associated with a sizeable increase in endorsement of evolution (present results). Combined, these competing insights suggest that there is still much need for research into the strength with which intuitions influence adult endorsement of evolution and creationism.

Finally, there is also exciting research suggesting that it is possible to use children’s intuitions to leverage early understanding of core evolutionary concepts. Different intuitive

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<sup>5</sup> I will leave it up to the intrepid reader to find such quotes in prominent and well-cited articles.

processes follow complex developmental trajectories, yielding a complex interplay between intuition and endorsement of evolution (Legare, et al., 2013). While some intuitions may bias children towards creationism, others may be harnessed to foster early understanding of evolution. The key contrast in early science education may thus not be intuitions versus analytic thinking, but rather a contrast between which intuitions must be successfully tapped to foster early evolutionary understanding. Consistent with this approach, Kelemen and colleagues (2014) recently produced a novel storybook intervention that reliably promotes a fairly sophisticated understanding of core evolutionary concepts in children as young as five. Further, these insights generalized and were retained up to three months later. This suggests that one avenue to promoting endorsement of evolution stems from recognizing and utilizing developmentally appropriate intuitive processes in early science education, a challenge that has been largely not met in extant curricula. As a result, children may initially approach evolution in the classroom (typically when they are 11+ years old in the USA) with internalized naïve theories of biology that are resistant to evolutionary theory (Kelemen, et al., 2014).

In sum, much more research is necessary to properly evaluate the strength of any bias against endorsement of evolution throughout development. Many of the hard cross-cultural tests of this hypothesis have not yet even been attempted, rendering it difficult to differentiate between early developing intuitive influences and early cultural advantages for some types of education over others. Finally, in addition to analytic approaches, it is also possible to promote endorsement of evolution by engaging developmentally appropriate intuitions. Even brief and stylized presentations may be sufficient to place evolution on a more even developmental playing field with creationism.

### **Coda**

Support for evolution is scientifically overwhelming, but popularly debated. The present research considered the basic cognitive processes that may influence stances towards evolution. Two studies revealed that—consistent with dual process approaches to cognition in general, and supernatural cognition in particular—an analytic cognitive style predicts increased endorsement of evolution. Reliably developing intuitions may give creationist views an early cognitive advantage. This early advantage also is likely bolstered by early enculturation advantages for creationist, rather than evolutionary, concepts in many cultural contexts. However, individuals who are better able to analytically control their thoughts are more likely to eventually endorse evolution's role in the diversity of life and the origin of our species.

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