Supernatural belief presents an explanatory challenge to evolutionary theorists—it is both costly and prevalent. One influential functional explanation claims that the imagined threat of supernatural punishment can suppress selfishness and enhance cooperation. Specifically, morally concerned supreme deities or ‘moralizing high gods’ have been argued to reduce free-riding in large social groups, enabling believers to build the kind of complex societies that define modern humanity. Previous cross-cultural studies claiming to support the MHG hypothesis rely on correlational analyses only and do not correct for the statistical non-independence of sampled cultures. Here we use a Bayesian phylogenetic approach with a sample of 96 Austronesian cultures to test the MHG hypothesis as well as an alternative supernatural punishment hypothesis that allows punishment by a broad range of moralizing agents. We find evidence that broad supernatural punishment drives political complexity, whereas MHGs follow political complexity. We suggest that the concept of MHGs diffused as part of a suite of traits arising from cultural exchange between complex societies. Our results show the power of phylogenetic methods to address long-standing debates about the origins and functions of religion in human society.

1. Introduction

Religion is a hallmark of our species. From the austere healing rituals of the Kalahari Desert foragers to the spectacular opulence of European cathedrals, religion has shaped all human societies. Though religions, which consist of shared supernatural beliefs and practices, have historically worshiped a diverse range of spirits and gods, today the most successful world religions worship moralizing high gods (MHGs) [1]; powerful supreme creator gods who monitor and enforce moral codes. It is widely claimed that beliefs in supernatural punishment increase cooperation and play a functional role in the evolution of complex societies [2–6], although there is little consensus over the kinds of supernatural agents that are effective. A major focus of the literature has been on powerful animistic gods, specifically MHGs, owing to their ability to reliably and automatically punish all transgressions [3–5,7–10]—referred to here as
MHG hypotheses. An alternative theory allows for a broad range of supernatural punishment found throughout ethnic and world religions, including fallible localized ancestral spirits and inanimate processes like karma as well as MHGs [5,6]—referred to here as the broad supernatural punishment (BSP) hypothesis.

Previous cross-cultural studies have found a correlation between MHGs and a range of measures of social complexity [5,9,11], supporting both the BSP and MHG hypotheses. However, these studies are problematic for two reasons. First, traditional analyses of cross-cultural data do not incorporate the necessary information about the cultural evolution of human societies to enable a satisfactory test of these hypotheses. The world’s cultures are related by descent and so are not statistically independent. Standard correlational methods do not account for common ancestry, resulting in potentially spurious correlations—a problem first noted by Sir Francis Galton [12]. Despite attempting to select only distantly related cultures, the samples used in previous comparative studies of MHGs are known to be non-independent [13]. Second, these studies are unable to distinguish the direction of causal relationship. Previous studies have assumed that a link between high gods and political complexity arises from the effect of the belief on political structure [5,9,11]. Yet the direction of causation could be reversed—complex societies might be more likely to gain MHG concepts. Only an approach that explicitly incorporates phylogenetic information is able to both address Galton’s problem and determine the temporal sequence in which MHGs and political complexity emerged [12].

Phylogenetic methods have revolutionized the biological sciences and have recently been used to make inferences about cultural evolution ranging from the kinship system of Proto-Indo-European and Austronesian cultures [14], to the evolution of political complexity across Austronesia [15], and the determinants of language structure [16]. Here we use a phylogenetic method to first test whether beliefs in MHGs and BSP coevolve with political complexity. Then we test if such beliefs (i) facilitate the evolution of political complexity and (ii) stabilize political complexity once it has arisen.

Austronesia provides a natural laboratory for studies of cultural evolution [17]. There is huge variation in community size, a profusion of religious beliefs ranging from localized ancestor worship to a structured pantheon of gods [18], and a diversity of political structures ranging from the simple seminomadic band of the Palawan Batak to the complex state of Bali [15]. Indeed, it was a fascination with the simple seminomadic band of the Palawan Batak to the complex state of Bali [15]. Indeed, it was a fascination with the specificity of human morality and (iii) is specifically supportive of human morality [22]. For BSP to be coded as present in a culture there must be the concept of a god who (i) created or governs the cosmos, (ii) is active in human affairs and (iii) is specifically supportive of human morality [22]. For BSP to be coded as present in a culture there must be the concept of a supernatural agent or process that reliably monitors and punishes selfish actions, and this concept must (i) be widely advocated within the community, (ii) involve punishment of a broad range of selfish behaviours and (iii) apply to a wide range of community members (electronic supplementary material provides detailed coding criteria of all variables).

(b) Phylogenetic trees

We used a sample of 4000 trees from a Bayesian analysis of Austronesian languages (see Gray et al. [20] for further details). The population history inferred from these trees fits very well with both what is known from archaeology about the sequence and timing of the Austronesian expansion in the Pacific [20] as well as current genetic data [23]. The original 400 cultures used to construct the tree were pruned down to the 96 cultures with the richest ethnographic records.

(c) Phylogenetic comparative method

We use Bayesian phylogenetic reversible-jump Markov chain Monte Carlo (RJMCMC) analyses in the program BayesTraits [24] to calculate the posterior distributions of dependent and independent models of trait evolution. In the dependent RJMCMC analysis, the Markov chain is able to sample from both dependent and independent models of evolution, sampling parameters in proportion to their posterior probability [24]. In the independent analysis, only independent models of evolution can be sampled. We compared the likelihood of the models found within each analysis by calculating a Bayes factor from their marginal likelihoods (electronic supplementary material).

Following Kass & Raftery [25], a Bayes factor of 0–3 is interpreted as providing no support for one model over the other, while a Bayes factor of 3–10 is taken as substantial support and a Bayes factor of over 10 is taken as very strong support.

in one trait is independent of the state of the other, supernatural beliefs and political complexity evolve independently. Functional hypotheses predict that (i) the independent model will fit best, (ii) beliefs in BSP and MHGs will facilitate the evolution of political complexity and that (iii) such beliefs will sustain political complexity once it has arisen [3,7,21].

2. Material and methods

(a) Ethnographic sources and coding

Ethnographic information was collected from periodicals, books and encyclopaedias (see electronic supplementary material, table S1 for a full list). Cultures are the unit of analysis as our hypotheses concern the features and evolutionary patterns at this level, not at the level of individuals within a culture. In order to minimize the effects of cultural borrowing, cultures have been coded based on the earliest available ethnographic records. Cases of known borrowing from Abrahamic religions were excluded. All variables used in this study were binary coded. Our coding criteria for political complexity and MHGs were based on variables in the Ethnographic Atlas and Standard Cross-Cultural Samples [22]. For political complexity, cultures were coded as low if they had no more than one level of jurisdictional hierarchy beyond the local community (acephalous societies and simple chiefdoms), or high if they had two or more levels of jurisdictional hierarchy beyond the local community (complex chiefdoms and states). For a MHG to be coded as present in a culture there must be the concept of a god who (i) created or governs the cosmos, (ii) is active in human affairs and (iii) is specifically supportive of human morality [22]. For BSP to be coded as present in a culture there must be the concept of a supernatural agent or process that reliably monitors and punishes selfish actions, and this concept must (i) be widely advocated within the community, (ii) involve punishment of a broad range of selfish behaviours and (iii) apply to a wide range of community members (electronic supplementary material provides detailed coding criteria of all variables).
3. Results

We found 22 instances of high political complexity throughout historically and geographically distant regions of Austronesia. Ancestral state reconstruction indicates that high levels of political complexity are likely to have independently evolved numerous times throughout the history of Austronesia (figure 1A). This result corroborates lexical and archaeological evidence indicating that proto-Austronesian culture distinguished rank based on gender, birth order,
age and genealogy, but lacked political stratification beyond the local community [26].

We found evidence of beliefs in BSP in 37 of the cultures sampled, however beliefs in MHGs were present in only six cultures. Considerable differences also exist in the geographical distribution of supernatural concepts. Notably, beliefs in BSP were found across an expansive range of Austronesian cultures (figure 2A), while beliefs in MHGs tended to be clustered predominantly in Southeast Asia (figure 1A). These Southeast Asian cultures are Bontok, Toba Batak, Manggarai and Tagbanua—the names of their gods are Lumawig, Mulajadi na Bolon, Mori Karaeng and Mangindusa,
strained-dependent models (Bayes factor independent models (Bayes factor supplementary material, table S4) fitted better than both the a before MHGs (rate e sampled model strings (electronic supplementary material, the difference was only substantial with the former. This stabilize political complexity by running two additional con-
dependent models of evolution.

relative rarity of both MHGs and complex societies in Austro-
traits is not necessarily strictly coupled. However, given the cally complex, indicating that the evolution of these two instances of MHGs have arisen both independently and relatively recently (figure 1A).

Testing for the coevolution of MHGs and political complex-
ity, we find that the models of the RJMCMC-dependent analysis (electronic supplementary material, table S2) are sub-
stantially more likely (Bayes factor = 3.60) than those of the independent analysis (electronic supplementary material, table S3). Of the six cultures with MHGs, three were politi-
cally complex, indicating that the evolution of these two traits is not necessarily strictly coupled. However, given the relative rarity of both MHGs and complex societies in Austronesia, this correlation is sufficient to drive support for dependent models of evolution.

We then tested whether beliefs in MHGs precede and stabilize political complexity by running two additional con-
strained-dependent analyses. In the first analysis, high levels of political complexity must be gained before MHGs (rate a in figure 1B was restricted to 0). The resulting models (electronic supplementary material, table S4) fitted better than both the independent models (Bayes factor = 4.52) and the unconstrained-dependent models (Bayes factor = 0.92), though the difference was only substantial with the former. This finding is consistent with our analysis of the unconstrained-dependent model in which seven of the 10 most frequently sampled model strings (electronic supplementary material, table S5) did not allow political complexity to be gained before MHGs (rate a in figure 1B was estimated as 0). In the second constrained analysis (electronic supplementary material, table S6) we forced cultures with and without MHGs to have the same chances of losing complexity (rates e and g were restricted to be equal). The resulting models were more likely than the independent model (Bayes factor = 4.74) and slightly more likely than the unre-
stricted-dependent model (Bayes factor = 1.14), though not substantially so. Taken together these findings indicate that MHGs did not drive or sustain the evolution of political complexity in indigenous Austronesia.

We then tested the general claim that beliefs in BSP play a functional role in the evolution of political complexity (figure 2A). We found support for dependent analysis (elec-
tronic supplementary material, table S7) over the independent analysis (electronic supplementary material, table S8) (Bayes factor = 3.24). In the posterior distribution of the dependent analysis, a single model structure accounted for 92.21% of all models sampled (electronic supplementary material, table S9). In this model seven of the eight transition rates were inferred to be equal—cultures without BSP did not gain political com-
plexity (rate b was estimated to be 0), but all other transition rates were equal (rates a, c, d, e, f, h were all equal).

We then ran two restricted-dependent analysis to test whether beliefs in BSP precedes and stabilizes political complex-
ity. In the first analysis (electronic supplementary material, table S10), we constrained the model so that beliefs in BSP needed to occur before the evolution of political complexity (rate b was restricted to 0). The resulting models were substantially more likely than the independent model (Bayes factor = 5.02), and slightly more likely than the unre-
stricted-dependent models (Bayes factor = 1.78) though not substantially so. In the second restricted analysis (electronic supplementary material, table S11) cultures with and without beliefs in BSP were equally likely to lose political complexity (rates e and g were restricted to be equal). The resulting models were substantially more likely than the models in the independent analysis (Bayes factor = 4.10) and were slightly more likely than those in the unrestricted-dependent analysis (Bayes factor = 0.88), though not substantially so. These restricted models indicate that beliefs in BSP facilitate political complexity, but cultures with beliefs in BSP are just as likely to lose complexity as cultures without BSP.

4. Discussion

The results presented here cast doubt on the widely held view that MHGs facilitate the emergence of political complexity [2,3,5,9,21]. Although beliefs in MHGs do coevolve with political complexity, beliefs follow rather than drive political complexity. Instead, we find that beliefs in BSP facilitate the evolution of political complexity, though neither MHGs nor BSP sustains political complexity once it has arisen. In Austro-
nesia many forms of supernatural beings, such as the tree and rock spirits of Eastern Toraja [33] and the lizard spirits of the Toba Batak [34] show little interest in human morality. The punishing agents that fall under BSP tend to be anthropo-
morphic beings such as the spirits of deceased ancestors and our results suggest that it is these kinds of supernatural punishers that have facilitated the evolution of political complexity in Austronesia. However, ancestral spirits are suboptimal supernatural punishers as they generally have restricted abilities to know about and influence the world, are only important to their own lineage and are biased to favour this lineage. Ancestral spirits may be suited to facilitating cooperation within small scale lineage based groups, but fail to maintain cooperation in larger more complex societies in which there are multiple lineages. While this explains why BSP is found to facilitate but not sustain political complexity, it does not account for why MHGs are not found to drive or sustain political complexity, despite claims that MHGs are the ultimate form of supernatural punishment [7].

An alternative explanation for the coevolution of BSP and political complexity is that beliefs in ancestral spirits are a common source of supernatural punishment, which are used to make claims of political authority. An example of a culture in which genealogy was used to justify political leadership is Hawaii, where the ancestors of chiefs were elevated to the place of gods and provided chiefs with both authority and supernatural power in the form of mana [35]. The extent to which beliefs in ancestral spirits facilitate political complexity by increasing cooperation, as opposed to motivating claims of political authority, needs to be tested in future research.

Previous cross-cultural support for both the MHG and BSP hypotheses has relied on the MHG variable coded in the EA and SCCS and there are three reasons our findings differ from previous studies. First, previous research has relied on standard correlational techniques that are unable to get at the direction of causality [5,9,11]. Second, previous
research has not fully taken into account the phylogenetic history of cultures. When cultural fission occurs, such as when a group splits off to inhabit a new island, the resulting cultures retain many of their ancestral traits. Supernatural beliefs and level of political complexity are no exception [15,26]. The sacred Polynesian concept of tapu, for example, probably originated in the ancestral proto-Polynesian society [26], and has now spread across far-flung islands of the Pacific. By making inferences based on phylogenetic trees, we were able to infer independent evolutionary events [12], rather than relying on potentially spurious correlations. The third reason our results differ from previous studies is that our coding eliminated cases of MHGs that were clearly attributable to contact with Abrahamic religions. External influence potentially confounds the correlations previously found between political complexity and beliefs in MHGs. For example, the Nias of Indonesia had both Christianity and a paramount chiefdom imposed on them by a Dutch colonial government [18]. Previous cross-cultural studies are based on data in the Ethnographic Atlas, or the Standard Cross-Cultural Sample. In the Ethnographic Atlas MHGs that are borrowed from Abrahamic religions are not systematically distinguished from those that have arisen indigenously and in the Standard Cross-Cultural Sample the majority of MHGs are found in Christian and Muslim cultures [36]. The scarcity of indigenous MHGs in the Standard Cross-Cultural Sample suggests that the frequency of these gods in indigenous Austronesian cultures is representative of patterns globally. Here we have systematically coded for the states of cultures prior to Abrahamic influence.

By excluding clear cases of conversion to Abrahamic religions from our dataset we have controlled for the most prominent form of religious borrowing in Austronesia. In linguistics a subtle form of borrowing, known as calquing, occurs where foreign concepts are adopted using native vocabulary. A similar process may have occurred in the religious beliefs of some Austronesian societies, where the concept of a MHG was borrowed under the name of an existing deity due to contact with Muslim traders. Four out of the six cultures with MHGs in out sample are located in the Southeast Asian cultures where early Muslim trade occurred [37].

example, in the Philippines, Muslim traders arrived at the Sultan of Sulu’s ports at least as far back as the fourteenth century. This fits with the relatively recent emergence of MHGs in Austronesia indicated by our ancestral state reconstructions (figure 1A). High complexity societies may have been more likely to have contact with Muslim traders because they had greater resource surpluses to trade [38]. Thus, instead of a direct causal connection between beliefs in MHGs and political complexity, we suggest that the relationship reflects the increased opportunity for more complex societies to have borrowed the concept of a MHG.

Since at least the time of ancient Greek philosophers, scholars have debated the role that religion plays in human society [39]. The last decade has seen a substantial growth in the contribution of evolutionary theory to these debates. Despite an appreciation of comparative methods in the study of religion, we know of only one other study that uses an explicit computational phylogenetic approach [40]. In contrast to a range of functionalist theories of supernatural punishment [2–4,6], and claims from previous comparative non-phylogenetic studies [5,9,11], our results indicate that beliefs in neither MHGs nor BSP sustains political complexity. While beliefs in BSP may play a role in the emergence of political complexity, beliefs in high gods did not drive the evolution of big societies. The fact that highly complex societies such as the ancient Greeks and Romans did not have MHGs either [39] raises the possibility that this finding may be quite general. This work shows a new way forward for historical and comparative research in the humanities—a rigorous scientific way of testing functionalist hypotheses using comparative phylogenetic methods.

Data accessibility. The data used in this study are contained in electronic supplementary material, table S1.

Acknowledgements. We thank Fiona Jordan for assistance identifying cultures and ethnographic sources, Andrew Meade and Mark Pagel for help with BayesTraits. Puja Singh and Emilie Anderson helped with the initial data coding, while Oliver Sheehan helped with the coding of the final dataset and provided valuable discussion.

Funding statement. This research was funded by grants from the New Zealand Marsden Fund and the John Templeton Foundation, as well as a doctoral scholarship from the University of Auckland.

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