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ABSTRACT

The God-As-Latent-Causes Model (GALCM) offers a Bayesian framework for understanding religious beliefs, positing that supernatural agents function as inferred latent causes when individuals encounter unexplained events or "residuals" – discrepancies between predictions and outcomes. This commentary evaluates GALCM's contributions and limitations, focusing on two key concerns: (1) its testability, given the model's flexibility in accommodating contradictory evidence, and (2) the conceptual role of residuals as either the driver of religious belief or the phenomenon requiring explanation. While GALCM provides valuable insights into probabilistic belief adaptation, it risks unfalsifiability unless constraints on when supernatural attributions do occur are specified. Additionally, the model would benefit from integrating cultural-evolutionary perspectives, emphasizing how religious priors shape long-term (religious) explanatory frameworks. Strengthening GALCM's empirical engagement and predictive precision could enhance its utility in cognitive and anthropological studies of religion, bridging Bayesian inference with broader cultural and historical processes.

Introduction

In "The Gods as Latent Causes: A Statistical Inference Theory of Religion," Rigoli and Lennon (2024) propose a compelling framework – hereafter referred to as the *God-As-Latent-Causes Model* (GALCM) – to explain religious beliefs from a Bayesian, statistical-inference perspective. GALCM posits that human minds naturally postulate "gods" or supernatural agents as unobservable, latent causes to explain deviations from everyday expectations or from the predictions of natural factors. These supernatural agents enter into probabilistic mental models to account for otherwise puzzling events, a process that is mirrored in how people use Bayesian inference in nonreligious contexts. In this view, religion emerges partly because individuals or communities, facing unexplained phenomena ("residuals" between prediction and outcome), seek explanations beyond strictly mechanistic or probabilistic accounts.

In many ways, GALCM represents an important step forward by building on and extending existing predictive-processing accounts of religion (Andersen, 2019; Schjoedt et al., 2013; Taves & Asprem, 2017; van Elk & Aleman, 2017). The model describes how believers might adjust probabilistic estimations or mental models to accommodate miracles, omens, oracles in terms of the perceived intervention of gods in daily life. By construing religious beliefs as probabilistic rather than all-or-nothing commitments, GALCM also helps to illuminate why religious believers can flexibly adapt to inconsistent evidence, such as why a failed prophecy may lead believers to reinterpret rather than abandon their supernatural assumptions. Specifically the notion of religious beliefs as probabilistic appears to fit well with empirical research for instance by Legare and Visala (2011) suggesting that

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many believers espouse *co-existence thinking*, where supernatural and natural explanations typically co-exist and depending on the context one explanation tends to prevail over the other.

Despite these valuable contributions, two overarching concerns arise when evaluating GALCM: (1) its testability, given the apparent flexibility in accommodating evidence, and (2) the role of "residuals" as either the explanation *for* religion or the phenomenon *to be explained*. These concerns point to deeper conceptual questions about the falsifiability of GALCM, its relationship to other Bayesian frameworks of religion, and its engagement with empirical literature on cultural-evolutionary and psychological factors in religious belief. This commentary discusses both the strengths and weaknesses of GALCM, offers suggestions for tightening its predictions and for integrating more thoroughly with relevant empirical research. Ultimately, while GALCM makes a novel and important contribution, further work is needed to render the model more tractable, testable, and congruent with the substantial body of research on the evolution, maintenance, and cognitive underpinnings of religion.

Testability and flexibility in hypotheses and predictions

One of the central appeals of GALCM is that it offers a broad, Bayesian account that can theoretically explain myriad religious phenomena. In practice, however, this wide reach also raises concerns about overflexibility. If a model can accommodate any possible outcome or contradiction – such as an unfulfilled prophecy or a contradictory omen – it risks being empirically unfalsifiable. A theory that can assimilate every piece of evidence, even failures of its own predictions, provides limited explanatory power and may not pass a robust test of scientific validity and even runs into the risk of being a "just-so-story" (Gould, 1977).

As an example, Rigoli and Lennon (2024) illustrate how, within GALCM, an event initially seen as an omen may later be discounted as a misinterpretation if the predicted outcome does not occur. Equally, a failed prophecy may be rolled over to the following year ("we misunderstood the timing"), or it could be explained away by introducing new latent variables ("a different deity intervened"). As a consequence, the line between a valid theoretical update and an ad hoc post hoc explanation becomes blurred.

Because GALCM allows for so many different potential ways to "reassign" residuals (changing timeframes, shifting from one deity to another), there is a risk of the model becoming circular. Testability demands operationalized predictions: under what precise circumstances would a mismatch (i.e., a residual) *not* be attributed to a supernatural agent? Or how many contradictory outcomes are required before a believer's posterior probability that "the harvest was a miracle" plummets? Without well-defined thresholds or constraints, GALCM struggles to delineate *which* sorts of residuals trigger religious beliefs versus other forms of compensatory explanations (like conspiracies, illusions, or acceptance of random chance).

GALCM briefly cites evidence that people turn to supernatural or religious explanations when control is low (Kay et al., 2010). Such "compensatory control" effects are indeed relevant to a bayesian framework: perceived unpredictability could cause "residual anxiety," fueling supernatural beliefs. Yet studies supporting compensatory control have come under scrutiny, with replication attempts often yielding mixed or null results (Hoogeveen et al., 2018; Van Elk & Lodder, 2018). The concept of "control" is also not isomorphic with "predictability." People may lack control yet still feel that the natural world is highly predictable; conversely, one might have control over a system that remains inherently unpredictable. Conflating the two can create overly broad, underspecified claims.

The same issue arises for other cited data. If GALCM makes novel predictions – say, that unpredictability in one domain leads to stronger supernatural attributions in that domain – strong empirical engagement with relevant cross-cultural evidence and debates in cultural evolution is necessary. Otherwise, a model may simply retrofit itself to existing data without advancing testable *a priori* claims. For instance, if GALCM hypothesizes that the scope and power of "big gods" depend on statistical regularities in larger societies (Rigoli & Lennon, 2024), then it must engage the literature on how moralizing high gods arose or did not arise in different historical contexts

(Baumard & Boyer, 2013; Norenzayan et al., 2016). A useful resource in this respect would be for instance the Seshat Global Historical Databank, which records environmental unpredictability and the presence and intensity of belief in "punitive" vs. "beneficient" deities. Cultural-phylogenetic models could be used to test whether societies with high ecological variability systematically exhibit higher inferred deity ~ intervention priors or more complex deity-domain taxonomies. A straightforward prediction following from GALCM would be that there is a positive relation between environmental unpredictability and supernatural priors. This approach could be complemented by using agent-based modeling, whereby each agent holds a Bayesian network and updates its priors based on observed event frequencies and encountered testimonies. By varying the network parameters, such as memory decay or social learning bias, it can be studied which settings produce stable religious priors that can also be observed using ethnographic and historical data.

Residuals as explanans versus explanandum

The second major conceptual concern is how GALCM frames "residuals" in relation to religious belief. Throughout the paper, Rigoli and Lennon (2024) present the model as if residuals – defined as the difference between observed outcomes and predictions—*drive* religion: improbable events or mysteries provoke a supernatural explanation. In philosophical terms, residuals become the *explanandum* (they require an explanation), and religion is the *explanans* (the explanation). Yet, many Bayesian or predictive-processing accounts of religiosity have proposed the opposite: they positioned residuals ("prediction errors") as *mechanisms* for why religion endures and *minimizes* further surprise (e.g., Andersen, 2019; Schjoedt et al., 2013; Taves & Asprem, 2017; van Elk & Aleman, 2017). In those accounts, religion is precisely a way to *avoid* the conscious perception of chronic unpredictability. That is, once supernatural beliefs are internalized as powerful priors, they help reduce continuous "surprise" by framing events consistently within an overarching divine plan. These accounts emphasized how a religious mind might adopt robust priors that interpret even ordinary events as meaningful "signs" and systematically discount disconfirmation. Such a system minimizes conscious surprise (or explicit "residuals") even when plenty of anomalies occur.

By framing religion as *triggered* by residuals, GALCM potentially inverts the sequence, and by doing so it overlooks the dynamic ways that religious worldviews modulate error signals and recontextualize them over time. A single improbable harvest might reinforce one's sense of a deity controlling nature, but repeated improbable events might lead to alternative responses – doubt, theological reinterpretations or a stronger acceptance of naturalistic explanations for events (Tylor, 1871). Many religious beliefs develop and endure across repeated exposures to seemingly "contradictory" evidence and individuals do not update on single-shot events alone. Religious traditions evolve over centuries, with rituals, doctrines, and communal practices that shape interpretive lenses (Geertz, 2013). A Bayesian network that models one harvest or one omen in isolation does not yet capture how repeated anomalies might be explained away or integrated over time, especially if believers rely on collective narratives rather than purely individual inferences. Contemporary cognitive approaches to religion increasingly stress social and cultural scaffolding (see for instance: Lanman, 2016). When contradictory information arises, communities can shift doctrines, designate heretical "variants," or generate new forms of active inference (e.g., ritual modifications) that reaffirm the group's theological model (Andersen, 2019). GALCM's single-event illustrations – though compelling – may underestimate these iterative and communal processes.

Hence, if *minimizing residuals* truly propels belief formation, a more rigorous articulation of how believers remain in states of minimal explicit contradiction is required. Without this, GALCM's portrayal as "residuals cause religion" inadvertently recreates the classic "god of the gaps" challenge. Over time, explanatory gaps shrink with increased scientific knowledge. And in the Bayesian mind, over time successful model updating effectively minimizes residuals and renders them superfluous. Reconciling these observations might involve a more dynamic and reciprocal model in which deeply

held religious priors systematically re-encode or diminish the salience of residuals, such that supernatural attributions flourish, ironically, by continuously deflecting contradictory data.

Engaging empirical and evolutionary perspectives

For GALCM to become a robust framework, it should engage more thoroughly with empirical evidence on the cultural and evolutionary pressures that foster or inhibit certain types of religious beliefs. Anthropological research into the origins of moralizing high gods suggests that belief in punitive, omniscient deities correlates with shifts to larger, more complex societies, potentially to facilitate cooperation (Norenzayan et al., 2016). Alternative theories propose that affluence fosters more abstract, moralistic deities who punish free-riders (Baumard & Boyer, 2013). At a cognitive level, biases in agency detection, mentalizing, and teleological reasoning (Barrett, 2000; Bloom, 2007) have all been implicated in religious belief formation. GALCM alludes to these findings but does not fully incorporate them. For example, GALCM predicts that more frequent ritual forecasts produce more residuals, which in turn should drive communities to posit additional latent causes. Societies that consult divination oracles more should thus end up with richer pantheons – a prediction that could be directly tested using for instance the Ethnographic Atlas (Murdock, 1967), where one could e.g., assess the relation between annual frequencies of high stake Vedic Yajña fire sacrifices – where priests monitor hundreds of micro-events as potential omens – and relate these to pantheon richness across ~ 80 societies.

Furthermore, strong religious traditions often rest upon communal identity, ritual practice, emotional reinforcement, and doctrinal authority. Individuals do not merely compute Bayesian probabilities in a vacuum – they are embedded in a culture that can define which events *count* as residuals and even actively encourage seeking out such events (see for instance: Van Leeuwen & Van Elk, 2019). To investigate the role of these social, emotional and cultural dynamics, one could survey for instance 20–30 communities varying in clerical hierarchy – assessing the level of doctrinal authority and measuring to what extent participants are inclined to attribute everyday ambiguous events in a vignette (e.g., a vivid dream; a flickering light, an unexplainable chill) to supernatural causes – to assess if stronger doctrinal norms expand the set of events labeled as divine. Likewise, a field experiment could randomly assign parishioners to a high-arousal healing ritual versus a low-arousal study session and then measure their attribution of ambiguous "near-miss" events (e.g., a candle flickering wildly but not going out; a car slipping briefly but regaining control). A greater tendency to see divine causation after the ritual would demonstrate how emotional arousal increases the perception of "residuals," in turn feeding GALCM's inference engine. In both examples, the ambiguity of the event could also be manipulated in a continuous fashion, to assess if there is a linear relation between ambiguity and supernatural attributions.

Conclusion and future directions

GALCM advances the discussion of how Bayesian principles might account for religious beliefs. By focusing on "residuals" as triggers for supernatural attributions and by modeling gods as latent variables in an agent's generative model, it bridges low-level statistical processes and high-level cultural phenomena. The model's advantage is its conceptual clarity about *why* people posit hidden causes – when mechanistic or probabilistic explanations fail to offer clarity, positing a deity can fill the explanatory gap. Moreover, the emphasis on probabilistic, rather than all-or-nothing, beliefs brings fresh insight to longstanding questions about how individuals can simultaneously hold naturalistic and religious interpretations.

Nevertheless, two critical issues demand further refinement if GALCM is to move from a suggestive framework to a fully testable theory. First, the model's flexibility risks undercutting its falsifiability. Researchers and theorists must articulate more stringent criteria for when and how supernatural attributions are *not* made in the face of ambiguous or anomalous events. Clarifying

thresholds for model revision, enumerating the range of plausible ad hoc explanations, and establishing domain-specific predictions would help to assess GALCM's explanatory rigor. Second, the question of how residuals function – whether as the *explanans* or the *explanandum* —requires a detailed treatment of dynamic and temporal processes. Previous predictive-processing models emphasize that religion often *pre-empts* perceived anomalies by providing robust priors, rather than being perpetually "caused" anew by rare events. GALCM's current account would benefit from modeling how residuals can be cognitively or culturally minimized, leading believers to resist disconfirmation.

In sum, GALCM represents an important theoretical advance, highlighting the creative ways Bayesian cognition might underlie religious attributions. It resonates with many prior predictive-processing perspectives on religiosity yet also invites deeper engagement with empirical literatures on replication, cross-cultural variation, and the cognitive-minimization of "residuals." A more explicit statement of testable hypotheses – complete with falsifiable predictions – would clarify GALCM's explanatory scope, offering scholars a novel lens through which to study how improbable events, coupled with intuitive theism, can shape humanity's enduring and richly varied religious traditions.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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