

Article

Examination of Retention and Recall of Polytheistic Versus Monotheistic Religious Concepts

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Abstract

Polytheistic and monotheistic ideas may lead to different processing in the brain, an understudied area generally and firmly within the 4E paradigm, especially in relation to embodiment. This paper uses a recognition memory paradigm to compare electroencephalography (EEG) signals and both reaction time and accuracy during the retrieval of polytheistic and monotheistic god concepts. We use EEG to analyze alpha oscillations whose de-synchronization reveals the neurological difficulty of ideas due to novelty or conceptual complexity. Word pairs of polytheistic or monotheistic ideas were presented to subjects, whose brains were analyzed during identification (polytheistic vs. monotheistic) and recall, alongside their reaction time and recall accuracy. No major support was found for different alpha oscillation levels during processing of polytheistic versus monotheistic ideas between monotheistic and religiously unaffiliated subjects. Meanwhile, a significant difference was found in reaction time during recall across both monotheistic and religiously unaffiliated subjects, as polytheistic ideas were recalled more quickly in both groups. These findings bear on dominant theories in the cognitive science of religion that privilege powerful and automatic agency detection in humans' evolved past, alongside the cultural record where the dominant form of religious belief historically was polytheistic. It also contributes to 4E approaches to religion, shedding light on how religious ideas and concepts—here in the form of word pairs—both draw from how the brain understands embodiment and themselves are processed in embodied, neurologically specific ways.

Keywords: cognitive science of religion; EEG; monotheism vs. polytheism; retention and recall



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1. Introduction

A key goal of the cognitive science of religion (CSR) is to explain cultural practices and beliefs using evolutionary, psychological, and behavioral methods. One of the defining components of religion in cultures worldwide and across history is the belief in supernatural agents (SAs) (Knight et al. 2004). SA belief is closely tied to Theory of Mind (ToM), as agency attribution likely evolved at least in part due to the advantages conferred by the ability to anticipate the actions of both people and animals for an increased chance of survival (Barrett 2000; Atran 2005). As humans are prone to the belief that supernatural agents play a role in our everyday lives (Shaver et al. 2016), this tendency to grant intentionality to both people

and non-agential objects likely evolved because the consequences of not detecting an agent would be far greater than a false alarm (Barrett 2000). This over-attribution of agency has been labeled “hyper-active agency detection device” (HADD) (Shaver et al. 2016; Barrett 2000; Barrett and Nyhof 2001). While the “hyper-active” component of HADD has been questioned and even retracted by some CSR scholars, the fast, automatic, and powerful instinctual attribution of agency to help explain phenomena remains a key component of CSR theories and studies from some of the earliest work on religious anthropomorphization onward (White 2021; Hoogeveen and van Elk 2021; Andersen 2019; Willard 2019; van Elk et al. 2016; Guthrie 1993). Shaver et al. (2016), for instance, specifically argued that the development of religion was a by-product of the cognitive framework set in place by HADD. The field of CSR has thus argued compellingly that the origins of beliefs in supernatural agents across cultures find at least partial explanation in our evolved, innate cognitive systems. More recently, the 4E paradigm has moved out of pure belief-based or mind-based models into a more nuanced consideration of how our embodied brain engages, processes, and manifests belief in supernatural agents. Consideration and study of the nature of supernatural agency detection and attribution—both generally and in this paper—should therefore take account of how this detection and attribution may reflect elements that are embodied, embedded, enacted, and extended.

In the human cultural record, meanwhile, historically most religions were polytheistic, with the emergence of monotheism (e.g., the so-called Abrahamic religions of Judaism, Christianity, and Islam as well as Zoroastrianism) occurring only relatively late in our species’ development. Indeed, the so-called ‘Big Gods debate’, whether advanced urban civilization gives rise to more singular moral high gods or vice versa, fundamentally turns on when and under which conditions the general polytheism of ancient human culture began to shift toward more monotheistic gods (Turchin et al. 2023; Whitehouse et al. 2022; Beheim et al. 2021; Norenzayan 2013). We remain agnostic on this particular debate around the direction of causality; its salience for this paper is simply that there was a notable shift in human history, and a relatively recent one in the history of the species, from a greater predominance of polytheistic-type beliefs toward monotheistic-type beliefs.

These two points—religious beliefs built upon evolved cognitive systems of frequent and automatic agency detection that may reflect 4E elements, and the historical dominance of polytheism—together seem to suggest that belief in multiple gods (SAs) is more intuitive than a singular high god. That is to say, ideas that draw more readily from existing cognitive systems will be easier to process and remember, which can be tested both neurologically (processing via EEG, for instance) and behaviorally (memory via speed and accuracy). If humans detect agents intuitively, automatically, and powerfully, then it would seem easier for humans to believe in multiple SAs instead of one at the expense of all others. The historical-cultural record seems to confirm this, as the belief in multiple SAs is one of the most enduring and widespread human cultural forms. This all begs an important question: is polytheism more intuitive than monotheism? Both our proclivity toward agency detection and the dominance of polytheism in human cultural history would suggest that the answer is yes.

However, the world religions today with the most followers are monotheistic: Christianity at 2.2 billion and Islam at 1.6 billion (both monotheistic) followed by Hinduism at 1 billion and Buddhism at 500 million with another 400 million practicing so-called folk religions (polytheistic) (Pew Research Center 2012). If monotheistic religions are less intuitive, then they would be less easily recalled, less easily transmitted, and less likely to lead to enduring cultural forms (Boyer 2001; Dawkins 1976, 1986), which is the opposite of what we find in the demographic data today. To compete with the more intuitive polytheistic beliefs in many SAs, monotheistic religions would have needed a different evolutionary

strategy than mere memorability, which may have borne out over human history as the species became more urban and technologically developed. Perhaps the advocates of the ‘Big Gods’ hypothesis are correct, that singular moral high gods helped police increasingly large, complex, and anonymous settlements. Or perhaps monotheism developed more cultural supports to thereby thrive via a different form of transmission, for example through the association with complex, society-supporting doctrines. Harvey Whitehouse’s modes of religiosity might explain such a strategy, whereby the “imagistic” ritual paradigms are highly memorable but scale poorly (perhaps traditional folk polytheism) whereas the “doctrinal” ritual paradigms require more rote recall but scale more widely due to the nature of their frequent, repetitive, and replicable ritual systems (monotheistic Christianity and Islam being relatively clear examples) (Whitehouse 2004). This line of thinking may be fruitful for further study, assessing whether monotheistic religions tend to have greater ritual support than polytheistic religions.

A further, complicating factor concerning monotheistic versus polytheistic religions involves Asian religions founded or reconfigured during the Axial Age, namely Hinduism, Buddhism, Daoism, and Confucianism/Ruism. Important forms of these religions include a significant element of “mono-ultimacy,” where an ultimate reality—usually transpersonal, including the Dao, Tian (as the principle of cosmic order) in Ruism, sunyata or the Buddha-nature in Mahayana Buddhism, and Brahman or the one ultimate God or Goddess in Hinduism—is paired with multiple SAs, of whom it is the creator or source. While Hinduism is seemingly the most polytheistic religion, most Hindus, the large majority of whom are followers of bhakti or devotional Hinduism, will say that the various deities are all manifestations or creations of the one God/dess. While part of the standard model’s overlooking of embodiment in religion is the neglect of transpersonal ultimates, this will not be further addressed in this article. In terms of future experiments relating to our project’s concerns, it will be difficult to find participants who practice an “unadulterated” form of polytheism in the sense that it was seemingly practiced in historical times previous to the emergence and formalized of both the Abrahamic monotheisms and the Axial Age Asian religions.

Yet here we propose testing monotheism versus polytheism not through cultural data but rather through cognitive neuroscience. This paper asks whether there are cognitive differences in people thinking of different god-concepts—monotheistic versus polytheism—as expressed in their neurobiology and behavior. The present study deploys measures from both neurobiology (EEG) and behavior (recall time and accuracy) to assess potential cognitive differences around polytheistic versus monotheistic ideas. Both measures reflect cognitive processes that are inherently embodied, as they reflect the biological brain’s activity around a set of stimuli and conditions. We thus attempt to test the notion of “intuitiveness” via two measures: ease of processing (EEG) and memory (in both accuracy and recall). EEG especially demonstrates the importance of direct biological measures instead of the behavioral measures that generally dominate the field of CSR. EEG is fundamentally an embodied measure around specific biological outputs, namely brain waves.

In neurobiology, we focus on the role of alpha oscillations in an EEG testing paradigm, in order to assess whether monotheistic versus polytheistic ideas are processed differently in the brain. Rhythmic changes in electrical charge within the brain have been associated with different cognitive abilities. These brain oscillations are theorized to aid successful communication both within and between different brain regions in support of different cognitive abilities, including attention and memory (Fries 2005, 2015, 2023; Klimesch 2012; Hanslmayr et al. 2016; Bonnefond et al. 2017; Spitzer and Haegens 2017). There are several different types of brain oscillations, but alpha oscillations are rhythmic fluctuations that occur at a frequency between 8 and 12 Hz and have been strongly related to attention

and memory during recognition memory tasks. In particular, the successful encoding and subsequent retrieval of stimuli during recognition memory tasks show decreases in the amplitude of brain oscillation in the alpha frequency range in posterior regions of the brain (Klimesch et al. 1996, 1997; Hanslmayr et al. 2009, 2012, 2016; Mölle et al. 2002; Khader and Rösler 2011; Clarke et al. 2018; Parish et al. 2018).

Importantly, the amplitude of alpha oscillations can be manipulated by explicitly directing attention towards (Minarik et al. 2018) or away (Depue et al. 2013) from memory information as well as implicitly increasing attention (Forner-Phillips et al. 2022) to stimuli during recognition memory tasks, supporting the idea that alpha oscillations work to gate information (Klimesch et al. 1997; Jensen and Mazaheri 2010; Bonnefond et al. 2017; Fries 2023). As such, examination of changes in amplitude of the alpha oscillations, often termed “power”, provides information related to attention. Greater decreases in power correlate to greater attention processing, a fact which can be used to examine cognitive differences during the encoding of different types of god-concepts (SAs). In short, alpha oscillations can help indicate whether an idea is cognitively relatively difficult or easy, by comparing the level of alpha power.

Thus, we designed a study whose goal was to link the evolutionary theory of religion to neural mechanisms seen in response to a religion-centered recognition memory task. Our first experiment examined alpha oscillatory activity during the encoding and retrieval of monotheistic and polytheistic stimuli in participants of monotheistic faith and those that were religiously unaffiliated. Because the desynchronization of alpha oscillations has been shown to reflect attentional resource allocation in previous studies, greater alpha desynchronization measures the greater amount of resources the brain allocates toward a particular idea. If one type of idea (monotheism) is indeed more difficult to process than another type (polytheism), then this difference might be detected by greater levels of alpha desynchronization.

Differences in processing may also take the form of behavioral data. If monotheistic concepts are less intuitive to process they may also take longer to recognize when successfully recalling whether the concept has been previously viewed in the context of a recognition memory task. In addition to our EEG measures, therefore, we analyze behavioral measures such as reaction time and accuracy to explore whether these suggest any processing differences between polytheistic versus monotheistic ideas. Such mental-behavioral measures are more biologically direct than the more indirect measures often used in CSR studies, such as behavior that is secondary and subsequent to a direct stimulus condition (e.g., see the measure of charity in Xygalatas et al. 2013; cf. Claire White’s “fractionated” method which also tends to be more indirectly behavioral, White 2021).

This research and types of 4E measures can be applied to the cognitive science of religion such that oscillatory responses and reaction responses to different types of religious stimuli can be measured. Based upon previous work with alpha oscillatory activity, as well as the idea that religious concepts of today are derived from our adaptive cognitive framework, it is hypothesized that there will be greater alpha desynchronization shown for monotheistic stimuli over polytheistic stimuli across both the monotheistic and unaffiliated religious groups. In other words, if monotheistic ideas are more difficult to process than polytheistic ones, then people processing monotheistic ideas will show greater alpha desynchronization, whereas those processing polytheistic ideas will show greater alpha synchronization (i.e., less desynchronization). Based on previous work around memory and recall, and again considering how modern cultural concepts relate to our adaptive cognitive framework, it is also hypothesized that monotheistic ideas will take longer to accurately identify from memory than polytheistic ones.

Some previous work has explored the role of alpha oscillations and religious thought, but little in terms of behavior. One study showed increased alpha power when Muslims listened to the Quran (Vaghefi et al. 2015), indicating that these ideas were familiar and easy for these religious adherents due to prior beliefs and practices, and therefore did not result in increased desynchronization. Similarly, another study showed increased alpha power (decreased de-synchronization) for Muslims during prayer (*salat*) (Doufesh et al. 2014). Yet meditative states generally—including simply closing one’s eyes—increase alpha power, so the alpha increase detected in these studies may simply be a reflection of a more meditative, internal processing state than having to do with the Quran (monotheistic ideas) itself. Further, while the former study has a good control, they do not correct for multiple comparisons despite making many comparisons. As such, many of the conclusions around differences are likely a Type I statistical error; we would add that the alpha values reported are likely not sufficiently significant to be persuasive.

Both these studies and their potential shortcomings indicate that little work has been done to explore brain oscillations generally, much less the comparison between monotheistic and polytheistic ideas per se, and that this is a significant gap in the literature in both quantity and quality. What other work has been done has explored some key components of CSR such as religious practice, theory of mind, SA intent, and fear regulation pathways, sometimes with neural measures such as fMRI (Grafman et al. 2020; van Elk and Aleman 2017; Kapogiannis et al. 2014; Schjoedt et al. 2011), but the field of CSR needs substantially more work from neuroscience—both EEG and behavioral measures—to explore and test some of its core theories.

2. Methods

2.1. Participants

Forty-eight participants gave written informed consent to participate in the present study with the approval of the Institutional Review Board of the University of New Hampshire, which follows the guidelines set by the Declaration of Helsinki. All participants were recruited from the University of New Hampshire community. Participants were excluded for a history of neurological problems, head trauma (2 or more concussions or mild traumatic brain injury), attention deficit/hyperactivity disorder, electric shock therapy, cardiac issues, or psychiatric problems. Data from 19 participants had to be removed from the analysis, 5 of which were due to ineligibility during screening, 3 due to non-compliance with the task instructions (e.g., pressing the same response key throughout experiment or non-responding), and 11 due to technical issues during EEG data collection (e.g., battery failure in the EEG system, software crashes, unexpected power loss, and experimenter error). The remaining 29 participants completed a religion survey and the recognition memory task during EEG data collection. The age of the participants completing the study ranged from 18 to 28 years old ($m = 20.7$ $sem = 3.94$). Years of education for the participants ranged from 12 to 21 years ($m = 14.2$, $sem = 2.2$ years). Data on sex/gender was not recorded. Participants were compensated for their participation with either a \$10 Amazon gift card or extra credit points for an introductory psychology class at the University of New Hampshire. Polytheistic participants were unable to be found of sufficient number to include in the study, a reflection of our regional pool, despite two years of collection efforts.

The participants were split into two groups, religious affiliated ($n = 17$) or unaffiliated ($n = 12$), based on their answers to a questionnaire assessing their religious affiliations. Participants were asked what they considered their current affiliation to be. If the participant indicated a religious affiliation, it was always a religion with monotheistic beliefs with the vast majority indicating a Christian denomination ($n = 16$) with one participant indicating

Islam. If the participant indicated their affiliation was a religion based upon monotheistic beliefs, they were put in the religious affiliated group.

The participants also completed a questionnaire consisting of 8 questions assessing the participants historical and current engagement with religious practice. The questionnaire was developed from the “Religious Commitment Index” used by Pew Research (Pew Research Center 2021). Questions like, “How often did you attend a formal religious service growing up?” or, “How often did you pray growing up?” inquired about past behavior while “How frequently do you attend religious service now?” and “How frequently do you pray now?” queried present religious practice. The participants rated their involvement in religious activities based on a 7-point scale: never, less than annually, annually, monthly, weekly, daily, more than daily. If the participant indicated that they considered themselves unaffiliated with a religion but they indicated that they engaged in religious practices at least monthly to 3 of the four historical religious engagement questions, they were put into the religiously affiliated group. There were 3 participants that considered themselves to be unaffiliated with a religion that we included in the religious affiliated group due to their at least monthly contact with monotheistic concepts while growing up, leading to the 17 religious affiliated participants. The final 12 participants were included in the unaffiliated group.

2.2. Stimuli

The stimuli used in the recognition memory experiment comprised word pairs (Appendix A). There was a total of 204 word stimuli selected for use in the experiment which were tested in an independent sample of participants from the University of New Hampshire community ($n = 15$) who were compensated for their participation with either a \$10 Amazon gift card or extra credit points for an introductory psychology class at the University of New Hampshire.

Each word stimulus had two words presented with the first word being a descriptive word and the second word being “god”. Examples of monotheistic concept stimuli used in the study are “transcendent god”, “infinite god”, “timeless god”, and “boundless god”. Examples of polytheistic concept stimuli used include “clothing god”, “beauty god”, “tree god”, and “family god”. Word pairs were selected as monotheistic based on whether they reflected the notion of a single, exclusionary deity (e.g., “exclusive god”). Adjectives paired with “god” in the monotheistic set reflected more abstract and transcendent (i.e., non-physical) characteristics (e.g., “forever god”, “transcendent god”), implying a non-plurality of beings. By contrast, polytheistic word pairs were categorized as such based on whether they reflected the notion of multiple possible deities, reflected in the notion of being physical, having human-like characteristics, and/or being tied to specific, localized characteristics (e.g., “crop god”, “laughing god”, “mischievous god”). We chose not to include the plural “s” on the polytheistic adjectives in order to try and maintain a one-to-one comparison (i.e., we did not simply say “laughing gods” which would inherently imply polytheism).

In our polytheistic stimuli, we see many examples of adjective + god combinations that are more familiar to polytheistic traditions. The epithets of ancient Greek divinities, for instance, are abundant and operate along such lines. This is true for ‘Zeus Cloud-Gatherer’, but also for ‘Artemis Mistress [of Beasts]’, ‘Aphrodite the [beautiful] armed’, ‘Demeter the Mother’, and so on. Many of the minor deities in Hinduism, Shinto, etc., operate along similar lines. Such polytheistic epithets, which tend to be embodied (see more below), can be usefully contrasted with the more abstract language used for god in, for instance, certain Christian denominational formulations that historically co-occurred with ancient Greek religion: ‘perfect god’, ‘sole god’, ‘universal god’, and so forth. Indeed, in the religio-political contests of the Late Antique Mediterranean, such abstract and more universalizing

formulations were often invoked in express contrast to the polytheistic terms in Greek and Roman religion.

The categorization of word pairs as monotheistic or polytheistic is inherently challenging, as it involves a component of subjectivity, reflects both cultural and individual differences, and indeed each word pair may not fit cleanly into a given category. Nonetheless, we offer these pairs as the first step toward differentiating between the two categories in ways that can be tested and iterated in future research. Furthermore, after populating our word pair stimuli in a list, we conducted an independent sample where a different set of participants rated each of these as monotheistic or polytheistic, in order to only use those stimuli with statistical backing for their belonging to a particular category.

The participants in the independent sample were shown a total of 204 word stimuli and were asked to indicate whether they thought each word stimulus represented a monotheistic or polytheistic concept. Words identified as belonging to a specific god-concept by >60% of the sample were selected for use in the subsequent recognition memory study. The average agreement across participants for all 162 word stimuli used in the monotheistic and polytheistic conditions of the recognition memory study was $83.19 \pm 0.11\%$ (mean $\pm$ standard deviation). The participants were also asked to indicate how well they thought each stimulus represented the identified god-concept on a 5-point scale (1 being the word pair represented the god-concept very well, 2 well, 3 good, 4 not really, and 5 not at all). Participants rated the words included in the recognition memory study to agree with the identified god-concept across both the monotheistic and polytheistic stimuli with a 2.41 ± 0.65 (mean $\pm$ standard deviation) score suggesting the stimuli were well suited to each god-concept.

The choice of stimuli and well-suitedness of these word pairs to the categories of polytheistic versus monotheistic may themselves reflect a key aspect of 4E around embodiment. Polytheistic cultures tend to understand SAs as more embodied and embedded. This includes both the types of SAs we might understand as directly anthropomorphic (witches, ancestors, ghosts, etc.) and the naturalistic features frequently found in animistic cultures (SAs as rivers, mountains, forests, trees, animals, etc.). Features such as physical clothing, physiological actions like laughter, and human relationality such as ‘brotherhood’ or ‘sisterhood’ are all highly embodied and embedded (and sometimes enacted) and therefore would be more likely to be intuited and remembered. The accurate mapping of such features to polytheistic concepts reflects a shared intuition around this point.

Monotheistic features, meanwhile, are more abstract and conceptual: “transcendent”, “boundless”, “infinite”, and so forth. Such characteristics are inherently less 4E, being much less embodied, enacted, and embedded. A robust and influential literature has shown the extent to which a great deal of language is only explicable within the context of embodiment, for instance Mark Johnson and George Lakoff’s work on bodily metaphors (Lakoff and Johnson 1980) and Antonio Damasio’s claims that linguistic understanding is grounded in cognizing bodily images (Damasio 2010, 2021). In our study, meanwhile, participants similarly mapped these with a high degree of fidelity to monotheistic gods that were historically understood as anthropomorphic and bodily but which have become less so in the doctrinal manifestations over time. The Jewish, Christian, and Muslim God are all frequently understood in human-bodily terms in our earliest and folk sources even today, but their formal and doctrinal understandings of such beings (often articulated in texts and by highly trained text specialists) are explicitly non-bodily.

2.3. Recognition Memory Task

The experimental design consisted of a resting state EEG phase, a memory encoding phase and a memory retrieval phase. In the resting state phase, participants sat quietly

in the EEG chair for 6 min while EEG data was collected. The resting state EEG data was used as part of a different experiment and is not included in this manuscript. During the recognition memory encoding phase, words related to monotheistic ($n = 54$) and polytheistic ($n = 54$) concepts were presented to the middle of the screen using E-prime 3.0 (Psychology Software Tools). Details of this experiment presented below. All 108 words to be remembered were presented in one run during the encoding phase.

The same 108 word stimuli presented during the encoding phase were presented during the retrieval phase mixed with 54 previously unseen words ($n = 162$ total stimuli). The retrieval phase consisted of two runs where 81 stimuli were presented in each run (for a total of 162 stimuli). Each run consisted of 27 previously presented monotheistic concept word stimuli, 27 previously presented polytheistic word stimuli, and 27 new word stimuli not previously seen. The new word stimuli were an equal mix of monotheistic concept stimuli and polytheistic concept stimuli across both runs (27 new monotheistic concept stimuli and 27 polytheistic concept stimuli were split as equally as possible across the two retrieval runs). The retrieval phase was split into two runs to allow participants a brief rest in the middle of the retrieval phase. During the retrieval phase, participants were asked to indicate whether the stimulus presented was old (presented during encoding) or new (not seen during encoding) by hitting either the 1 (old) or 2 (new) key on a keyboard.

The retrieval trials used the same format as the encoding trials except that participants were instructed to respond on the keyboard during the stimulus presentation. Specifically, each trial during the retrieval phase started with a fixation cross presented in the middle of the screen for a varying amount of time between 500 ms and 1000 ms using 50 ms intervals for an average of 750 ms. Each word stimulus was then presented for 2000 ms in the center of the screen. Participants were instructed to respond old or new during the word stimulus presentation. An intertrial interval consisting of a blank screen was presented following the stimulus for a varying time between 1500 ms and 2500 ms in 50 ms intervals and averaging 2000 ms (Figure 1). The jittering of the length of time the fixation cross was present helped to ensure participants were paying attention to the fixation cross for when the stimulus appeared. If the participant correctly indicated a stimulus was old and the stimulus represented a monotheistic god-concept, that was termed a monotheistic hit. If the participant correctly indicated a stimulus was old and the stimulus represented a polytheistic god-concept, that was termed a polytheistic hit. If the participant correctly indicated the stimulus was a new stimulus, that was termed a correct rejection meaning correct rejections comprised correctly identifying new stimuli as new regardless of which religious concept was presented.

2.4. Behavioral Analysis

Hit accuracy was calculated as a proportion of items correctly identified as old stimuli during the retrieval phase for both monotheistic and polytheistic god-concepts while correct rejection was calculated as the proportion of correctly identified new items presented during the retrieval phase. Behavioral accuracy was compared using a 2×3 mixed ANOVA with the factors group (religious affiliated and unaffiliated) and condition (monotheistic hits, polytheistic hits, correct rejections) in SPSS (V 26, IBM Corp.). Reaction times for monotheistic hits, polytheistic hits, and correct rejections for each group were also recorded using E-prime and compared using a second 2 (group) $\times$ 3 (condition) mixed ANOVA. Both 2×3 ANOVAs used a 0.05 alpha level. Mauchly's test of Sphericity indicated a significant result so Huynh-Feld's sphericity correction was used to determine whether the ANOVAs illustrated significant differences. Where appropriate, post hoc paired samples t-tests were done across the different conditions.

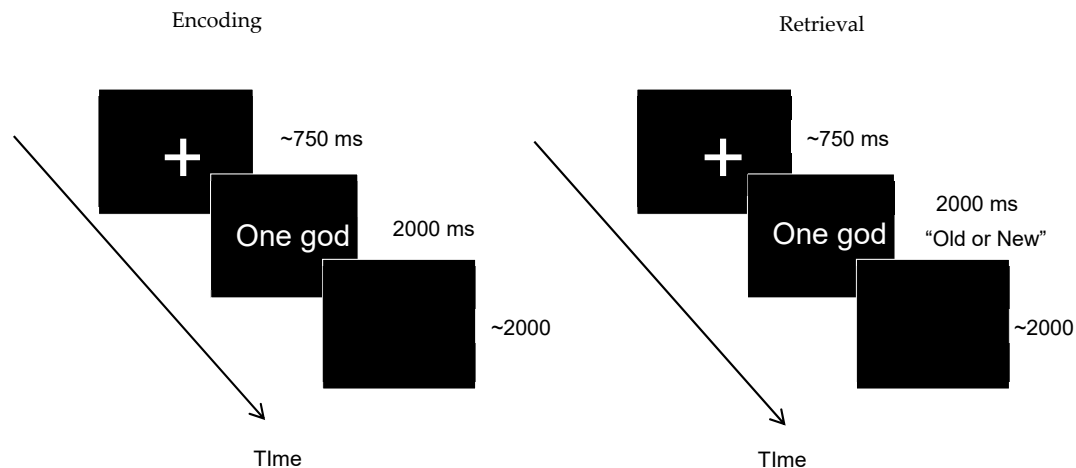


Figure 1. Recognition test paradigm. Participants performed a recognition memory test where they were shown word pairs representing monotheistic and polytheistic god-concepts during encoding. A fixation cross was presented for an average of 750 ms (range 500–1000 ms) followed by a 2000 ms presentation of a pair of words the participants were instructed to remember. The inter-trial interval was a blank screen shown an average of 2000 ms (range 1500–2500 ms). The retrieval phase was exactly the same except participants were instructed to answer “old” or “new” during word presentation.

2.5. EEG Data Acquisition

A radiofrequency shielded room (Universal Shielding Corp., Deerpark, NY, USA) was used for all EEG data recordings. Recordings were done using a 64-channel BrainVision antichamp EEG system with Ag-AgCl electrodes (Brain Products GmbH, Munich, Germany) with a sampling rate of 500 Hz. An analog filter of 0.1–200 Hz was used and conductance gel was placed on the scalp of each participant until impedances for all electrodes were below 25 k Ω . The first 14 EEG data recordings were collected using Pycorder software from BrainVision (version 1). The final 15 EEG data recordings were collected using the Recorder software from BrainVision.

2.6. Spectral Analysis Pre-Processing

EEG data was processed using MATLAB (MathWorks, version R2019a) and the plug-in EEGLAB (v. 2020.0, [Delorme and Makeig 2004](#)). The data was filtered from 1 to 50 Hz and the automatic channel rejection function was used to guide which channels to leave out when re-referencing data to the average signal across all remaining channels. Channels indicated for automatic rejection were not removed from the dataset but were excluded from being used to form the re-referenced baseline. The data then underwent an epoch procedure, which separated the EEG data into discrete trial events. The epochs were defined based on the timing of the stimulus presentation with 0 ms equal to the onset of the stimulus. Each epoch contained data from 1000 ms before the stimulus was presented (pre-stimulus baseline) to 2000 ms after stimulus presentation (the offset of the presented stimulus) for a total epoch of –1000 to 2000 ms surrounding the onset of stimulus presentation. A subsequent memory design was used to sort the epochs during encoding into successful encoding of monotheistic god-concepts and successful encoding of polytheistic god-concepts. As such, the retrieval data was used to retroactively sort the encoding data so that if a stimulus was correctly identified as old during retrieval, then that stimulus presentation during encoding was considered successful. Epochs were sorted into three bins, monotheistic hits, polytheistic hits, and correct rejections. Each epoch then underwent a baseline procedure where the 1000 ms before stimulus presentation was averaged and then used to baseline the entire epoch. Following epoch processing, noisy epochs were removed from the data via manual inspection. During manual inspection, epochs were

rejected if they contained EEG data that changed by more than 75 microvolts, as any change over that size was likely a muscle movement (blinking and forehead crunching). Data was then separated into independent components using Informat Independent Components Analysis (ICA) (Bell and Sejnowski 1995). The resulting components were then source localized using the DIPFIT2 EEGLAB plug-in (Oostenveld et al. 2011). The ADJUST plug-in for EEGLAB was used to then manually inspect the ICA components for components primary comprising noise. Specifically, components located outside the brain after dipole fitting, components comprising eyeblinks, single electrode components, and movement related components were all removed from the data. The data was then converted from independent components back into EEG sensor space for subsequent time-frequency transformation and analysis at the electrode level.

2.7. Time-Frequency Transformation and Oscillatory Analysis

A Morlet wavelet was used for time-frequency decomposition in 25 ms bins (98 time points along the epoch) for 30 log-spaced frequencies between 4 and 50 Hz. The Morlet wavelet used 2 cycles at 4 Hz and 5 cycles at 50 Hz. Epochs were trimmed at the edges so that each epoch only contained data from -721.0 ms before stimulus presentation to 1719.0 ms after stimulus presentation. This epoch trimming was done automatically in EEGLAB in order to reduce boundary effects due to the time-frequency transformation. After time-frequency transformation, event-related spatial perturbation (ERSP) maps were generated in EEGLAB for both encoding trials and retrieval trials for the religious affiliated and unaffiliated groups. During encoding, the successfully encoding of monotheistic god-concepts was compared to the successful encoding of polytheistic god-concepts while the retrieval data compared monotheistic hits, polytheistic hits, and correct rejections. During retrieval, the monotheistic hit, polytheistic hit, and correct rejection ERSP maps were compared. The EEG analyses were done in two different regions of interest (Figure 2). An anterior region of interest was formed by averaging the F1, Fz, F2, FC1, FCz, and FC2 electrodes together. The P1, P3, Pz, P2, P4, PO3, POz, and PO4 electrodes were averaged together to form a posterior electrode region of interest. Permutation based-statistics based on 5000 iterations with a p -value of 0.05 was used to determine significance. Correction for multiple comparisons within the EEG data was achieved using a modified Holms sequential Bonferonni correction within EEGLAB. Specifically, the False Discovery Rate (FDR) method was used in EEGLAB which uses the final value that reaches significance in a Holms sequential methodology as the p -value for all tests.

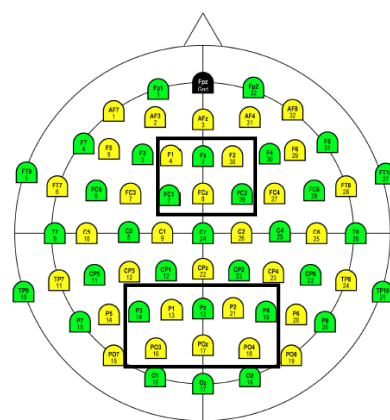


Figure 2. Regions of interest for EEG data analysis. The two sets of electrodes outlined with black squares served as the regions of interest for EEG data analysis. The F1, Fz, F2, FC1, FCz, and FC2 were averaged together to form an anterior electrode region of interest. The P1, P3, Pz, P2, P4, PO3, POz, and PO4 electrodes were averaged together to form a posterior electrode region of interest.

3. Results

3.1. Behavioral Results

Two different 2×3 mixed ANOVAs were run to assess differences between the religious affiliated and the unaffiliated groups in accuracy and hit reaction time for the monotheistic god-concepts, polytheistic god concepts, and correct rejections. The 2×3 ANOVA assessing differences in accuracy between the religious affiliated and unaffiliated groups for the monotheistic god-concepts, polytheistic god-concepts, and correct rejections revealed no differences. There was no main effect of condition ($F(1.51, 40.74) = 0.77, p > 0.05$), no main effect of group ($F(1, 27) = 1.42, p > 0.05$), nor a group $\times$ condition interaction ($F(1.51, 40.74) = 0.08, p > 0.05$; Figure 3A).

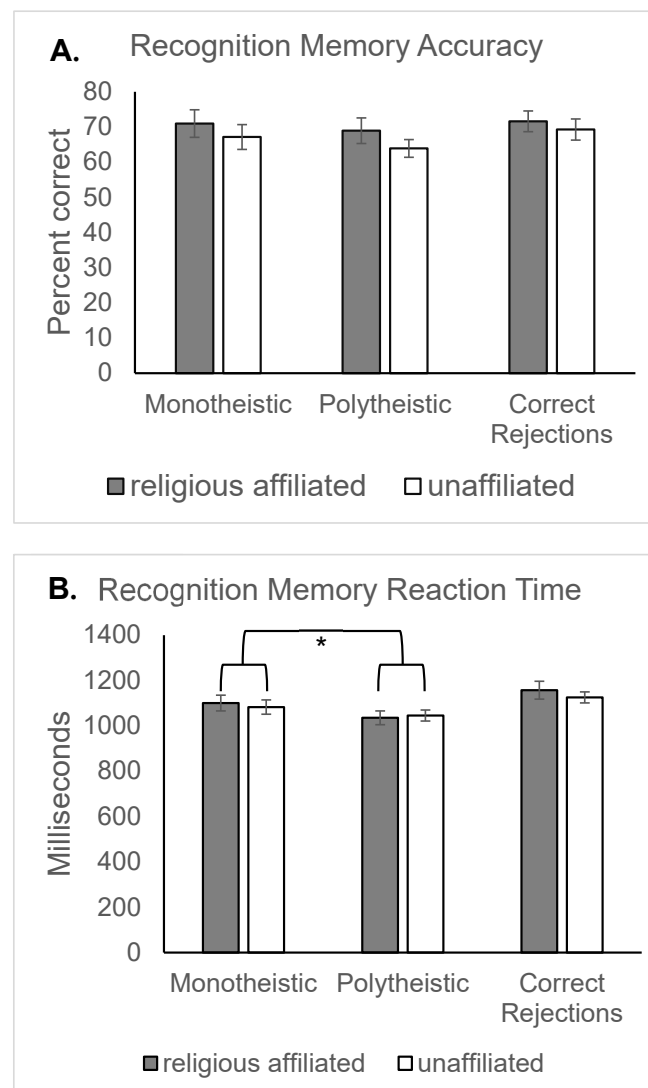


Figure 3. Behavioral data. (A) Recognition memory accuracy for the religious affiliated (gray) and unaffiliated (white) groups is displayed for the monotheistic hit, polytheistic hit, and correct rejection conditions in percentage correct. A 2×3 mixed ANOVA revealed no significant differences. (B) Reaction time for the religious affiliated (gray) and unaffiliated (white) groups are shown for three different conditions. A 2×3 mixed ANOVA revealed a significant main effect of condition where the marginal mean for monotheistic hits was larger than the marginal mean for polytheistic hits. Correct rejections were significantly different from both conditions.

The 2×3 mixed ANOVA analyzing reaction time differences revealed a significant main effect of condition ($F(1.54, 41.65) = 16.65, p < 0.001$) suggesting differences in the time

it took to respond across the 3 conditions (Figure 3B). However, there was no main effect of group ($F(1, 27) = 0.76, p > 0.05$) nor a group $\times$ condition interaction ($F(1.54, 41.65) = 0.74, p > 0.05$). Analysis of the marginal means for condition showed that across all participants, reaction time for monotheistic god-concepts ($M = 1093.29$ ms, $SEM = 23.92$ ms) was slower than reaction time for polytheistic god-concepts ($M = 1039.82$ ms, $SEM = 20.25$ ms, $t(28) = 4.13, p < 0.05$, Cohen's $d = 0.44$). Post hoc testing revealed that monotheistic god-concepts took longer to recognize than polytheistic god-concepts in the monotheistic group (monotheistic concepts $M = 1100.61$ ms, $SEM = 34.85$, polytheistic concepts $M = 1035.64$ ms, $SEM = 30.48$; $t(16) = 3.91, p < 0.05$, Cohen's $d = 0.47$) but not the unaffiliated group (monotheistic concepts $M = 1082.9$, polytheistic concepts $M = 1045.7$, $t(11) = 1.82, p > 0.05$, Cohen's $d = 0.38$). Reaction time across all the participants for correct rejections ($M = 1144.32$, $SEM = 24.98$) was significantly slower than for both monotheistic god-concept hits ($t(28) = 2.37, p < 0.05$, Cohen's $d = 0.39$) and polytheistic god-concept hits ($t(28) = 6.59, p < 0.05$, Cohen's $d = 0.80$). These results illustrate that regardless of whether an individual grew up engaging in religious practices associated with a monotheistic religion or was unaffiliated with a religion, recognizing monotheistic god-concepts took longer than recognizing polytheistic god-concepts.

3.2. ERSP Results

ERSP maps were generated in two different regions of interest by averaging together the EEG data in each electrode within the region (Figure 2). These regions of interest were chosen based on their past association with oscillatory changes during cognition (Hanslmayr et al. 2009, 2016). Permutation based statistics comparing changes in oscillatory power for the different groups and conditions revealed no significant differences for either region of interest during encoding or retrieval of different types of god-concepts after correcting for multiple comparisons. There was no main effect of condition, group, or a group $\times$ condition interaction after correcting for multiple comparisons (Figure 4).

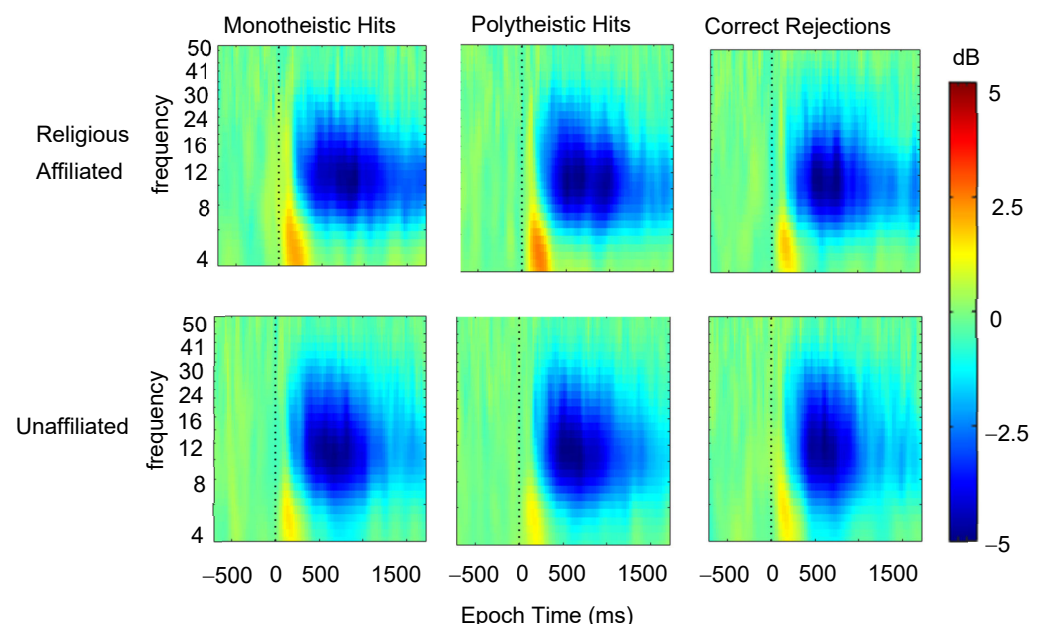


Figure 4. ERSP maps illustrating changes in oscillatory power from the pre-stimulus baseline during retrieval for the different groups and conditions. The 0 time-point is referenced to stimulus presentation. As expected, there is a decrease (blue) in alpha oscillatory power (8–12 Hz) following stimulus presentation which appears in all conditions in both groups of participants. However, there was no difference in the amount of alpha power decreases across the groups or conditions after correcting for multiple comparisons.

4. Limitations

This study contained several notable limitations in design, data collection, and analysis, which are worth highlighting before proceeding to the Discussion. Due to difficulties in data collection and institutional-personnel changes, the sample size was smaller than desired: 17 participants for the monotheistic religiously affiliated condition and 12 for the religiously unaffiliated condition. After two years of attempts at data collection, due to our regional demographics we did not recruit sufficient polytheistic participants to include in the study analysis. Related, our subject pool was primarily WEIRD, relying on a rather homogeneous demographic in a university setting, further underscoring the desirability of replicating or expanding this study in a different demographic context. We also did not collect information on sex/gender in our data, and perhaps there would be a detectable effect there around recall in a subsequent study. Given these limitations in participants, our analyses and conclusions should be treated more suggestively than conclusively, pointing toward a need for further research in this area that substantially expands the participant pool and demographic diversity.

On a more conceptual level, our core approach attempted to test differences around monotheistic versus polytheistic ideas. To do so, we used word pairs, which as noted above for monotheistic ideas tended to be more abstract and for polytheistic ideas tended to be more concrete. It merits mention that any difference between these two conditions could be explained not as a difference in monotheism/polytheism per se, but due to the well-established concreteness effect (Paivio 1991), which shows that tangible objects are remembered better than non-tangible objects (Taylor et al. 2019; Jessen et al. 2000). While the following Discussion explores at some length the notion that polytheistic ideas tend to be more concrete and thus polytheism can be inferred from our results, this is only one possible hypothesis that explains the present data and these other hypotheses are also mentioned. We suggest further areas of study that might disentangle monotheism/polytheism from the concreteness effect.

5. Discussion

The present study examined EEG and behavioral performance differences in response to monotheistic and polytheistic related concepts presented in a recognition memory task. We attempted to interrogate the theory of cognitive intuitiveness of monotheistic versus polytheistic ideas through two experimental paradigms: alpha desynchronization (EEG) and recall both in speed and accuracy (behavioral). There were two notable findings. First, our EEG data showed no significant differences in processing (alpha desynchronization) between monotheistic versus polytheistic word pairs. As one main objective of our study, we therefore found no EEG evidence to support our hypothesis that singular gods (SAs) or plural gods are processed any differently in terms of conceptual difficulty as evinced by alpha oscillations.

For our second main study objective, our behavioral data did show a significant reaction time difference in that both monotheistic and unaffiliated groups took longer to recognize monotheistic ideas than polytheistic ideas (Figure 3). This longer reaction time for monotheistic ideas across both groups may indicate that monotheistic ideas were more difficult to process and recall. This conclusion stands in some tension with our first conclusion above. However, the reaction time results may be more sensitive to differences in processing monotheistic and polytheistic concepts than alpha oscillations as alpha oscillations have been shown to only differ with highly salient information (Gutteling et al. 2022). Low salience distractors, by contrast, do not modulate alpha. This may suggest that the reaction time was sensitive to a difficulty difference between monotheistic versus polytheistic ideas, but that the alpha oscillations were not sensitive to such a difference.

likely due to the low level of difficulty change. While the introduction of this proposal might be fairly critiqued as a post hoc explanation or hypothesis, the divergence in findings between our behavioral and EEG data requires explanation, as well as likely further testing.

We might also conjecture, from a more 4E perspective, that because our polytheistic stimuli involve more embodied and embedded concepts that they were recalled more readily given the direct and additional salience of embodiment and embeddedness. Indeed, while we have largely coded polytheistic ideas as more embodied and monotheistic ideas as more abstract, it is entirely possible to understand this as a difference in levels of embodiment, regardless of religion type (monotheistic/polytheistic). Further, the faster and more accurate recall of our polytheistic/embodied ideas can also be understood to reflect the ‘concreteness effect’, a well-studied phenomenon since Paivio’s dual-coding theory. These points notwithstanding, these two findings (EEG vs. behavioral) certainly beg further questions and require further research.

Third, while behaviorally there was no difference in accuracy for either the monotheistic or unaffiliated group (Figure 1), both groups had faster reaction times for polytheistic stimuli than for correct rejections, and the monotheistic group also had faster reaction times for polytheistic stimuli than for monotheistic stimuli (Figure 2). This may indicate that both groups had an easier time remembering polytheistic stimuli and therefore recognized them at a faster rate, especially given that we might expect the monotheistic group to remember monotheistic stimuli at a fast rate given prior exposure and behavioral interest in such concepts.

Faster processing might reflect several factors from a cognitive and 4E perspective, such as (1) the more embodied and embedded nature of polytheistic SAs and their characteristics, (2) more familiarity with the polytheistic words, (3) a greater inference for monotheistic words, and (4) greater contemplation and reflection on monotheistic words, whose reflection could be either positive or negative in nature. These four options are not mutually exclusive. The lack of alpha differences suggests that option 4 is less feasible as the retrieval of more information leads to greater alpha desynchronization (Khader and Rösler 2011; Griffiths et al. 2021). Option 3 is a possibility given that distracting information only impacts alpha when the distractor is hard to ignore (Gutteling et al. 2022). Option 2 is likewise possible given that that explanation might not impact alpha.

Option 1 reflects our particular stimuli and the doctrinal traditions around polytheistic versus monotheistic traditions. As discussed above, polytheistic cultures tend to understand their SAs as highly embodied and embedded. For this reason, 4E approaches suggest that ideas that reflect embodied and embedded (and sometimes enacted) understandings will be easier for the human brain to process and thereby remember accurately and quickly. Polytheism’s greater 4E qualities, in other words, may help explain why those (more embodied and embedded) word pairs were easier to remember quickly for both the monotheistic and polytheistic groups. Monotheism’s trend toward abstract understandings of SAs—at least in part due to the influence of ancient Greek philosophy that influenced later Judaism (cf. earlier Judaism and its strongly embodied notions of God), Christianity, and Islam all—thus marks these subsequent “non-embodied” notions of SAs as less easily memorable across participant types.

As a corollary, we can suggest that polytheistic concepts are more intuitive—that is, less counterintuitive than monotheistic ones, though still counterintuitive—which help explain why polytheism evolved earlier than monotheism, as detailed in our introduction. We would also add that the concreteness effect, mentioned above, suggests that polytheistic/embodied areas are recalled faster and more accurately than abstract ones. This would lend credence to the idea that polytheism evolved earlier in human history and that monotheism and its greater emphasis on abstract ideas came later and required new forms

of cultural support to overcome this relative cognitive obstacle. It is worth remembering, however, that our study was only able to test monotheistically affiliated and unaffiliated participants, and thus caution is warranted around extending these conclusions to broader sample sizes, much less the human species generally.

Our findings also have wider implications for broader theories within CSR. Many studies have shown that religious ideas such as SAs have an aspect that is counterintuitive, giving rise to the notion of minimally counterintuitive ideas (MCIs) (Boyer 2001; Barrett 2000, 2004; Barrett and Nyhof 2001; Upal 2011; Sommer et al. 2023). These MCI concepts have been shown to have better retention and transmission rates (Porubanova et al. 2014). While it may be that belief in SAs arose from our other cognitive adaptations (Shaver et al. 2016), the ERSP oscillatory results of the present study do not indicate that monotheistic concepts are counterintuitive enough compared to polytheistic concepts to illicit alpha oscillatory changes.

However, the notion that monotheistic religions may have originally required more cultural superstructure in order to disseminate ideas may be merited due to the increased reaction time. We noted above that alpha differences tend to occur only with highly salient information, so it may be that the attention difference between monotheistic and polytheistic ideas is too small for alpha oscillations to detect but not too small for reaction time. This finding of increased difficulty of monotheistic ideas as evidenced by reaction time could suggest that monotheistic ideas require more of what we might term cultural superstructure as seen in the daily or weekly services and prayer practices of the major monotheistic religions of Christianity, Islam, and Judaism (again see possible mapping onto Whitehouse 2004). This increased practice and engagement often includes devotions such as fasting and celibacy, as well as rituals, which are used to deepen commitment to counterintuitive beliefs (Atran and Henrich 2010). If monotheistic concepts are more difficult to process and therefore recall, these costly commitment investments might help overcome this disadvantage (Atran and Henrich 2010). Therefore, the cognitive underpinnings of polytheistic, embodied, and concrete religious ideas should be integrated into CSR accounts of the development of religious thought, for example the emergence of moral high gods and monotheistic religions generally, the ‘Big Gods’ hypothesis (Turchin et al. 2023; Whitehouse et al. 2022; Beheim et al. 2021; Norenzayan 2013).

It has also been argued that rituals that have stronger conceptual control have a greater chance of survival than others (Barrett 2004). These religious practice requirements put in place may help deepen commitment to the religion and further connect followers’ identification of themselves with the monotheistic ideals that may be less intuitive. However, such costly rituals are not exclusive to monotheistic religions and indeed are widely seen in world religions of different types (Xygalatas 2021). While we therefore deem our findings inconclusive in this area, nonetheless the presence of costly bodily rituals—often highly embodied, embedded, enacted, and extended—across both polytheistic and monotheistic religions speaks to the importance of 4E approaches that bring in a stronger role for the body instead of purely cognitive or “mind-based” approaches that emphasize only religious beliefs, ideas, or concepts.

Monotheistic religions nonetheless show a difference in the types of rituals enacted, as they tend to be less costly, but still ordinary and embodied. In the case of Christianity, to take one example, the percentage of Christians that practice strict asceticism, celibacy, or self-harm are rare. Yet the importance of embodied rituals persists in meal and clothing practices, performative elements at weekly services, and in the physical practice of prayer. A greater cultural superstructure for monotheism, in other words, continues to manifest embodied rituals but in a less costly way. This might suggest that 4E approaches remain relevant but find a difference between polytheistic versus monotheistic traditions. Robin Dunbar’s

work, for instance, highlights the importance of embodied ritual such as drumming and high intensity dancing in earliest ritual belief, which is less present in later monotheistic traditions even as elements persist such as synchronicity in singing and liturgical response (Dunbar 2022, esp. 73–4, 129, 136–37, 144–48). All of these embodied rituals facilitate belonging, bonding, and cooperation in both polytheistic and monotheistic religions, even as they tend to be less costly in monotheism. Such a view seems to be compatible with Whitehouse's views about the different types of beliefs, some of which are small scale and higher intensity in terms of the types of memories they invoke ("imagistic", more polytheistic) whereas others are less intense but more regular and scale more widely ("doctrinal", more monotheistic).

The difference in our behavioral results, meanwhile, in which the monotheistic participants had faster reaction times for the polytheistic concepts than for the monotheistic concepts (Figure 2), might have some relevance toward still other CSR theories. As MCI concepts are generally inconsistent with our expectations, they are defined by our experiences and beliefs. Due to the higher commitment expectations in place with monotheistic religions, the beliefs that might be otherwise regarded as counterintuitive become commonplace to those who practice such religions. In this situation, monotheistic people believe in an all-powerful god, and have the religious experience to create the expectation of encountering such monotheistic concepts in their day to day lives. This sentiment is expressed in a 2011 article (Upal 2011), in which another term for these types of concepts is proposed—minimally socially counterintuitive concepts, or MSI. These MSI concepts are more focused to a smaller population or group of people, such that the group's expectations based on their beliefs are violated. It also stands to reason that MSI and MCI concepts are functionally the same (Upal 2011). MSI concepts can be explained by the distinctiveness effect, which details that an item that stands out more than others in context is more likely to be remembered.

Another possible explanation for our results lies in the cognitive concept of Theory of Mind (ToM). A study done by Barrett and Nyhof (2001) examined the way god concepts develop in children ages 2–6 years through the use of a false belief task. Children were shown a cracker box with rocks in it and asked what their mother and God would believe was in the box. Around ages 3–4, children thought that both their mother and God would think that rocks were in the box. By ages 5–6, the children began attributing false beliefs to their mothers, saying that they would believe that there were crackers in the box. However, they still believed that God would know that there were rocks in the box. This was further examined in a group of Maya children by Knight et al. (2004), and similar results were found, though it took the children about a year longer to develop the same false beliefs about their mothers. Therefore, children hold the belief that others have the same amount of knowledge as them, regardless of whether the agent has had the same experiences until about 5 or 6 years old. After this stage in development, children can then adopt the viewpoint of another person, and can reason that their parents do not know what is inside the box.

However, the same does not apply for God (Barrett and Nyhof 2001; Knight et al. 2004). It is argued in a review by Barrett (2004) that due to this natural progression in development, both god concepts in general and the belief in an all-knowing, infallible god may be more natural than we may think. These basic cognitive developments may also tie into the idea presented above regarding cultural superstructure. If children are being raised in a monotheistic household, these beliefs that God is infallible would be further reinforced by the religious practices being carried out during an important developmental period. Therefore, it may be possible that once these children reach adulthood, they would hold onto these beliefs in an all-knowing god, making the polytheistic concepts

in our experiment MSI to them. It is thus possible that our original hypothesis that polytheistic concepts may be more intuitive is not entirely accurate; an increased cultural superstructure for monotheism might compensate for its less-intuitive, abstract ideas as compared to polytheism's more embodied concepts, and therefore by adulthood we may not see significant processing differences between monotheistic and polytheistic ideas in a monotheistic group. Moreover, this knowledge about the developmental stages through which children retain these god concepts coupled with the notion of MSI concepts makes a compelling argument for the lack of counterintuitiveness of monotheism with repeated exposure and practice, as the monotheistic participants had. This would suggest a potentially productive follow-up study that analyzed children's processing and recall of these ideas, at as young of an age as possible in order to minimize cultural influence.

6. Conclusions

Our experiment found mixed evidence that polytheistic concepts are more intuitive for our brains than monotheistic concepts. We did not find significantly increased alpha and beta desynchronization for the polytheistic stimuli as compared to the monotheistic stimuli; this finding held across groups. Given the present sample size and analysis approach, this should not be interpreted as evidence of equivalent processing between monotheistic/polytheistic (or abstract/concrete) ideas, but rather an absence of statistically significance differences within this study's content and limitations.

We did find significant behavioral data that monotheistic ideas resulted in a slower reaction time than polytheistic ideas, but only in the monotheistic and unaffiliated participants which we were able to recruit. This points toward the notion that polytheistic ideas are perhaps more intuitive and thus easier to recall, or simply that there is a processing advantage for concrete/embodied god concepts which may be more prevalent in polytheistic god concepts. As our two main findings (null EEG; positive behavioral) might seem to stand in contrast they require explanation and so we propose three possibilities.

First, significant findings in behavioral data (and indeed our data, which showed a medium effect size at a 53 ms difference) might not be large enough to see alpha differences. Alpha differences and behavioral data do not always line up, and we noted the above reasons for this possibility. For example, alpha oscillations generally only differ with highly salient information (Gutteling et al. 2022), which also raises the question of our stimuli's relative salience. This suggests another avenue of possible research, in assessing salience and then exploring high salience stimuli via EEG. This explanation is related to a second possibility, that the detected behavioral difference might reflect a processing of a kind (e.g., semantic integration) that alpha desynchronization does not index. And third, there is a possibility that the behavioral difference reflects a lexical-level concreteness effect that need not modulate alpha. We have noted the concreteness effect above, but for now it suffices to note that there are complex cognitive linguistic interactions occurring that could be further explored. All three of these possibilities highlight the reality that alpha is not a perfect or complete measure, and thus underscore the complexities and limitations of oscillatory studies and findings for such theoretical questions in CSR.

In order to further examine the link between oscillatory activity and religion, it would be beneficial to recreate the present study and fill in some of this study's gaps. This would include increasing our sample size and ensuring equal numbers for each affiliation group, as well as seeking out polytheistic participants for comparison who were unavailable within our regional participant pool, though as noted earlier truly polytheistic participants might be difficult to find. As noted in our introduction and discussion, our polytheistic criteria tended to be more embodied and our monotheistic criteria tended to be more abstract. It thus begs the question if a subsequent study could productively interrogate embodied

versus abstract ideas within both monotheistic and polytheistic religions. As noted earlier, many of the globally dominant polytheistic religions have over time developed significant and important abstract components (e.g., the Tao); many monotheisms have also historically contained many significant and important embodied components (e.g., Catholic saints).

Regarding this study, meanwhile, as is often the case with EEG studies, the significant problems in data variance highlight the importance of triangulating this type of data with other forms of neurological and behavioral data. Finally, while we readily concede the small sample size of our experiments and the concomitant degree of reliability, the results of the recall experiment are productively suggestive in terms of the current debate in the cognitive science of religion between adherents of the standard model and adherents of embodied cognition. We hope that this limited study, the first of its kind, leads to subsequent work analyzing types of religious concepts using both neurological and behavioral data.

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Data Availability Statement: Behavioral data is available on Zenodo (accessed on 2 June 2026). The underlying processed EEG datasets/statistical outputs necessary are no longer available. <https://zenodo.org/records/20514153> (accessed on 1 July 2026). DOI: 10.5281/zenodo.20514153. The study's hypotheses were not pre-registered, as the IRB for the study was attained before pre-registration became standard in many fields.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. List of Monotheistic and Polytheistic Terms

Monotheistic Terms	Polytheistic Terms
absolute god	active god
abstract god	aging god
ageless god	angry god
all god	annoyed god
all-encompassing god	beauty god
aloof god	business god
always god	cave god
atemporal god	celebration god
best god	child god
boundless god	clothing god
ceaseless god	crime god
collective god	crops god
complete god	curious god
consummate god	dancing god
continual god	driving god
creation god	dying god

Monotheistic Terms	Polytheistic Terms
divine god	educated god
endless god	empathetic god
entire god	energetic god
eternal god	envious god
everlasting god	erotic god
every god	failure god
everywhere god	fame god
exceeding god	family god
exclusive god	fate god
faultless god	fighting god
flawless god	flawed god
forever god	flying god
full god	food god
general god	foolish god
greatest god	fortune god
high god	friendship god
ideal god	generous god
immaculate god	harmful god
imminent god	healing god
immortal god	helpful god
immutable god	human god
imperishable god	hungry god
incalculable god	illness god
incomparable god	interested god
incomprehensible god	judging god
indestructible god	kind god
inestimable god	lake god
inexhaustible god	laughing god
infinite god	lawful god
inhuman god	listening god
inimitable god	losing god
innate god	lottery god
interminable god	love god
just god	luck god
limitless god	manipulative god
lone god	mischievous god
measureless god	misfortune god
moral god	money god
numberless god	mountain god
obscure god	old god
omnipotent god	party god
omnipresent god	playful god
omniscient god	poverty god
one god	procreation god
only god	punishing god
original god	random god
otherworldly god	rewarding god
peerless god	river god

Monotheistic Terms	Polytheistic Terms
perfect god	rock god
permanent god	sad god
perpetual god	sibling god
powerful god	sickly god
pure god	simple god
righteous god	sleep god
sheer god	small god
single god	smart god
sole god	smelling god
sublime god	smoking god
superlative god	sneaky god
supreme god	sneezing god
thorough god	speed god
timeless god	spiteful god
total god	stupid god
transcendent god	success god
ultimate god	swimming god
unaccompanied god	tasting god
unadulterated god	thirsty god
unbegotten god	tired god
unbounded god	travel god
unconditional god	tree god
unconfined god	tripping god
undivided god	vengeful god
unending god	victory god
unequaled god	violent god
unfathomable god	walking god
unified god	watching god
unitary god	weak god
universal god	wealth god
unreckonable god	weather god
unspeakable god	wise god
unsurpassable god	wish god
untold god	wounded god
utter god	yelling god
whole god	young god

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