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The Cultural Evolution of Epistemic Practices

The Case of Divination

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Abstract
Although a substantial literature in anthropology and comparative religion explores divination across diverse societies and back into history, little research has integrated the older ethnographic and historical work with recent insights on human learning, cultural transmission, and cognitive science. Here we present evidence showing that divination practices are often best viewed as an epistemic technology, and we formally model the scenarios under which individuals may overestimate the efficacy of divination that contribute to its cultural omnipresence and historical persistence. We found that strong prior belief, underreporting of negative evidence, and misinferring belief from behavior can all contribute to biased and inaccurate beliefs about the effectiveness of epistemic technologies. We finally suggest how scientific epistemology, as it emerged in Western societies over the past few centuries, has influenced the importance and cultural centrality of divination practices.

Keywords Cultural evolution · Divination · Information transmission · Bayesian reasoning · Decision-making

The ethnographic and historical record suggests that most, and potentially all, human societies have developed techniques, processes, or technologies that reveal otherwise hidden or obscure information, often about unknown causes or future events. In historical and contemporary small-scale societies around the globe, divination—"the foretelling of future events or discovery of what is hidden or obscure by supernatural or magical means" (Oxford English Dictionary)—has been extremely common, possibly even universal (Boyer, 2020; Flad, 2008). Despite this prevalence, the specific methods of divination exhibit substantial variability: what scholars today refer to as

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"divination" includes inferring meaning from yarrow sticks (I-Ching), deciphering gods' messages from the flight patterns of birds (augury), inquiring about one's fate through the position of the stars and planets at the time of one's birth (astrology), or identifying the cause of a disease by feeding poison to a chicken (chicken oracle).

For most readers, these practices appear striking: they do not seem to be effective ways to generate accurate information or forecasts based on our understanding of the causal structure of reality. Given our confidence in our causal models, we thus confront a puzzle: why do so many divination practices, whose primary goal would appear to be the generation of accurate information, fail so spectacularly to achieve their apparent purpose?

One obvious answer is that people are indeed seeking their explicit goals to obtain accurate information, yet fail to do so because they are making a mistake—they've come to believe that certain practices often supply the information they seek but, in fact, their practices are not effective. If true, accounting for the cross-cultural recurrence and historical persistence of divination requires explaining how and why people—and indeed entire populations—would repeatedly make such mistakes. Interestingly, while early positivists held this view of divination practices (Tedlock, 2006), modern scholars have sought to contrive all manner of non-instrumental explanations, seemingly to avoid the conclusion that divination practices represent stubborn errors. Common alternative explanations have proposed that divination is a way to (1) claim political legitimacy and power (Flad, 2008), (2) reduce anxiety (Kracke, 1992), (3) circumvent indecision and resolve disputes (Burkert, 1985), or express particular intuitions (Struck, 2016). Indeed, the prevalence of non-instrumental explanations in the anthropological and historical literature led Boyer (2020:100) to quip that divination practices have been explained by, "in short, everything one could think of, except as an attempt to acquire accurate information about some matter of interest."

It is almost certainly true that divination does indeed have some of these effects, but many of these impacts only make sense if people place at least some faith in the divination's epistemic value. For example, military commanders in ancient Greece could use divination to motivate or manipulate soldiers (Meyer 1902, as cited in Naiden, 2013); but the effectiveness of such trickery hinged on the fact that many or most soldiers believed in the validity of the relevant divinatory techniques. Similarly, farmers in late imperial China may have used geomancy ("earth vein") as a valid legal mechanism to resist the construction of railways by foreign powers (Brown, 2017)[1]; yet the fact that this population extensively used geomancy means that its validity was widely acknowledged. In either case, readers should consider how people would react if military generals or courts similarly used divination practices in their societies. Thus, even if these other explanations are relevant in some cases, the task to explain why these divination practices are perceived as efficacious in the first place remains.

This paper is organized into two parts. First we present evidence that (a) most divination practices are best viewed as epistemic technologies (tools or methods that

[1] The idea here is that geomancy can be used to identify "earth veins" (龙脉), and that the construction of railways would "disrupt" these earth veins. Disrupting an earth vein was illegal.

people use to reveal hidden information) and (b) people use these technologies in an effort to obtain factually accurate information about their world in order to inform their decisions and actions. People care about the predictive accuracy of these technologies. Next, to understand how and why such ineffective epistemic technologies evolve, we develop a formal model to decompose and study the process of belief formation. Our model considers the role of intuitive expectations, personal experience, and two forms of cultural learning (testimony and observation). Using biased or incomplete cultural information can lead to an overestimation of the efficacy of divination practices in the population, while the heterogeneity in individual beliefs may remain substantial. We also propose an explanation for how many contemporary populations differ from traditional ones, with a focus on epistemic orientations and institutions.

Divination as Technology

Understanding divination as technology has a long history in anthropology. To define "technology," we employ Merriam-Webster's definition "the practical application of knowledge especially in a particular area," with a focus on the means-end aspect of such knowledge application. Early thinkers such as Edward Tylor and James Frazer unambiguously treat magic (including divination) as false science, or a failed attempt to achieve alleged goals. This school of thought was later termed "intellectualism" and remains controversial among anthropologists today. Early ethnographers such as Bronislaw Malinowski and E. E. Evans-Pritchard rejected Tylor and Frazer's stagist view of human societal evolution but shared the earlier view that magic and divination were instrumental tools aimed at pragmatic goals (Evans-Pritchard, 1937; Malinowski, 1955). Later, Horton (1967) expanded on the Tylor-Frazer thesis and forcefully argued that some traditional religious practices in Africa are really efforts to explain, predict, and control worldly events; thus, these practices were not fundamentally different from the approach of Western scientists. The instrumentalist or "intellectualist" view has nearly vanished since then; more recently, scholars in anthropology and comparative religion have largely focused on the expressive and symbolic aspect of divination (Akinnaso, 1995; Barley, 1983; Geertz, 1983), while more cognitive minded researchers have focused on the psychology of superstition in contemporary Western populations (Risen, 2016; Rudski, 2004; Vyse, 1997).

Although an instrumentalist approach likely fails to explain some, and perhaps many, aspects of religion, ritual, and magic (Keita, 2007), divination practices specifically have a distinctively instrumental flavor. This is because divination—the generation of otherwise unknown information—is rarely an end in itself; the information generated by divination almost always serves as instructions for further action. Divination has several recurrent features that point to its instrumentality as an epistemic technology: it is (1) used for important decisions, (2) costly and often requires a specialist, and (3) approached in ways that only make sense if the actor is actually seeking accurate information.

The first two points are not particularly controversial. Kings and emperors have long used divination to decide when to start a war and with whom to build alliances (Chou, 1979). Farmers have used divination to decide where to plant their crops or to figure out why they were sick (Fiskesjö, 2017). Performing a divinatory ritual or consulting a diviner can often be rather costly: animal sacrifices, which occasionally involve humans, are frequently needed (Akiga et al., 1939; Kopytoff, 1965; La Fontaine, 1959) and the diviners often charge an non-trivial fee for their services (Beattie, 1960; Faulkingham, 1971; Gulliver, 1951; McCulloch, 1952).

The third feature is less well appreciated: many recurrent features of divination only make sense when such activities are viewed as attempts to generate true information. Divination practices, for example, often involve repetition to ensure that the revealed information isn't due to "chance"—like scientific experiments, divination protocols demand replication to build confidence. Consider five examples:

1. In ancient Greece, generals would perform divination procedures multiple times before making important military decisions. As Raphals (2013) points out, if the primary function of divination were to ensure consensus or to boost morale, there would be no incentive to repeat divinatory procedures, at least once the desired response is obtained. This is however the exact opposite of the Greek military practice.
2. In early China, although upper-level military decisions were made by the state, battlefield divination protocols were frequently repeated to determine and verify the most auspicious dates for military action (Yates, 2005).
3. In northern Nigeria during the 1930s, Nupe diviners would sometimes repeat shell throws two or three times to ensure the patterns generated could be replicated, which confirmed the results (Nadel, 1954).
4. The Tiv had even higher standards in the 1950s: people were only satisfied when at least four signs from a "divining chain" were in agreement (Bohannan & Bohannan, 1969).
5. In South Asia in the 1940s, the Santal people would repeat a "twig-planting" divination procedure to determine the location of a witch. When different verdicts were rendered, suspicions arose that a witch was actively working to conceal their location (Archer, 1984).

Besides favoring repetition and the convergence of results, people carefully discriminate among diviners according to perceived skill, ability, or success (Beattie, 1967; Dyson-Hudson & McCabe, 1985; Métraux, 1948). As with physicians and auto mechanics in industrialized societies, diviners with better reputations attract more clients and can charge more (McCulloch, 1952). If divination was not about obtaining accurate information, why bother to carefully discriminate skill and pay more for popular practitioners? Among the Turkana of East Africa, even laymen could earn a reputation of successfully forecasting the outcome of raids and determining the auspicious occasions, effectively fulfilling the role of a diviner (Gulliver, 1951). In other words, diviners are perceived as "skilled" and "unskilled" in pretty much the same way as any other artisans whose abilities can be evaluated by other

community members. When raids fail, the Turkana also blame their leaders if the leader failed to heed the results of a divination (Handley & Mathew, 2020).

Historically, ancient societies classed divination with other technical skills. In ancient Greece, divination (mantikē) was unambiguously categorized as a kind of technique (technē). Pre-Socratic thinkers such as the Athenian statesman Solon (writing around 600 BC) includes prophecy as a *technē*, along with fishing and farming (Roochnik, 2010). The word historically referred to crafts or skills in general, and it is no coincidence that the modern English term "technology" traces its etymological root to this ancient Greek word. Famously, Plato distinguishes divination into *possession divination*, where a seer/diviner directly reveals information acquired from a deity, and *technical divination* (mantikē technē), where the seer/diviner interprets the hidden meaning of natural phenomenon, signs, or portents (Flower, 2008). While technical divination clearly delineates some ability or skill rooted in a learned or inherited ability to produce useful outcomes, it has even been suggested that possession divination was considered a technē by the Greeks (Brickhouse & Smith, 2014; Landry, 2014). Both mantikē and technē serve to produce some desirable or useful outcome, and in this respect an ancient Greek diviner (mantis) who identifies malicious spirits is no different from a modern physician who diagnoses diseases. Paralleling the ancient Greek usage, the classic "Book of Rites" (礼记,~206 BC) from early China explicitly lists divination (卜) as a form of art/technique (技), and placed diviners into the same category as scribes, archers, carriage-drivers, doctors, and other artisans.[2]

The relationship between divination and medicine deserves special mention. Historically, there was significant overlap between divination/magic and more naturalistic healing methods in both ancient Greece and China as well as other prominent early civilizations (He & Zhang, 1994; Raphals, 2017; Sigerist, 1951; Van Nuffelen, 2014). In many traditional societies, the causes of illness are often identified by divinatory methods (Murdock, 1980; Sigerist, 1951) in order to determine the best course of treatment; thus, divination is not unlike a blood test. Just as hospital patients care about the diagnostic accuracy of checking their pulse or heartbeat, people in traditional societies care about whether examining the thigh bones from a sacrificed chicken provides the diviner with valuable diagnostic information.

Divination in Southwest China: An Ethnographic Case

To explore this more deeply, we consider the results of four months of ethnographic research on divination in southwestern China among the Yi in Sichuan and the Wa in Yunnan. Both ethnic groups are small-scale agriculturalists with substantial market integration and access to modern medicine but retain much of their traditional culture. In these populations, a troubled person may consult a diviner for a multitude of reasons, but their primary aim is still to obtain information upon which they

[2] See chapter 5,<Wángzhì>, in *Book of Rites*: "凡执技以是上者: 祝史射御医卜及百工... 不贰事, 不移官." ("All who professed particular arts for the service of their superiors, such as prayer makers, writers, archers, carriage-drivers, doctors, diviners, and other artisans... are not allowed to practice any other thing.").

could base their action. A person may wish to know the whereabouts of his lost cattle so he could go find them; the sex of his wife's unborn child so he may decide whether or not to abort it; or the identity of the malicious spirit that is causing him illness so he could provide the appropriate offerings and sacrifices to send it away. For all these practical purposes, villagers always expressed concern about the diagnostic accuracy (准) of local diviners' predictions and the reputations of different diviners. Though in theory a diviner can reveal all kinds of information, in these populations divination is most often performed to identify the cause of some illness or misfortune.

Interviews with 76 Wa and Yi villagers suggest that they overwhelmingly (96%) believe that certain diviners are "better" than others (for the interview protocol, see the Electronic Supplemental Material [ESM]). It is also acceptable to consult multiple diviners to "get a second opinion," and people frequently make the analogy that consulting multiple diviners is just like seeking advice from multiple doctors (100%, $n=16$). When different diviners give the same diagnosis, people feel more confident that the diagnosis is accurate and thus are more likely to follow the advice regarding which animal to sacrifice (e.g., chicken, pig). People are also explicit in treating traditional forms of divination and modern medicinal diagnoses as alternatives—a common finding in medical anthropology (Legare & Gelman, 2009). Reports from local doctors confirm the instrumentality of illness-related divination; one doctor illustratively said, "the primary goal of local health education is to convince people to go to the hospitals first when they get ill," since the traditional healing processes often result in people going to the doctor at a later and more dangerous stage of their illness—for example, after appendicitis has become acute. Many local villagers, however, exhibit a clear preference for modern medical treatments because of its apparent effectiveness (it works) and plausibility (doctors can literally "see" what goes wrong in their bodies through CT scans and other technologies).

In Sichuan province, the Yi even have a second divination procedure to provide corroborating "evidence" (证据) for the first divination. The full process goes like this: in order to determine what animals to sacrifice for a particular illness (which is believed to be caused by spirits), a diviner drops an egg yolk into a bowl with water, stirs the mix, and then reads the pattern of bubbles on the surface to determine the animal to be sacrificed. If the client is skeptical or uncertain about whether the suggested sacrifice will work, he consults another diviner who ritually asks a question of the form, "Will sacrificing a chicken (or whatever was stated by the first diviner) appease the spirit?" and then burns the shoulder blade of a sheep to create cracks (Fig. 1). This second diviner then reads the cracks to decide whether the chicken sacrifice is likely to do the job. If the signs (the cracks) are auspicious, the client is more likely to proceed with the proposed sacrifice; if the sign is inauspicious, the client must repeat the whole procedure until an auspicious sign appears.[3]

[3] Sometimes the client could ask the second diviner on the spot for suggestions for other candidate animals to sacrifice and perform the sheep shoulder blade divination immediately.

Fig. 1 Sheep shoulder blade bone used by the Yi diviners to "verify" whether a proposed animal to sacrifice will "work"

Both our interviews and many informal ethnographic observations indicate that people believe that divination (and magic more generally) doesn't always work—meaning that it doesn't always deliver accurate information. In the illness context, people frequently make the explicit analogy that visiting a traditional diviner/healer is just like going to the medical doctor, and since doctors also occasionally fail to provide an accurate diagnosis (and a cure), it's unrealistic to expect diviners/healers to get it right every time.[4] To explore this, we straightforwardly asked a sample of 47 Yi adults, "What percentage of the time do you think divination/magic (迷信) works?"[5] The histogram in Fig. 2 illustrates the variation in this population. Strikingly, the distribution shows that most people think divination/magic works most of the time. The modal percentage indicates that it works about three quarters of the time, and 83% of participants reported values over 50%. However, significant variation in the responses exists (mean = 64.25, SD = 26.48), and 9% reported that it never works. Note that people's responses here do not pattern with their sex, age, or level of formal schooling (see the regression analysis in the ESM, Table S1).

Of course, these percentages should not be taken too literally as people may not be able to fully access or articulate their beliefs in a quantified form (Blanton et al., 2007; Nisbett & Wilson, 1977). Nevertheless, it does demonstrate that the majority of people believe that divination/magic often works, but certainly not always. If anything, these reports may be biased downward because both the identity of the interviewer (a Mandarin-speaking ethnic Han from the United States) and the simple act of posing such a question might bias participants towards more skeptical reports.

[4] Both the Yi and the Wa are politically integrated into the People's Republic of China and have access to hospitals. The quality of the doctors and equipment in these hospitals, however, is generally inferior to that in large hospitals in urban areas. Depending on the seriousness of the illness, going to hospitals in the city can be rather costly (payment to the hospital and travel expenses).

[5] Most people did not struggle with being asked for a percentage. It seems that a significant proportion of the Wa and Yi population have some understanding of percentages, possibly because most fertilizers have nutrient percentage information on their packing bags.

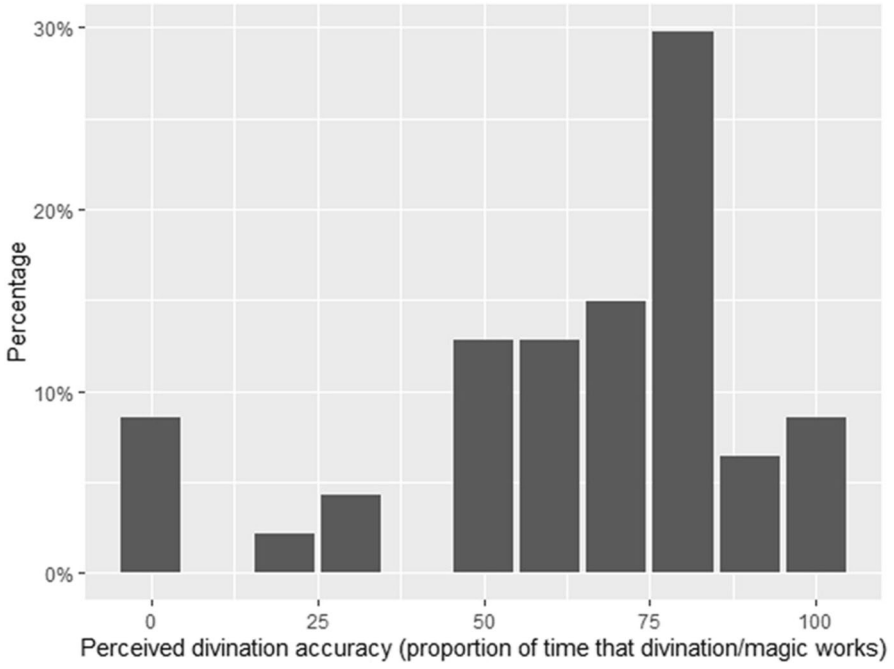

Fig. 2 Distribution of perceived accuracy of divination and magic in general ($N = 47$)

To summarize, several lines of evidence from diverse societies suggest that people in many populations approach divination as an epistemic technology that they aim to employ to improve their decision-making. This evidence includes responses to direct questions regarding the effectiveness of such technology, implicit behavioral patterns such as repeating or checking divination procedures and looking for converging or confirmatory evidence, and the categorization of diviners with other skilled occupations such as artisans.

Why Divination?

Given that divination practices seem unlikely to generate accurate information or diagnosis (unless chicken sacrifices do indeed improve health conditions), we return to our puzzle: why do people believe and perform divination practices? Psychologists and cognitive scientists have tried to answer this question by focusing on two aspects:

a. What are the recurrent features of divination practices?
b. How do such recurrent features contribute to the belief in, or performance of, divination?

Researchers have proposed that the universality and persistence of divination is partly a result of "magical thinking," which all humans are capable of and is likely a reliably developing feature of human cognition (Barrett, 2004; Gardner & Boyer, 1995; Nemeroff & Rozin, 2010). This type of explanation directly addresses question (a) and indirectly question (b): because humans evolved specific intuitions about the causal structures of the world, certain magical or divinatory rituals simply appear more plausible or believable than others. Cognitive scientists have made much progress in explaining the recurring features of divination and magic in general. For example, Legare and Souza (2012) experimentally show that ritual procedures involving more steps and specific times are regarded as more efficacious; Nemeroff and Rozin (2010; Rozin and Nemeroff, 1986; Rozin et al., 1990) argue that people's susceptibility to contagious magic may confer adaptive benefits because the disgust reaction toward unclean items may contribute to pathogen avoidance; Singh (2017) suggests that specific aspects of shamanism, such as their inhumanness (being unlike ordinary humans in appearance and behavior), culturally evolved as a result of selective retention processes; Boyer (2020) proposes "ostensive detachment" as a feature of divination protocols that makes them appear relatively more credible. In sum, this line of work has successfully attributed many recurring features (e.g., repetition, redundancy, presence of supernatural agents) of technological practices to our evolved causal intuitions regarding what constitutes effective practices.

While contributing to an overall explanation, such evolved intuitions seem unlikely to provide the full story. Consider the naïve Tylor-Frazer reformulation of the original puzzle: why do such practices exist and persist if they frequently do not obtain the promised results (Tambiah, 1990)? In other words, why were these technologies not abandoned as the empirical evidence accumulated, even if only in the experience and lifetime of one person? Tylor himself offers some tentative suggestions, including successful outcome by natural means (chance), vague diagnosis, and an underappreciation of negative evidence, though he does not endeavor to deliver a definitive theory. This way of framing the question, however, makes it clear that empirical evidence needs to play a role in the evaluation of divination practices, as with any form of technology. This is particularly salient given that many cognitive and evolutionary scientists (1) argue that humans have powerful mechanisms for epistemic vigilance (Henrich, 2009; Mercier, 2017; Sperber et al., 2010) that have evolved to protect us from being duped into adopting maladaptive practices or beliefs and (2) have emphasized the ways in which our cognition updates in an approximately Bayesian (and optimal) manner (Tenenbaum et al., 2006). Indeed, learning from past experience is a fundamental cognitive adaptation that humans share with many other animals (Pearce & Bouton, 2001; Rescorla & Holland, 1982), and it would be unlikely that people completely ignore empirical evidence when it comes to divination.

Interestingly, to our knowledge, no nonhuman animals waste valuable resources using divination-like practices to supply information for hunting, attacking other animals, or treating illnesses. This point may seem trite, but it highlights the fact that despite our big brains and sophisticated learning abilities, we can still adopt epistemically uninformative practices. One reason why this occurs might be our species' heavy reliance on cultural learning for acquiring our beliefs (Gervais &

Henrich, 2010; Gervais et al., 2011). For humans, empirical evidence consists of more than individuals' firsthand personal experience. Anecdotes, testimony from others and behavioral observations of others, can also serve as important forms of evidence or input into belief formation (Harris et al., 2018; Henrich, 2009, 2016). Though anthropologists and cultural evolutionists have long pointed out that divination practices are transmitted from generation to generation (Watts et al., 2015), how culturally transmitted information shapes people's perceptions of technological efficacy has largely been ignored by both anthropologists as well as the mainstream cognitive approaches (with the exception of Souza & Legare, 2011). Much ethnography suggests that information regarding the efficacy of divination is acquired through testimony rather than direct experience (Fodde-Reguer, 2014; Singh & Henrich, 2020). This is because (1) under uncertainty and especially when costs are high, humans are psychologically predisposed to learn from others (Boyd & Richerson, 1985; Laland, 2004); (2) many divination practices require substantial expertise and thus nonspecialists cannot really "experiment" to check the efficacy of these practices on their own (try doing surgery on your back); and (3) not every individual has the chance to personally consult a diviner to be able to evaluate the predictions. Even in situations where personal experience is involved, the acknowledged uncertainty in divination predictions (people do not expect divination to always generate accurate information) makes a few personal experiences insufficient to reject traditionally accepted claims of predictive accuracy. Occasional failed predictions can be explained away easily, and ethnographic evidence suggests that people readily attribute the predictive failures of divination to technical malfunctions, unfulfilled ritual requirements, or the lack of skill of the diviner (Annus, 2010). By contrast, few see divination failures as reason to question their fundamental validity. Importantly, post-hoc rationalizations of divination failure *should not* be interpreted as people not caring about predictive accuracy. To the contrary, the fact that people feel it necessary to account for predictive failures suggests that they are concerned about such failures and feel compelled to address the outcome (Horton, 1993).

Ample work in economics and psychology suggests that despite our cornucopia of decision-making errors and cognitive biases (Henrich, 2002; Korn et al., 2014; Sharot, 2011), humans do probabilistically modify their beliefs in adaptive ways as evidence accumulates (Ambuehl & Li, 2018; Shah et al., 2016). Belief updating often requires one to integrate information from qualitatively different sources, and research in cultural evolution suggests that humans are "adaptively gullible" (Henrich & McElreath, 2007)—in other words, we may have evolved psychological tendencies to rely heavily on social sources, especially when uncertainty is high (Muthukrishna et al., 2016). Although social learning strategies evolved to enable individuals to acquire adaptive cultural practices, they can occasionally result in the adoption of maladaptive behaviors (Henrich & McElreath, 2003; Richerson & Boyd, 2005).

This view is entirely compatible with recent work arguing that humans have cognitive mechanisms supporting "epistemic vigilance" (Mercier, 2017; Sperber et al., 2010), including some that evolved to avoid or inhibit manipulation by others (Kraft-Todd et al., 2018; Willard et al., 2016). Ethnographically, there's little doubt that epistemic vigilance plays a role in divination: people have always

been, often justifiably, worried that diviners may be incompetent, intentionally deceptive, or charlatans. Boyer (2020), for example, points this out, calling it "private doubt," with ample ethnographic examples (Holbraad, 2012; Jackson, 1978). However, the existence of such epistemic defense mechanisms does not mean humans reject dubious social information completely—Fig. 2 suggests that only 9% of the respondents see divination as always uninformative. A number of cognitive or decision-making mechanisms might promote the persistence of epistemically ineffective practices.

To begin, one obvious reason to not discard a culturally transmitted but dubious practice might be that if the perceived benefit of acting in accordance with social information is high, then people may behave as if the socially transmitted information is true while remaining rather cognitively skeptical. This is effectively a rational choice version of error management theory (Haselton & Buss, 2000; Johnson et al., 2013; McKay & Efferson, 2010), where individuals maximize expected utility given a set of probabilistic beliefs. A person suffering from some illness may consult a diviner, hoping that the diviner may be able to offer the correct diagnosis, which presumably could lead to the correct treatment. The patient here does not need to be certain about the predictive accuracy of the diviner; in fact he can be quite skeptical, but because the potential benefit of recovering as a result of the diviner offering the correct diagnosis is much more than the cost (payment to the diviner and possibly some sacrificed animals), he is willing to give it a try. This type of situation probably happens frequently in modern medical settings: when conventional treatment fails, many people are willing to try alternative medicine and healing methods even though they may be quite skeptical of their efficacy—otherwise they would have used such alternative treatments first (Kantor, 2009; Vohra et al., 2005).

Second, for a naive observer assessing the efficacy of a particular divination practice, a useful source of information comes from observing the costly actions of other people. Noting that other, older, and more successful people consult diviners may lead learners to infer that others really believe in the efficacy of divination. If they update their beliefs accordingly and sufficiently, a positive feedback loop may be created that, operating recursively over generations, could inflate efficacy estimation. Such a phenomenon could result from one of the first mechanisms of epistemic vigilance to be proposed: Henrich (2009) argues that learners should rely on "CRedibility-Enhancing Displays" (CREDs) to avoid being duped or manipulated. The idea here is that learners should be more likely to acquire the beliefs of others when those others perform costly actions that they would only perform if they truly hold their stated beliefs: hearing an esteemed member of one's community extoll the importance of using divination to fight illness is a lot more persuasive if those same individuals also pay diviners for rituals when they are ill. A growing body of empirical work supports this hypothesis (Cho et al., 2012; Kraft-Todd et al., 2018), including work among shamans (Singh & Henrich, 2020).

Behaving optimally in the presence of different information sources can be difficult. Indeed, even pure Bayesians can sometimes end up with suboptimal behavior in certain situations. For example, when individuals can observe others' behavior and make their own decisions in a sequential manner, the first few individuals' decisions may heavily influence later decision-makers to the extent that

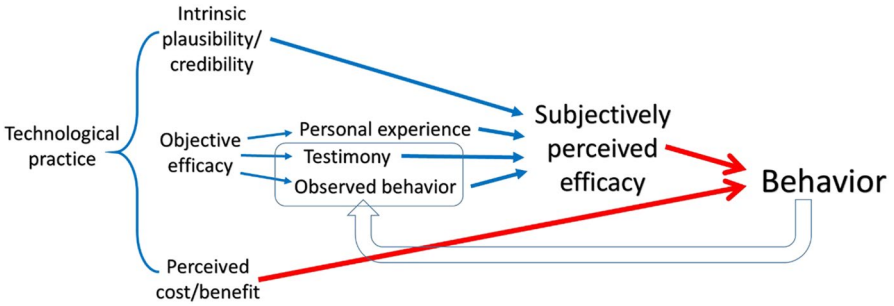

Fig. 3 Causal diagram of factors that affect subjectively perceived efficacy. The three components of a given technological practice (intuitive plausibility/credibility, objective efficacy, perceived cost/benefit) are listed on the left side after the curly bracket; causal relationships that contribute to subjectively perceived efficacy are represented by blue arrows, and causal relationships that contribute to behavior (whether to engage in the technological practice or not) are represented by red arrows. The feedback occurs when one individual's behavior becomes other naive individuals' observations, which may be affected by reporting and inferential biases (hollow blue arrow)

they sometimes completely ignore their own private signal and behave suboptimally. Such "informational cascades" or "herding" has been extensively discussed in economics (Banerjee, 1992; Bikhchandani et al., 1992) and finds ample empirical support (Duan et al., 2009; Kim et al., 2004; Lohmann, 1994). In reality, humans are unlikely to carry out the exact Bayesian computations and therefore imperfect inferences should occur rather often.

Modeling the Transmission of Epistemic Practices

In today's anthropological literature on divination there seems to be an implicit assumption that because divination is not objectively effective, it cannot be the case that people are striving to obtain more accurate information about the world. This narrative logic ignores the fact it is ultimately the subjectively perceived efficacy that matters (Singh, 2017), and objective efficacy is not the only factor that contributes to subjective perception. People's final evaluation of the efficacy of divination (or any technological practice), though mediated by the processing of information from different sources, ultimately has objective efficacy as one important input (Fig. 3). In the introduction, we provided ample evidence for the instrumental nature of divination, which begs the question of its persistence; then we reviewed the existing literature in psychology and cognitive science on the psychological factors that sustain ineffective technologies as well as the importance of cultural learning in belief formation. In this section, we take a formal modeling approach to take into account both the dominant view that the persistence of these ineffective technologies is primarily the result of our evolved intuitions and our proposed learning component in belief updating by tracking individuals' belief in the efficacy of some epistemic technology in a dynamic setting. In doing so, we provide a more rigorous analysis of how different types of information (evolved intuitions, testimony, and

observation of other's actions) contribute to people's belief and confidence in the efficacy of some technology.

Figure 3 shows that divination, or any technological practice, can be perceived as efficacious due to either its intuitive plausibility or objective efficacy. In reality, however, both factors are likely at play. As mentioned earlier, much work has been done to examine the relationship between intuitive plausibility and subjectively perceived efficacy. What is notable about objective efficacy is that it does not manifest itself directly; rather, it contributes to subjectively perceived efficacy via various epistemic routes: personal experience, testimony, observed behavior, etc. Crucially, such epistemic routes do not always guarantee the accurate translation of objective efficacy into subjectively perceived efficacy. In the model, we integrate these different sources of information to analyze how beliefs are updated and when individuals might systematically overestimate the effectiveness of different technologies. We also consider how these beliefs then impact decision-making and behavior, given people's perceived costs and benefits of potential outcomes. In our model, people's behavior is then observed by others in the community, who then use these observations to update their own evaluation of the efficacy of the technology, initiating sequential belief and behavior change at the population level—that is, cultural evolution.

Model Description

Here, we provide only a verbal description of our model, leaving the mathematical details to the ESM. In the model, individuals' belief in some technological practice (Δ) is represented by a beta distribution with parameters α and β that can be updated from various social information sources in a Bayesian fashion. Here α and β denote the relative amount of positive and negative evidence for/or against the efficacy of Δ. Larger α relative to β thus means a strong belief in Δ's efficacy. The mean (expectation) of beta (α, β) is $\frac{\alpha}{\alpha+\beta}$ and can be roughly viewed as a subjective estimation of the proportion of time that Δ yields positive outcome. Importantly, individuals do not distinguish real effectiveness and chance; that is, individuals do not actively try to figure out whether some technological practice performs better than chance. We feel that this is a reasonable assumption as problems routinely solve themselves (e.g., regression to the mean or placebo effect) and individuals are much more likely to focus on cognitively salient events (e.g., divination) that occur prior.

An individual always starts with beta ($\alpha=\alpha_0$, $\beta=\beta_0$), where α_0 and β_0 are the *prior* belief of an individual, which represents her confidence in the efficacy of Δ in the absence of data. Strong, biased priors could result either because humans have evolved psychological intuitions (Nemeroff & Rozin, 2010) or because they fit better with existing beliefs in some cognitive sense (Henrich & McElreath, 2003). A person's α and β values then gradually change as she acquires relevant information from three sources: (1) personal experience, (2) the testimony of others (positive/negative outcome of Δ reported), and (3) the observed actions of others (practicing Δ). In deciding whether to perform Δ, an individual will sample from her belief

distribution and perform Δ if the expected benefit b is larger than the cost c ($p_{\text{sampled}} * b > c$). This is simply a formal way of saying that people who are more confident in the efficacy of Δ are more likely to practice Δ while taking costs and benefits into consideration.

Since we are describing individuals' beliefs probabilistically, the primary aim of this model is thus to examine the conditions under which people's subjectively perceived efficacies deviate from the objective frequency and the associated behavioral outcomes. We are especially interested in any condition that might generate subjectively perceived efficacy greater than the true efficacy (denoted by r; often chance, in the case of divination) because such overestimation could result in costly and ineffective information-seeking behaviors such as divination.

To fully explore the cultural evolutionary dynamics produced by these individual-level processes of belief updating, we constructed an agent-based simulation. Each individual agent in the first generation encounters a situation in which they need to decide whether or not to perform a technological action based on their belief about the efficacy of the technology and a cost–benefit calculation. Agents in the next generation update their belief regarding the efficacy of the technology using the observed behavior and the associated outcomes from a subset of agents in the previous generation (cultural models) and then further update their beliefs using personal experience. As such, the number of different types of information instances is determined by the dynamics of the system, and we examine the parameters that affect the distribution of the individual agents' beliefs at equilibrium (i.e., when the belief distributions of the populations become relatively stable over time).

Although agents in our simulation update their belief in a Bayesian way, the insights that our model generates does not depend on pure Bayesian reasoning. In fact, as long as people update their beliefs in a way that qualitatively resembles Bayesian updating (i.e., increase belief estimate as positive information comes in and decrease belief estimate as negative information comes in), they may end up with biased estimation of the efficacy of these technologies.

Simulation Results

We ran many simulations to examine the relationship between agents' belief distribution and various parameter combinations. See Table S2 in the ESM for a list of the parameters used in the simulation. We first present the distribution of agents' mean belief $\frac{\alpha}{\alpha+\beta}$ for the entire population at equilibrium states by varying a few key parameters, and then we focus on the population average belief levels and further explore the parameter space in a combinatorial fashion.

Strong Intuitions? The Impact of Priors

As mentioned, the a priori plausibility of epistemic practices could contribute to subjectively perceived efficacy. In a Bayesian context, such plausibility translates into non-flat priors. Figure 4 shows the distribution of individual mean beliefs at equilibrium. This result is consistent with our intuition: large α_0 values shift agents'

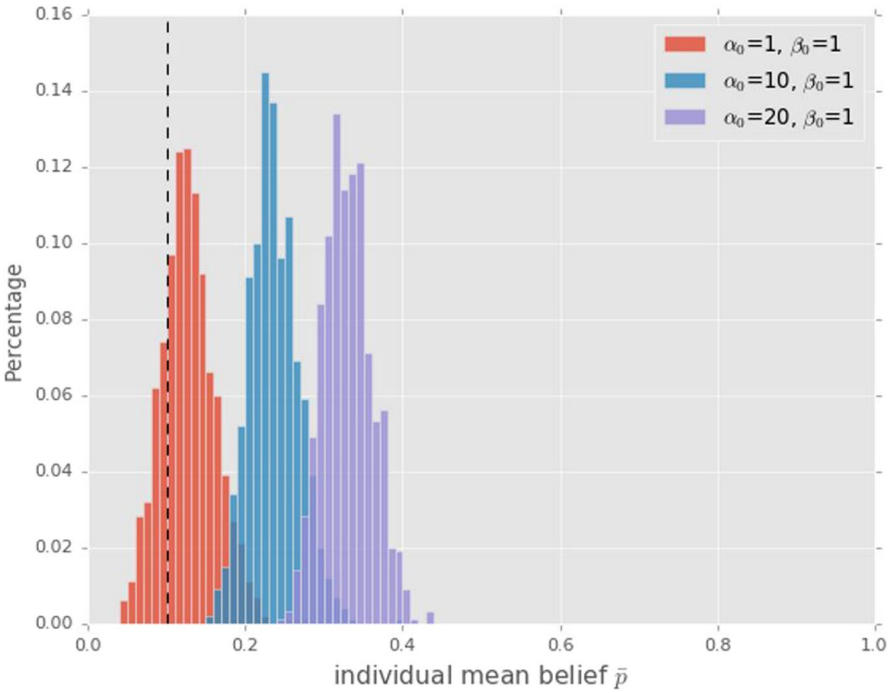

Fig. 4 The distribution of individual mean belief under different prior belief conditions. Mean of the above distributions: 0.11 ($\alpha_0 = 1$), 0.22 ($\alpha_0 = 10$) and 0.34 ($\alpha_0 = 20$). Other parameter values: $b = 5$, $c = 1$, $\theta = 0.0$. Dashed line represents the true efficacy of the technology ($r = 0.1$)

belief distribution toward 1, meaning agents are more likely to believe in the efficacy of technology Δ. Aside from setting the initial belief conditions to get Bayesian updating going, priors in our simulation play a special role: they prevent individuals' beliefs from converging. This is because each generation of naive individuals starts anew with the innate or intuitive prior, which means that they have to reacquire information from various sources. In other words, such "reassertion of the prior" every generation makes empirical experience insufficient to overwhelm the influence of priors, meaning that generations of individuals may always have substantial confidence in the efficacy of some epistemic practice due to its intuitive appeal.

Underreporting of Negative Evidence

As mentioned, instances where epistemic practices fail to yield accurate information may be underreported. Such underreporting could result from multiple factors. First, a rich literature in psychology on "confirmation bias" suggests that people have a tendency to selectively interpret, favor, or recall information that confirms their existing beliefs (Johnson, 2017; Nickerson, 1998). Predictive failures, therefore, may be overlooked because they contradict people's priors. Second, because epistemic technologies (or any technologies for that matter) often require skills and have reputational consequences, diviners themselves may be more willing to advertise their

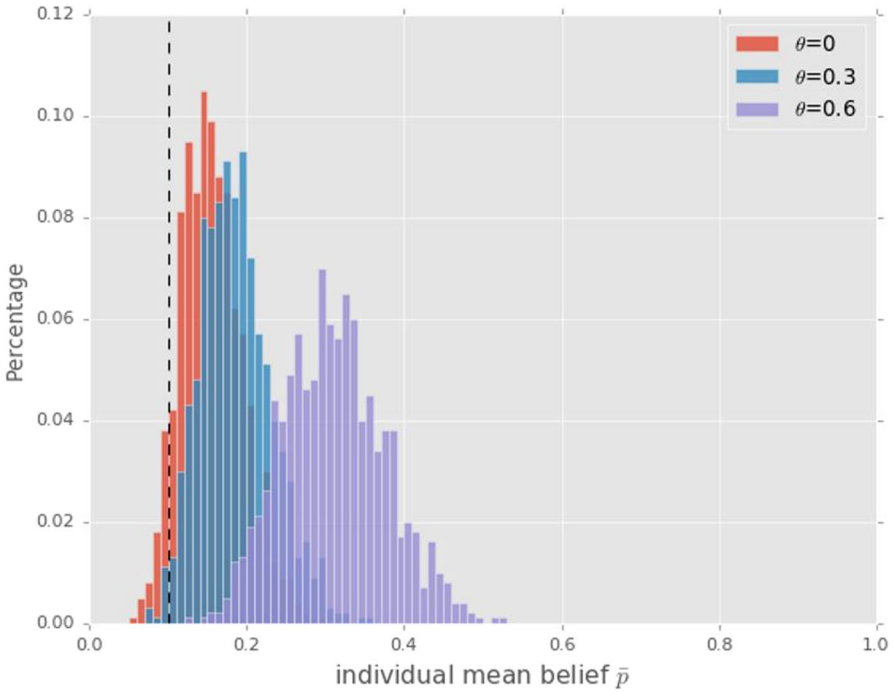

Fig. 5 The distribution of individual mean belief under different underreporting conditions. Mean of the above distributions: 0.26 (θ = 0.13), 0.19 (θ = 0.0) and 0.32 (θ = 0.0). Other parameter values: α = β = 1, $b = 5$, $c = 1$. Dashed line represents the true efficacy of the technology ($r = 0.1$)

success stories as they serve as a signal of competence. Finally, the literature on norm psychology suggests that one of the most fundamental human psychological tendencies is to observe, internalize, and follow rules (Chudek & Henrich, 2011; Schmidt et al., 2016), and in societies where divinatory practices are the dominant method of generating information, revealing negative results may be viewed as a norm violation since doing so would suggest the individual doubts the validity of such divinatory practice. From a historical perspective, the Chinese textual record shows that there likely exists significant underreporting of failed predictions of divination as well as failed attempts in such magical practices as rainmaking (Hong, Slingerland, and Henrich, n.d.) and dream divination (Hong, n.d.).

Figure 5 shows the distribution of individuals' mean belief under different degrees of underreporting bias. Here θ represents the proportion of negative outcomes that is unreported. When no bias exists (θ = 0.0) and people report in proportion to the true rates, the distribution of individuals' beliefs (red) ends up much closer to the true efficacy (dotted vertical line) relative to the distribution when some such bias is present (blue and purple, 30% and 60% negative cases not revealed, respectively).

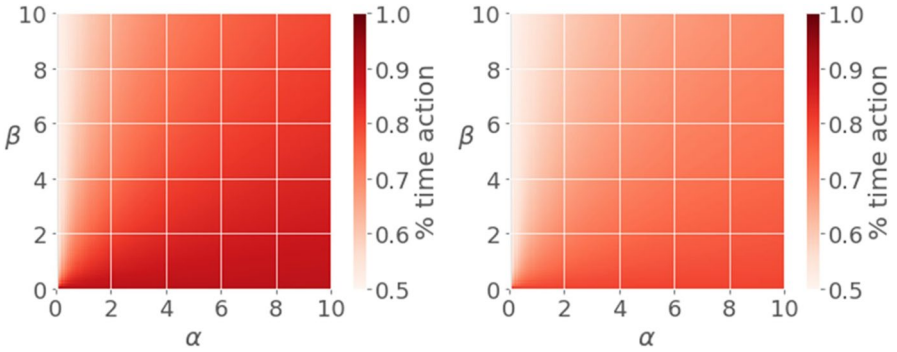

Fig. 6 The relationship between belief distribution parameters (α and β) and the proportion of times agents perform the action (represented by color intensity) under two different cost/benefit scenarios (left: $b/c = 10$; right: $b/c = 5$)

Misinferring/Updating Belief from Observed Behavior

Inferring other individuals' belief based on their behavior is nontrivial, and using such observation to update one's own belief correctly may be very difficult. This is because when we take the cost/benefit ratio into consideration, the relationship between belief and behavior is not one-to-one. In our simulation, individuals sample a belief from their belief distribution (p_{sampled}) and use it to make cost/benefit calculations. Recall we have shown that action will occur when

$$p_{\text{sampled}} * b > c$$

where p_{sampled} is a single value sampled from an individual's beta distribution regarding the efficacy of technology Δ. Rearranging the equation, we have

$$p_{\text{sampled}} > \frac{c}{b}$$

Because using the epistemic practice Δ is a dichotomous action (one either performs the divination practice or not), the relationship between agents' belief and action is a piecewise function, which means the same action/inaction can be the result of a wide range of belief values. Figure 6 shows heatmaps representing the relationship between agents' belief distribution parameters (α, β) and the expected proportion of times agents perform the action under various cost/benefit ratios. Notice that different α and β values often lead to similar frequencies of action performed. When the perceived benefit is larger than the cost (b/c = 10 and 5, respectively, in Fig. 6), the majority of beliefs correspond to a high percentage of "action" decisions, and therefore it would be difficult for naive agents to correctly infer individuals' underlying belief distribution from observed behavior. So, high b/c ratios can conceal valuable information.

Figure 7 shows the distribution of individual mean beliefs under different cost/benefit ratio conditions. When the perceived benefit is relatively low, agents are less likely to believe in the efficacy of technology Δ compared with when perceived

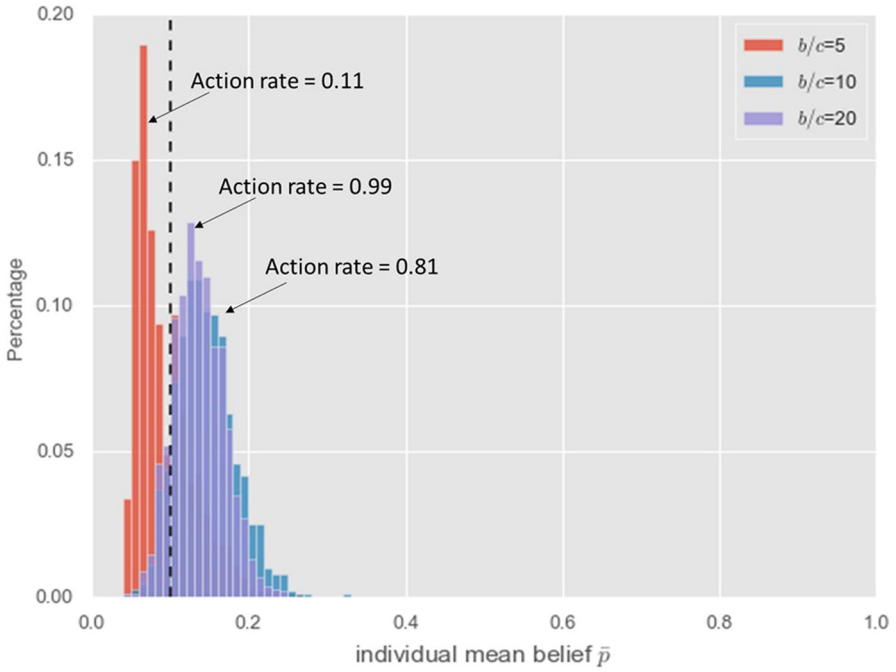

Fig. 7 The distribution of individual mean belief under different cost/benefit conditions. Action rate refers to the proportion of agents who performed Δ in the last step (personal experience) of their life cycle. Mean of the above distributions: 0.092 ($b/c = 5$), 0.145 ($b/c = 10$), and 0.136 ($b/c = 20$). Other parameter values: $\alpha = \beta = 1$, $\theta = 0.0$. Dashed line represents the true efficacy of technology ($r = 0.1$)

benefit is high. This is largely because only a small proportion of the agents in the populations are still performing the action (action rate = 0.11) and therefore agents in the next generation take such inaction as evidence against Δ's efficacy. In contrast, when perceived benefit is very high, almost all individuals perform the action, which, when the epistemic weight on observed action is large, increases individuals' estimation of Δ's efficacy.

Finally, we present a more extensive exploration of the parameter space (Fig. 8). Here, w_0 denotes the epistemic weight of observed action. The error bars indicate that our simulation results are robust, and the results here are consistent with what has already been presented. Nevertheless, visualizing the influence of multiple parameters simultaneously yields some additional insight. Notice that although the contribution of the epistemic weight of observed action (w_0) is positive when the perceived benefit of performing the action is large, w_0 is negatively correlated with the efficacy estimate when perceived benefit is low. The left panel of Fig. 8 ($b/c = 1$) is an extreme scenario: when the cost of performing the action and the perceived benefit is the same, no individual will perform the action because while the cost is certain, the benefit is probabilistic; therefore, p_{sampled} is always smaller than b/c, or 1. Large weight on observed action w_0 will thus decrease individuals' confidence that Δ is efficacious.

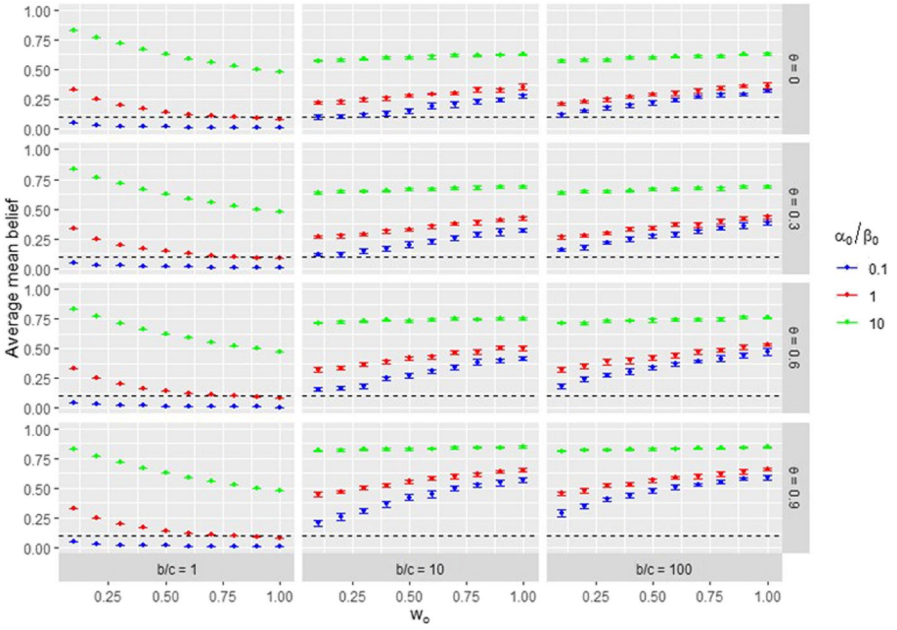

Fig. 8 Exploration of parameter space in a combinatorial fashion. Each data point represents the population average of individual mean belief at equilibrium for a given parameter combination. Error bars represents 95% confidence interval for 10 independent simulation runs. Values of unspecified parameters are as in Table S2 in the ESM. Horizontal dashed lines represent the true efficacy of technology ($r = 0.1$)

Although priors may interact with other parameters, reassuringly, in all conditions stronger priors (large α_0/β_0) lead to higher efficacy estimate. Even in cases where individuals may be skeptical of the technological practice ($\alpha_0/\beta_0 = 0.1$), however, they may still end up estimating its efficacy above its real value ($r = 0.1$). This is especially true when perceived benefit and the epistemic weight on observed action is large.

One implication of this finding is that it may not be necessary to invoke "evolved psychology" favoring certain kinds of content to explain people's belief in seemingly counterintuitive divinatory practices (Boyer, 2020). People in traditional societies may find some practices as odd as modern people do[6]; it's just that the cultural information traditional people receive trumps their intuition. Indeed, Margaret Mead (1932) showed that among the Manus in Papua New Guinea, it was the adults rather than the children who were more prone to magical thinking and supernatural beliefs. More recently, Harris (2012) suggests that people in certain religious societies may even be described as "shedding Enlightenment and moving toward magical thinking" as a result of cultural transmission. Ample developmental research has shown that children acquire a significant amount of information from asking questions (Chouinard, 2007; Frazier et al., 2009) and heavily rely on what they are told,

[6] "Modern" is used here in the sense of epistemically modern, post-Enlightenment, or "Western."

especially by familiar individuals (Corriveau et al., 2009; Harris et al., 2006), since children are often not in an epistemic position to evaluate the validity of culturally transmitted claims.

Our simulation has shown that a few factors, including strong priors, the underreporting of negative evidence, and high perceived benefit to cost ratios combined with the epistemic weight attached to observed actions could all bias individuals to overestimate Δ's efficacy. People are most likely to believe in the efficacy of some technology when it is intuitively plausible, its negative instance is underreported, and its perceived benefit is large, particularly in communities where people heavily rely on observed behavior to infer efficacy. In reality, these factors may all coexist, which could render the deviation between individuals' subjective belief and the true efficacy quite large. We emphasize that although biased priors, which have been extensively discussed in the psychological and cognitive science literature, may certainly contribute to our biased belief, social and cultural factors, in particular the generation and transmission of cultural information, may also play important roles in affecting our evaluation of the efficacy of technologies.

Discussion

We have presented converging lines of evidence showing that many forms of divination can and should be viewed as technological practices, and given that people often have a probabilistic understanding of their efficacy, a combination of biases could generate excessive confidence in the effectiveness of these practices at the population level. Below we discuss the relationship between divination and some early modern epistemic practices in the West, the interplay between evolved intuition and cultural transmission in maintaining ineffective technologies, and some comments on the evolution of divinatory practices as societies transition toward epistemic modernity.

Divination: Just Like any Other Technological Practice?

Many authors have pointed out that viewing divination as a method or device to generate information is not qualitatively different from other types of ordinary technology. In her book *Ancient Greek Divination*, Sarah Johnston (2009) points out.

> The good diviner knew about the sympathetic links between, say, the appearance of a night-owl during the day and political insurrection and could therefore predict what was going to happen when such a bird showed up. But this prompted such questions as how we should distinguish between the art of the diviner and the art of the doctor, the farmer, the sailor or anyone else who made it his business to learn how one thing signified another that was yet to come—is it divination to know that an olive crop will be abundant by looking at blooms early in the season, or is that just good arboriculture? Is it divination to predict rain by looking at a dark cloud, or is that simply the sort of practi-

> cal meteorology that every reasonably intelligent person picks up during the course of life? (2009:5)

What Johnston suggests here is that it may be difficult to classify divination as a special kind of activity which is fundamentally different from everyday means-end practices in any definitive way. Furthermore, what contemporary researchers refer to as divination was also often part of the general epistemic effort to identify regularities in the world. Indeed, what was viewed as legitimate ways of producing knowledge in one historical period could be considered divination (or pseudo-science) in a later time (Thagard, 1978): both astrology and physiognomy have suffered from this fate. Note that the historical development of astrology has always been linked with astronomy, which nobody today would deny as a legitimate science. In many early civilizations such as those in ancient Greece, Babylon, and China, astronomers and astrologers were the very same people (Huber & Swerdlow, 2001; Pankenier, 2011; Rochberg, 2004). In fact, the goal of astronomy was often to inform practical astrological applications (Nakayama, 1966). This was even true for some of the great early modern thinkers: both Johannes Kepler and Isaac Newton were interested in astrology (Boner, 2008; Field, 1984; Force & Popkin, 1999); Kepler's fascination with astrology even led him to personally produce more than 800 horoscopes (North & Hoskin, 1995).

Physiognomy has a similar story. In many ancient civilizations, physiognomy, or the study of the correspondence between facial/physical features and psychological characteristics, constituted much of their practical philosophy. Influential thinkers such as Aristotle wrote extensively on physiognomy, primarily on the resemblance of humans and animals regarding certain characteristics; for example, a person with a large (ox-like) forehead is sluggish (Raphals, 2013), which in cognitive scientific terms would be a kind of similarity-based induction (Heit, 1997; Weber & Osherson, 2010). Throughout Western intellectual history the study of physiognomy has long been regarded as a valid science with a sound theoretical basis despite occasional skeptics (Ziegler, 2007). Physiognomy's younger brother, phrenology, also played a significant role in early studies in psychology and anthropology as late as the nineteenth century (Greenblatt, 1995; Staum, 1995). To be fair, the meta-idea that physical traits may be correlated with psychological ones is not totally implausible even by today's standards; behavioral and anatomical phenotypes could share an underlying genetic basis and could therefore be correlated. For example, individuals with Down syndrome have very characteristic physical appearances that are often accompanied by cognitive deficiencies and distinct behavioral patterns (Patterson, 1987).

Why Divination? Evolved Intuitions and Cultural Transmission

This paper has emphasized the role of adaptive learning mechanisms in shaping individuals' beliefs and technological behavior at the population level. Of course, this is not to deny the importance of content-specific intuitions; as mentioned, they likely contribute to our priors in the belief-updating process. The "priors" in the model (α_0/β_0) refer to both the evolved and *transmitted* or *developed* intuitions. In

other words, the "priors" need not be specific evolved psychological tendencies; they could also be culturally transmitted worldviews or meta-understandings of the causal structure of reality. With such priors, belief updating based on information from different sources takes place. In this paper, we asked if such updating, even if incoming information is optimally processed, always produces the correct belief regarding the efficacy of various technological practices. We have provided a theoretical framework to illustrate that subjectively perceived efficacy can be different from objective efficacy, and we presented a few scenarios where both biases (e.g., underreporting of negative evidence) as well as learning and decision-making dynamics (e.g., misinferring belief from behavior in the presence of cost/benefit analysis) can lead to an overestimation of the efficacy. Across historical/cultural space and time, humans everywhere have been empiricists, in the sense that they incorporate sensory data obtained from their experience into their beliefs and subsequent decision-making. These data are often not sufficient or even available, in which case we necessarily rely on socially transmitted information, which itself may occasionally be inaccurate.

In a Bayesian framework, the relative weight of different information sources becomes key in determining the eventual belief-updating outcome. Do humans weigh personal experience more than anecdotal stories or observed behavior? What are the types of mental calculations when different sources provide conflicting information? These important, unanswered empirical questions should be addressed in the future. We suggest that significant cultural variations on these epistemic weights may exist. Most notably, post-Enlightenment societies have undergone a profound epistemic transition toward an emphasis on experience over transmitted wisdom (Strevens, 2020; Wootton, 2016), and such a transition may have induced a cascade of institutional and psychological changes regarding what individuals consider to be legitimate ways of generating genuine knowledge (Henrich, 2020).

Modernity, Science, and the Evolution of Epistemic Norms

Modern societies differ from traditional societies in many ways. (As noted above, we use the words "modern" and traditional" to refer to differences in individual epistemic orientations [preferred ways of accessing and evaluating knowledge] and in societal epistemic institutions.) We argue that two crucial differences explain why people in modern societies are able to obtain relatively more accurate beliefs. First, technology, science, and Western-style education that emphasizes a materialistic worldview produce a different kind of "prior" in post-Enlightenment, contemporary societies. A person who lives in such societies does not need data to be deeply suspicious of the claim that illnesses can be diagnosed by examining the holes in chicken thigh bones and be cured by sacrificing domesticated animals to appease the spirit; our metaphysical theory about causality is mechanical and materialistic, and it actively denies the causal relevance between events that do not have plausible physical connections. Second, modern societies have a larger division of labor in knowledge production and transmission: scientists as the producers of knowledge and lay people as the consumers of knowledge. Scientists value personal experience

and anecdotal experience, but they do so in a systematized way: personal experience becomes randomized, controlled trials and anecdotal stories become meta-reviews and meta-analysis, which largely avoids the underreporting of negative evidence and other biases. Additionally, many lay people in such science-reliant cultures also develop a sense of how knowledge should be reliably generated; for example, one does not need to be a scientist to know that evaluation of the efficacy of drugs requires randomized, controlled trials (minimally, some kind of experimentation), or that a neighbor's anecdotal story of her horoscope correctly predicting her personality does not qualify as evidence for the validity of astrology. In this way, scientists are able to generate accurate information, and lay people, by devaluing personal experience and anecdotal stories, heavily weigh information from scientists (who are the epistemic authorities) and thus acquire relatively more accurate beliefs and effective technologies.

Given the profound difference between modern and traditional societies in this epistemic aspect, it may be useful and informative to dig deeper and examine the historical context in which such epistemic transition happened. Historians of science have been arguing over whether there was such a thing as the "Scientific Revolution" (Beale & Hall, 1956; Keller et al., 1993; Shapin, 2018), and there has been no lack of speculation regarding why the rise of empirical science occurred in Europe (Singh, 1987; Sivan, 1985). Yet, whatever the initial cause, few would deny that their spectacular scientific and technological developments gave the Europeans a definitive advantage in their interaction with other societies. We suggest that the spread of scientific institutions and experimental methods may be viewed as an example of cultural group selection (Richerson et al., 2016). On the one hand, the products of science, such as military technologies, undoubtedly contributed to the success of Europeans in conquering other groups, after which European cultural practices diffused to these groups through colonization and prestige-biased transmission (Henrich et al., 2012). On the other hand, the realization of the superiority of modern science and technology also prompted non-European societies to adopt both practical technologies and the scientific institutions that generate such technologies. Below, we examine two historical cases (Japan and China) with some details of how such transitions occurred. Both nations were exposed to Western military technology during the mid-nineteenth century (Cheng & Waley, 1960; Hones & Endo, 2006) and were overwhelmed by its technological superiority. The scholar of late Edo period Japan, Sakuma Shozan, famously proposed: "Eastern ethics, Western science" (Van Sant, 2004), and in the subsequent Meiji restoration more substantial westernization occurred, including the establishment of Western-style scientific and educational institutions (Bartholomew, 1989). Many traditional cultural practices and beliefs were labeled superstitious (迷信/めいしん), and some were banned at the legislative level (Figal, 1999). The Qing dynasty of China initially focused on adopting western military technology as the ruling class and the literati attributed losing the First Opium War solely to the superior ships and cannons (船坚炮利) of the British Navy (Cheng & Waley, 1960) but later also established Western-style schools and set up programs to send promising Chinese students to Europe and the US for higher education almost exclusively in applied science and technology (Deng, 1995; Xiu-li, 2008). The Qing dynasty, however, did

not last long and was overthrown in 1911 (Gao et al., 2015). Shortly thereafter (in 1919), a massive political-cultural movement (known as the May Fourth Movement) deemed the fundamental source of China's weakness as traditional value systems and culture in general; leaders of this movement proposed a categorical rejection of almost everything traditional and strongly espoused Western ideals of democracy and science (Spence, 1982) as well as kinship and marriage institutions, such as normative monogamy, bilateral inheritance, and prohibitions on arranged marriages (Henrich, 2020). During the Republic of China era (1912–1949), divination, along with a range of other traditional cultural practices, came to be viewed as irrational superstitions that should be eradicated (Zhiwei, 2009). Note that both Japan and China have sustained various kinds of divination and magic practices for millennia; it can be very difficult for societies to epistemically modernize on their own, and such modernization often requires external influences at the group level.

From critical reliance to marginalization, the substantial decline of divination in many parts of the world cannot be fully explained without considering the diffusion of Western science and the epistemic culture it fosters. To reiterate, the technological nature of divination practices means that it suffers in the presence of science on two fronts: (1) divination loses its intrinsic plausibility and (2) the efficacy of divination practices does not survive systematic scientific examination. Granted, astrology and various kinds of fortune-telling remain popular across the world, but their popularity is rather marginal compared with our trust in scientific authorities (in the West at least) as reliable information sources, and people's attitude toward them is markedly different from that in traditional societies. In fact, astrology and many kinds of fortune-telling in epistemically modern societies have transformed into a form of entertainment (Johnston, 2009; Miller, 2014; Šaknys, 2015).

Conclusion

We contend that divination should be viewed as epistemic technology based on ethnographic accounts, historical evidence, and fieldwork details. Many factors, including evolved intuitions and biased forms of cultural transmission, may contribute to subjectively perceived efficacy of divination and may lead to overestimation of efficacy. Modern societies are more able to recognize the ineffectiveness of divination practices through their interrelated epistemic institutions, norms, and beliefs. The global spread of these epistemic institutions and norms has been driven by their contribution to the success of European populations in intergroup competition.

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Code Availability Code used for simulation is publicly available at https://github.com/kevintoy/divination_as_technology

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

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