The Evolution of Ineffective Technologies in Human Societies – A Cognitive and Cultural Evolutionary Perspective

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The Evolution of Ineffective Technologies in Human Societies – A Cognitive and Cultural Evolutionary Perspective

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The Evolution of Ineffective Technologies in Human Societies – A Cognitive and Cultural Evolutionary Perspective

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3/2/2022

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Abstract

Throughout history and across human societies, people practiced magic, divination, and other objectively ineffective technologies. Why would people engage in these ineffective and often costly practices? In this dissertation, I draw extensively from the literature of cognitive science and cultural evolution, and provide a theoretical framework for understanding the nature of ineffective technologies as well as empirical data (historical and ethnographic) that highlight some of the factors that contribute to their persistence. Briefly, I suggest that individuals often entertain much uncertainty in the efficacy of these technologies – they are aware that technological practices do not "work" 100% of the time, yet may be willing to try them as a result of rudimentary cost-benefit analysis. Importantly, the belief component is affected by both biases in cultural transmission (e.g., under-reporting of failures) and biases in individual cognition (lack of active comparison between perceived efficacy and chance). I also discuss the epistemic difference between traditional and modern societies, and why individuals in the latter have access to more genuinely effective technologies.

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Acknowledgements

I would like to thank my mentor Vince Eckhart at Grinnell College for inspiring me to become a scientist, Erol Akcay and Coren Apicella at Penn for sparking my interest in evolutionary sciences, Joseph Henrich for giving me the intellectual freedom to explore everything that makes us human, Susan Carey and Erin Hecht for serving in my thesis committee and offering valuable suggestions on earlier drafts of the dissertation, and all those who have had stimulating intellectual exchanges with me. I would not proudly call myself an evolutionary anthropologist without these people.

Introduction.

Why do ineffective technologies such as magic and divination recurringly appear and persist in human societies? In this dissertation, I address this anthropological puzzle by focusing on individual cognition (how people construct their belief in the efficacy[1] of magic and divination) and information transmission (how efficacy information is passed on amongst individuals in a population). Through a combination of theoretical modeling, qualitative/quantitative historical data and ethnographic observations, I argue that people overestimate the efficacy of ineffective technologies due to 1) a worldview that supports the theoretical plausibility of these technologies and 2) inference errors where people mis-infer belief from observed action, 3) reporting biases where failures are under-reported, and 4) individuals lacking statistical training ignores baseline efficacy (chance) when evaluating the efficacy of some technological practice. While previous evolutionary researchers have mostly invoked evolved intuitions to explain the cultural success of ineffective technologies, I aim to emphasize the empirical aspect of human cognition and use ample historical and ethnographic examples to illustrate how ineffective technologies may persist despite the ubiquitous human concern for these technologies to yield desired outcomes.

This dissertation consists of three parts. In Chapter 1, I review existing literature on magic and divination, and strongly argue for the instrumentality of magic and divination; that is, what has been referred to as magic and divination in the western anthropological literature are genuine goal-directed actions, and share the same fundamental aim as modern science: to explain, predict, and possibly control worldly events (Horton 1967). Divination in particular, is

[1] Throughout this paper, efficacy represents the probability that a desired outcome occurs after a particular technological practice is performed.

no more than man's effort to obtain accurate information upon which to base his decisions. In the Divination paper, we specifically examine divination practices and offer extensive historical and ethnographic evidence showing how they were/are viewed and used as ordinary epistemic technologies. In the same paper, we consider both how individuals update their beliefs and how beliefs are transmitted/inferred, and theoretically model this process at the population level. Both intrinsic plausibility which may be due to evolved intuition or culturally transmitted worldviews and objective efficacy contribute to subjectively perceived efficacy which represents how much individuals believe in the efficacy of the technology. Importantly, the translation of objective efficacy into subjective efficacy occurs via various channels, and may be subject to reporting and inferential biases.

In Chapter 2, I present three different case studies (rainmaking, dream divination, fetal sex prognostication) that take advantage of the extensive historical record in traditional China to examine how each is affect by the above factors. In the rainmaking paper, we provide a comprehensive analysis of traditional rainmaking practices in China and construct a dataset with the contextual details of rainmaking, especially the outcome of rainmaking attempts through keyword queries in the official Chinese dynastic histories (二十四史). In the same paper, we also point out that when evaluating the efficacy of various rainmaking methods, people often do not treat all traditional rainmaking as a single method to be evaluated, but rather consider multiple individual rainmaking protocols as separate technologies which results in a "multiple testing" problem. The idea is that when a large number of hypotheses were being considered simultaneously without controlled measure such as the Bonferroni correction (Armstrong 2014), some hypotheses may appear statistically significant simply due to chance. In the context of rainmaking, this means that some rainmaking methods may appear to be effective because many

different methods are available in the market and some happen to obtain a successful track record by chance.

In another paper that examines dream divination using the same dynastic sources, a similar reporting bias is revealed: most of reported predictive outcomes are successes. In the paper we extensively discuss the reasons for such overwhelming success: in addition to the aforementioned under-reporting of predictive failures, dreams may be deliberately fabricated or retrospectively inferred to match reality. That is to say, because dreams are private phenomenon, people can "make up" dream strategically to their advantageous (e.g. an emperor could say that her mother had dreamt of sun or dragon when pregnant with him[2]). Nonetheless, regardless of the mechanism, a naïve reader will be faced with the overwhelming success of dream divination which will undoubtedly increase his belief in the efficacy of dream divination. At the very minimum, these successful records may convince the reader that dreams can at least in theory be used for predictive purposes, and the occasional failures may be attributed to the incompetence of individual diviners (see also the rainmaking paper for the scenario where the efficacy of individual rainmaking protocols is evaluated instead of rainmaking as a whole, resulting in the perceived efficacy of some rainmaking methods to be higher than chance efficacy due to chance). These readers, in turn, will become more likely to under-report and retrospectively infer dreams ("where there is a outcome, there must be a sign" mentality), resulting in a feedback cycle where the efficacy estimate of dream divination as an information technology gets recurrently inflated.

[2] Of course, when recorded by ancient historian, these made-up stories will be recorded as factual episodes. See the Dream paper for more historical details.

My third case study concerns fetal sex prognostication where the sex of a fetus (boy or girl) is predicted by some folk method. Regarding the reporting bias, fetal sex prognostication is an ideal case because unlike rainmaking or dream divination where we do not know the true efficacy (i.e. chance efficacy), or the probability that an attempt will be followed by a success, in the case of fetal sex we know that the chance efficacy of correctly predicting the sex of a yet-to-be-born baby is roughly 50%. As such, any substantial deviation from 50% in reporting would be definitive evidence of a reporting bias. Because the recorded cases of fetal sex prognostication is relatively few, we queried cases in three different genre of texts: official dynastic history, encyclopedia books (类书), and local gazetteers (地方志). All three genres show a similar pattern: there are more predicted boys than girls and much more predicted successes than failures.

In Chapter 3, the last part of my dissertation, I present a detailed ethnography of the Yi people in Southwest China (Hongxi town, Meigu County) regarding their ghost/spirit belief system, divination, and magic healing practices based on seven months of fieldwork conducted between 2019 and 2021. I show that Yi people's belief in ghosts and spirits serve as the theoretical basis for various divination and magic practices, which are treated as means-end actions like any other ordinary technologies just as we argued in the Divination paper. In addition to invoking intuitive dualism to explain the belief in ghosts and spirits, I emphasize the role of cultural transmission in sustaining and reinforcing such beliefs at the population level via abductive reasoning. I point out that for the Yi, the presumed existence of ghosts and spirits are strongly supported by inference from observations and transmitted testimony. Specifically, many public rituals assume the existence of ghost and people often reason in the following way: "if there are no ghosts, why would people perform these rituals?" and for instrumental rituals whose

outcome can be easily observed, “if there are no ghosts, why would these rituals work?” As Horton (1967) points out, such erroneous reasoning is likely due to a lack of awareness of alternative explanations, or more generally, inference to the best (available) explanation. Regarding transmitted testimony, individuals may interpret ambiguous given some sufficiently strong initial belief in the existence of ghosts, yet during the transmission process (sharing of the ghost stories) the uncertainty involved in the interpretation of the situation may get lost and the “fill in the blank” memory reconstruction process (Schacter, Guerin, and St. Jacques 2011; Manning and Loftus 1996) may cause the “ghostness” of the story to be exaggerated. The listener will then get a “false impression” regarding the likelihood of ghosts/spirits existing.

As in the above historical studies, I also identified significant under-reporting of ritual failures among the Yi. Additionally, I discovered a Kahneman-Tversky type heuristic bias where the base-rate of some uncertain event occurring is ignored when individuals make judgements that implicitly requires the base-rate for comparison purposes. In the case of fetal sex prognostication, for example, in order to evaluate the ability of some diviner or the efficacy of some divination techniques, one needs to compare the performance in question with chance, which is 50%. The Yi people in the field, however, do not even appear to know this chance value (at least explicitly). To obtain systematic data, I take a vignette approach and asked the two following questions:

> Q1) If a diviner correctly predicts the fetal sex 50 out of 100 pregnant women, what do you think of his/her divining ability? (5-point Likert scale from very low to very high)
>
> Q2) If someone without any divining ability only randomly guesses fetal sex, how many out of 100 do you think he’ll guess correctly?

On the surface, the answers to these questions should be very obvious to anyone with basis knowledge of statistics and probability. However, these are far from trivial questions for Yi participants. The majority of participants think that a diviner that performs exactly at chance level has some divining ability after all. While over half of the participants think diviner with 50% success record is merely "mediocre" (note that even "mediocre" here is a somewhat positive evaluation and can also be translated in English as "fair"), a substantial amount (over a quarter) of the participants rate the diviner's ability as either "high" or "very high". Correspondingly, few participants (less than 15%) think that a random guesser would achieve a 50% success rate (which from a statistical perspective is the most likely outcome), and the majority think that he/she would have a success rate much smaller than 50%.

The exact mechanism of such phenomenon remains to be discovered, and I have additional survey data suggesting that this is very robust bias (Hong, unpublished). Like under-reporting of negative evidence, such bias in thinking about chance and uncertainty may contribute to the recurrence and persistence of ineffective technologies quite generally. As long as the promised result can appear by chance, people may fail to recognize that technologies do not perform any better than "doing nothing". The key here is that people are not consciously comparing the efficacy of some technology with the natural frequency of positive outcomes, which, when sufficiently large, may create the illusion that technologies aiming at producing these outcomes have a fairly high success rate and are thus worth using. Note that this phenomenon occurs even when individuals have full access to the empirical data needed for such comparison such as fetal sex prognostication. In reality, such information is often not readily available in most other domains, creating an additional layer of difficulty for definitively rejecting certain technologies as ineffective.

Chapter 1. Theoretical Framework for Understanding Ineffective Technologies

(Publication: The Cultural Evolution of Epistemic Practices: The Case of Divination, *Human Nature* 32(3), 2021)

In this chapter, we lay out the theoretical framework for understanding the cognitive basis and the cultural evolutionary dynamics for understanding human technologies, using divination as an example. Briefly, we draw from the extensive ethnographic and historical evidence and argue that divination should be viewed as epistemic technologies and its persistence is due to various psychological and social factors. Through agent-based simulations, we found that strong prior belief, under-reporting of negative evidence, and mis-inferring 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 the Western societies over the last few centuries, has influenced the importance and cultural centrality of divination practices.

1. Introduction

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" –has been extremely common, possibly even universal (Flad 2008; Boyer 2020). Despite this prevalence, the specific methods of divination exhibit tremendous substantial variability: what scholars today refer to as "divination" includes inferring meaning from yarrow sticks (I-Ching), deciphering gods' message from the flight patterns of birds (augury), inquiring about one's fate through the position of the stars at his birth time (astrology), or identifying the cause of a disease by feeding poison to a chicken (chicken oracle).

For most modern 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) to quip that divination practices have ben 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 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 Greek could use divination to motivate or manipulate soldiers (Meyer 1925-58); but, the effectiveness of such trickery hinged on the fact that many or most soldiers believed 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[3] (Brown 2017); 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

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

explanations are relevant in some cases, the task remains to explain why these divination practices are perceived as efficacious in the first place.

This paper will be organized into two parts. In Part 1 (section 2), we present evidence that (a) most divination practices are best viewed as epistemic technologies (tools or methods that 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. In Part 2 (section 3), to understand how and why such ineffective epistemic technologies can 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. Using biased or incomplete cultural information can lead to an over-estimation of the efficacy of divination practices in the population on average, 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.

2.1. Divination as technology

Understanding divination as technology has a long history in anthropology. To define "technology", we employ the dictionary definition "the practical application of knowledge especially in a particular area" (Merriam-Webster), 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 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 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 (Geertz 1983; Barley 1983; Akinnaso 1995), while more cognitive minded researchers have focused on the psychology of superstition in contemporary western populations (Rudski 2004; Risen 2016; Vyse 1997)

While 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 (Chou 1979) have long used divination to decide when to start a war and with whom to build alliances. 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 (Kopytoff

1965; La Fontaine 1959; Akiga, East, and International Institute Of African Languages And Cultures 1939) and the diviners often charge an non-trivial fee for their services (Faulkingham 1971; Beattie 1960; 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, divinations 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, while 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 4 signs from a "divining chain" were in agreement (Bohannan and 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,

suspicious arose that a witch was actively working to conceal their location (Archer 1984).

Beside repetition and the convergence of results, people carefully discriminate among diviners according to perceived skill, ability or success (Beattie 1967; Dyson-Hudson and 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 and 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 "technē" 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 (Landry 2014; Brickhouse and Smith 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 western 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[4].

The relationship between divination and medicine deserves a 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 (L. Raphals 2017; Yumin He and Zhang 1994; Van Nuffelen 2014; Sigerist 1951). In many traditional societies, the causes of illness are often identified by divinatory methods (Sigerist 1951; Murdock 1980) 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, they care about whether examining the thigh bones from a sacrificed chicken provides the diviner with valuable diagnostic information.

2.2 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

[4] See chapter <Wangzhi> in Book or Rite: "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."

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 could base their treatment. Farmers may wish to know the whereabout of his lost cattle so that he could go find it, the sex of his pregnant wife's fetus so that he may decide whether to abort it, or the malicious spirits that is causing him illness so that he could provide to 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 about 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 Supplemental Information). 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, etc.). People are also explicit in treating traditional forms of divination and modern medicinal diagnoses and alternatives—a common finding in medical anthropology (Legare and Gelman 2009). Reports from local doctors also confirm the instrumentality of illness related divination; one doctor said "the primary goal of local health education is to convince people to go to the hospitals first when they get ill", as the traditional healing processes often result in people going to the doctor at a later and more

dangerous stage of their illness – e.g. after an appendicitis has become acute. Many local villagers, however, exhibit a clear preference for modern medical treatments because of its effectiveness (it works) and its plausibility (doctors can literally "see" what goes wrong in their bodies through things like CT scans).

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 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 (Figure 1.1). 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.[5]

FIGURE 1.1. SHEEP SHOULDER BLADE BONE USED BY THE YI DIVINERS TO "VERIFY" WHETHER A PROPOSED ANIMAL TO SACRIFICE WILL "WORK."

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

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.[6] To explore this, KH straightforwardly asked a sample of 47 Yi adults, "what percentage of the time do you think divination/magic (迷信) works?"[7] The histogram in Figure 1.2 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, there exists significant variation in the responses (mean = 64.25, standard deviation = 26.48) and 9% reported that it never works. Note that people's responses here do not patterns with their sex, age or level of formal schooling (see the regression analysis in supplemental Table 1.S1).

[6] 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, are much inferior to 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).

[7] 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.

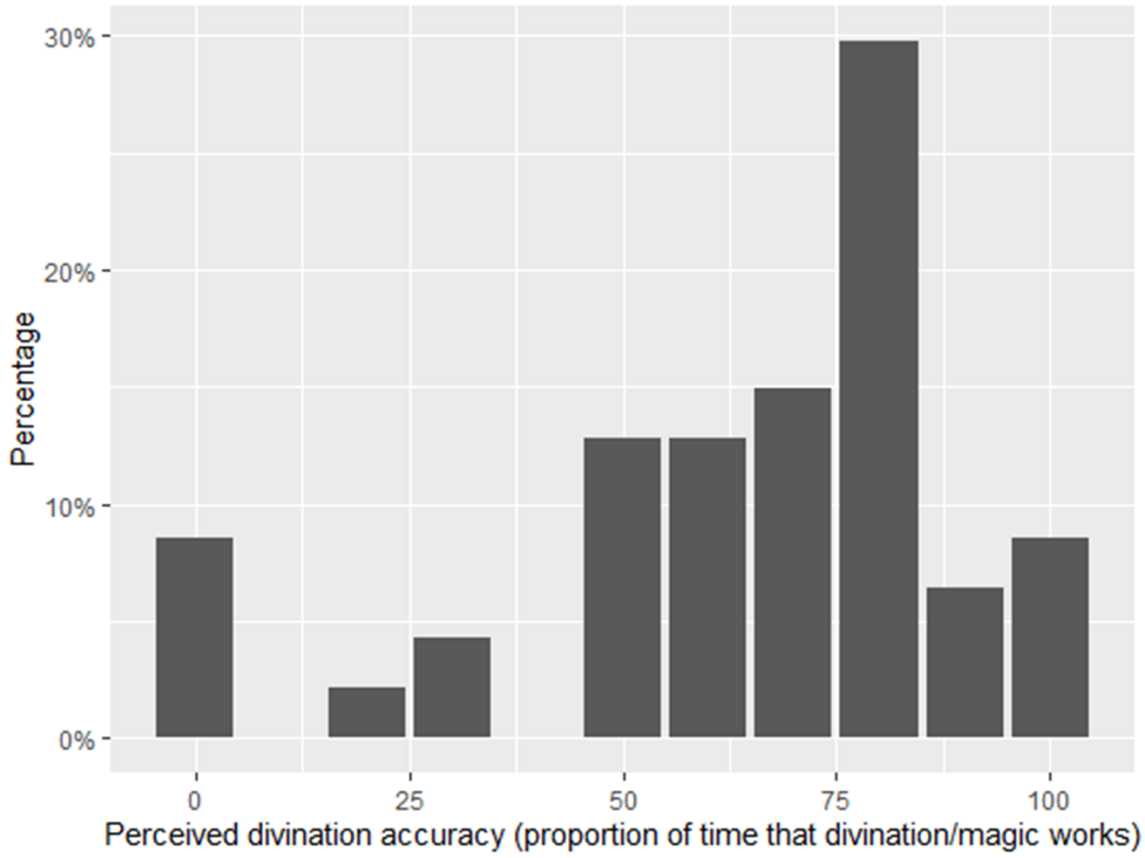

Figure 1.2. Distribution of perceived accuracy of divination and magic in general. Sample size = 47.

Of course, these percentage should not be taken as too literally as people may not be able to fully access or articulate their beliefs in quantified form (Blanton et al. 2007; Nisbett and 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 (an ethnic Han speaking Mandarin from the United States) and the simple act of posing such a question, might bias participants towards more skeptical reports.

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 like artisans.

2.3 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 the following 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 (Nemeroff and Rozin 2000; Gardner and Boyer 1995; J. Barrett 2004). 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 & Souza (2012) experimentally show that ritual procedures involving more steps and specific times are regarded as more efficacious; Nemeroff & Rozin (2010, 1986, 1990) argue that people's susceptibility to contagious magic may confer adaptive

benefits as the disgust reaction towards unclean items may contribute to pathogen avoidance ; Singh (2017) suggests that specific aspects of shamanism such as inhumanness 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 constitute as effective practices.

While contributing to an overall explanation, such evolved intuitions seem unlikely to provide the full story. Consider the naïve Tylor-Frazer re-formulation 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 under-appreciation 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, Griffiths, and Kemp 2006). Indeed, learning from past experience is a fundamental cognitive adaptation that humans share with many other animals (Pearce and Bouton 2001; Rescorla and Holland

1982), and it would be unlikely that people completely ignore empirical evidence when it comes to divination.

Interestingly, to our knowledge, no non-human 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 and Henrich 2010; Gervais, Norenzayan, and Henrich 2011). For humans, empirical evidence consists of more than individuals' first-hand 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 2009a; Henrich 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 and Henrich 2020). This is because (1) under uncertainty and especially when costs are high, humans are psychologically predisposed to learn from others (Boyd and Richerson 1985; Laland 2004); (2) many divination practices require substantial expertise and thus non-specialists 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 traditional 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 core understanding of the nature of reality.

Importantly, post-hoc rationalizations of divination failure *should not* be interpreted as people not caring about predictive accuracy. To the contrary, the fact the people feel it necessary to account for predictive failures suggests that they are concerned about such failures and feel compelled address the outcome (Horton 1993a). Realizing that one fouled up the ritual protocol or employed an amateur diviner to save money, improves one chances of getting a more accurate answer in the future.

Ample work in economics and psychology suggests that despite our cornucopia of judgement and decision-making errors and biases (Korn et al. 2014; Sharot 2011; Joseph Henrich 2002), humans do probabilistically modify their beliefs in adaptive ways as evidence accumulates (Ambuehl and 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); i.e. we may have evolved psychological tendencies to heavily rely on social sources, especially when uncertainty is high (Muthukrishna, Morgan, and Henrich 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 and McElreath 2003; Richerson and 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 (Willard, Henrich, and Norenzayan 2016; Kraft-Todd et al. 2018). 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—Figure 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 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 and Buss 2000; D. D. P. Johnson et al. 2013; McKay and 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 needs not 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 (Vohra et al. 2005; Kantor 2009).

Second, for a naïve 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 action that they would only perform if they truly held their stated beliefs: hearing an esteemed members of one's community extoll the importance of using divination to fight illness is a lot more persuasive if those same individuals pay diviners for rituals when they are ill. A growing body of empirical work supports this hypothesis (Kraft-Todd et al. 2018; Cho et al. 2012), including work among shamans (Singh and Henrich 2020).

Behaving optimally in the presence of different information sources can be difficult. Indeed, even perfect Bayesians can sometimes end up with sub-optimal behavior in certain situations. For example, when individuals can observe other's 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 they sometimes completely ignore their private signal and behave sub-optimally. Such "informational cascades" or "herding" have been extensively

discussed in economics (Banerjee 1992; Bikhchandani, Hirshleifer, and Welch 1992) and find ample empirical support (Kim et al. 2004; W. Duan, Gu, and Whinston 2009; Lohmann 1994). In reality, humans are unlikely to carry out the exact Bayesian computations and therefore imperfect inferences should occur rather often.

3. 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 (Figure 1.3). In section 1, we have provided ample evidence for the instrumental nature of divination, which begs the question of its persistence; in section 2, we have 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 dominating 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.

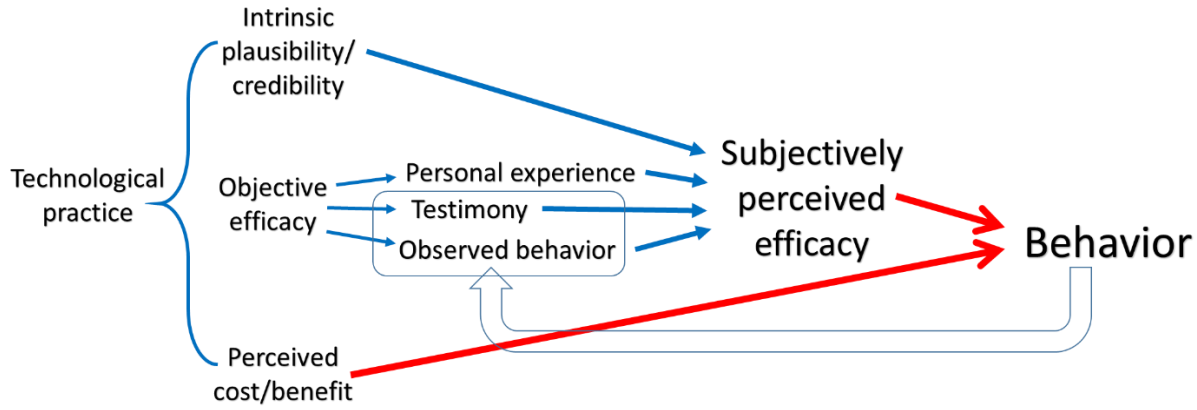

Figure 1.3. Causal diagrams of factors that affect subjectively perceived efficacy (SPE). The three components of a given technological practice (intuitive plausibility/credibility, objective efficacy, perceived cost/benefit) are listed on the left side after the curly bracket; causal relationships that contribute to SPE 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 naïve individuals' observations which may be affected by reporting and inferential biases (hollow blue arrow).

Figure 1.3 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 SPE via various epistemic routes: via personal experience, testimony, observed behavior, etc. Crucially, such epistemic routes do not always guarantee the accurate translation of OE into SPE. 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.

3.1. Model description

Here, we provide only a verbal description of our model, leaving the mathematical details to the Supplemental Information (SI). 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 represent 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 and Rozin 2000) or because they fit better with existing beliefs in some cognitive

sense (Henrich and 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 ($p_{sampled} * b > c$). 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 over-estimation could result in costly and ineffective information seeking behaviors like 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 to perform a technological action or not 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 individual

agents' beliefs at equilibrium (i.e. when the belief distributions of the populations become relatively stable over time).

It is worth noting that although in our simulation agents update their belief in a Bayesian way, the insights that our model generate does not depend on perfect Bayesian reasoning. In fact, as long as people update their beliefs 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.

3.1.1. Simulation results

We ran many simulations to examine the relationship between agents' belief distribution and various parameter combinations. See supplemental Table S2 for a list of the parameters used in the simulation. We will 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, then focus on the population average belief levels and further explore the parameter space in a combinatorial fashion.

3.1.2. 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 1.4 shows the distribution of individual mean beliefs at equilibrium. This result is consistent with our intuition: large α_0 values shift agents' belief distribution towards 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 individual's beliefs from converging. This is because each generation of naïve individuals starts

anew with the innate or intuitive prior, which mean that they have to re-acquire 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.

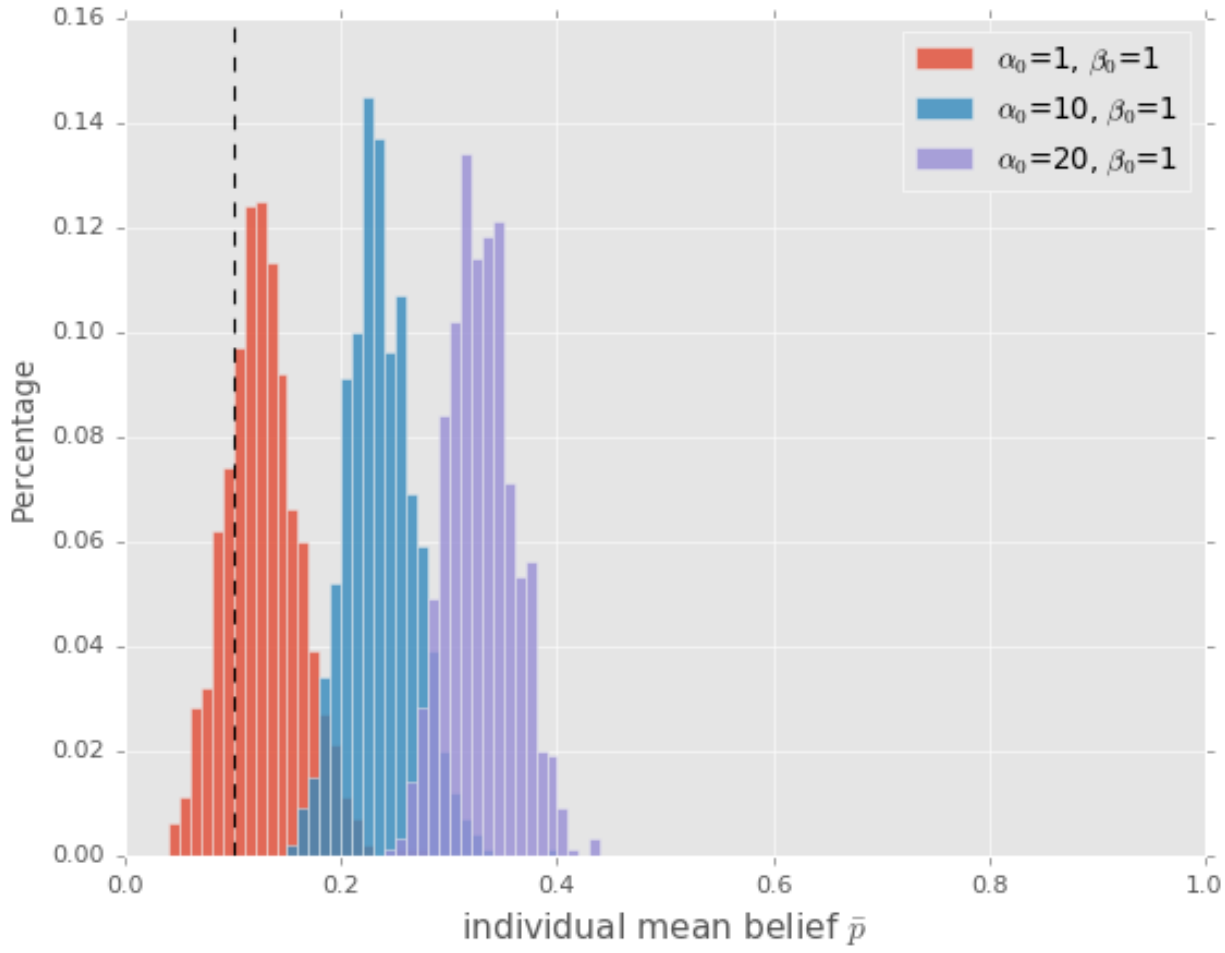

Figure 1.4. The distribution of individual mean belief under different prior belief conditions. Mean of the above distributions: 0.11 (α_0 = 1), 0.22 (α_0 = 10) and 0.34 (α_0 = 20). Other parameter values: b = 5, $c = 1, \theta = 0.0$. Dashed line represents the true efficacy of the technology (r = 0.1).

3.1.3. Under-reporting of Negative Evidence:

As mentioned, instances where epistemic practices fail to yield accurate information may be under-reported. Such under-reporting 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 (Nickerson 1998; D. K. Johnson 2017). 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 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 and 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, as 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 under-reporting of failed predictions of divination as well as failed attempts in magical practices such as rainmaking (Hong, in preparation).

Figure 1.5 shows the distribution of individuals' mean belief under different degrees of under-reporting 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) compare to when such some bias is present (blue and purple, 30% and 60% negative cases not revealed respectively).

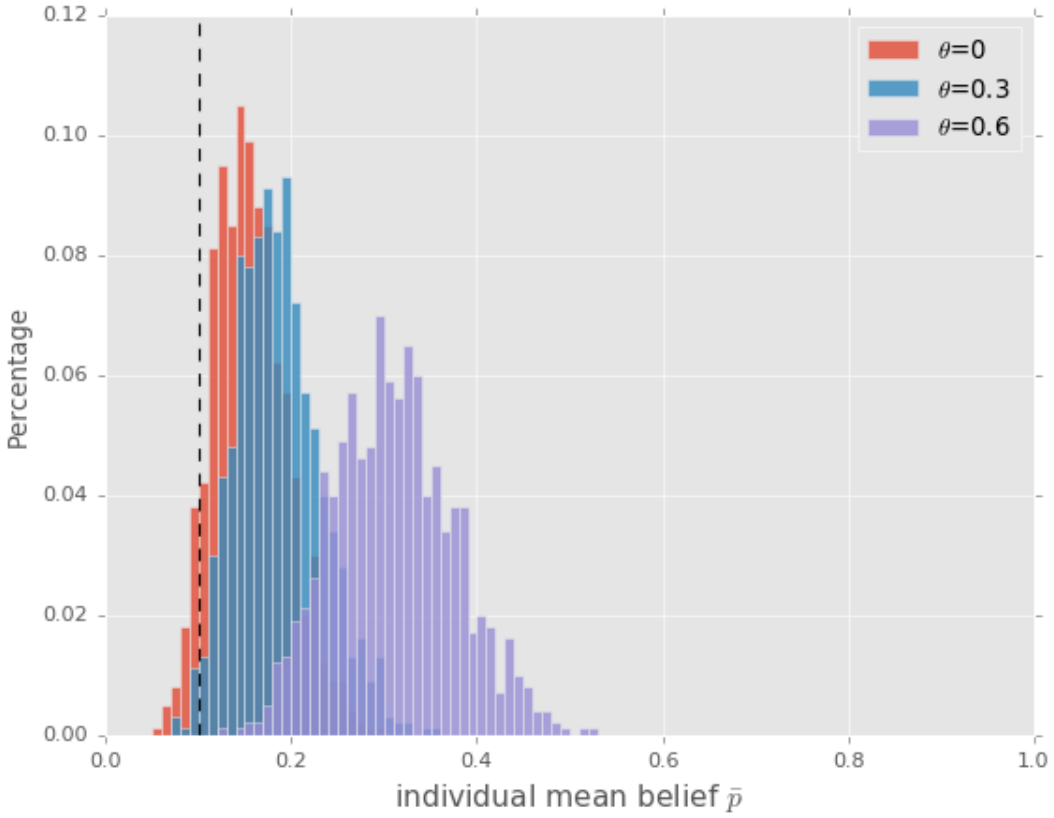

Figure 1.5. The distribution of individual mean belief under different under-reporting conditions. Mean of the above distributions: 0.26 (θ = 0.13), 0.19 (θ = 0.0) and 0.32 (θ = 0.0). Other parameter values: $\alpha = \beta = 1$, b = 5, $c = 1$. Dashed line represents the true efficacy of the technology (r = 0.1).

3.1.4. Mis-inferring/updating Belief from Observed Behavior

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

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

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

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

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 ($\frac{b}{c} = 10$ and 5 respectively in Figure 1.6), the majority of beliefs corresponds to high percentage of "action" decisions, and therefore it would be difficult for naïve agents to correctly infer individuals' underlying belief distribution from observed behavior. So, high $\frac{b}{c}$ ratios can conceal valuable information.

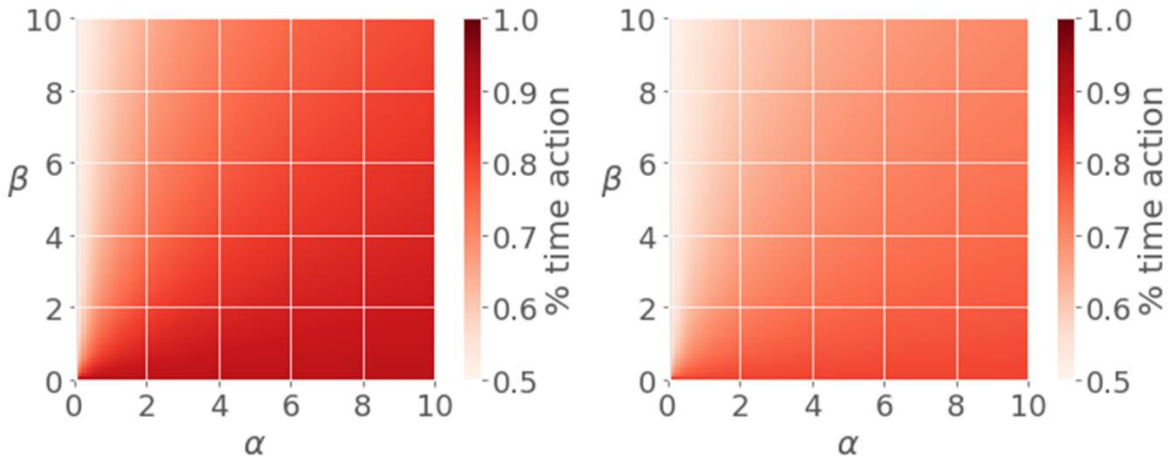

Figure 1.6. The relationship between belief distribution parameters (α and β) and the proportion of times agents perform the action (represented by color intensity) under two different cost/benefit scenarios (left: $\frac{b}{c} = 10$; right: $\frac{b}{c} = 5$).

Figure 1.7 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 to when perceived 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.

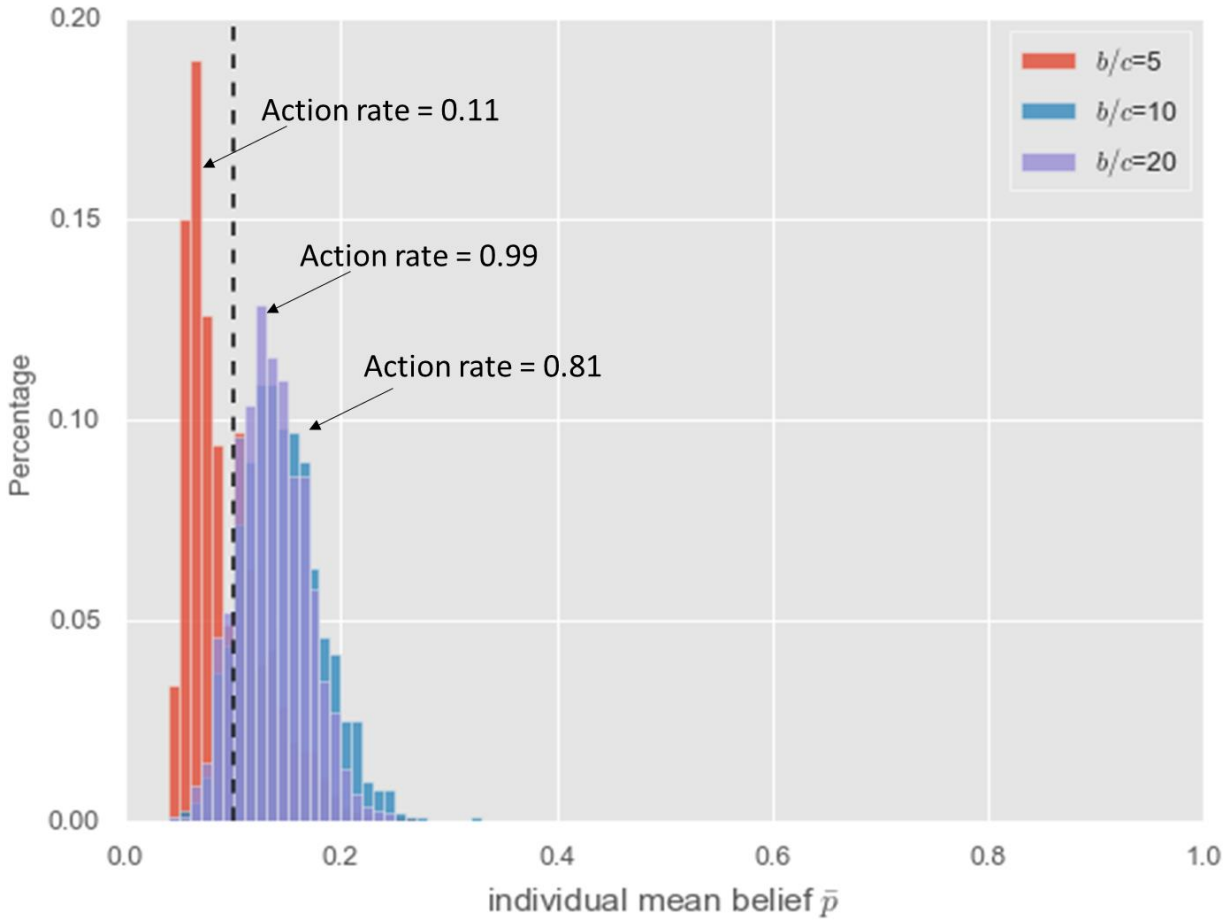

Figure 1.7. The distribution of individual mean belief under different cost/benefit conditions. Action rate refers to the proportion of agents who performed Δ in the last step (personal experience) of their life cycle. Mean of the above distributions: 0.092 (b/c=5), 0.145 (b/c=10) and 0.136 (b/c=20). Other parameter values: $\alpha = \beta = 1$, $\theta = 0.0$. Dashed line represents the true efficacy of technology (r = 0.1).

Finally, we present a more extensive exploration of the parameter space (Figure 1.8). Here, w_o denotes the epistemic weight of observed action. The error bars indicate that our simulation 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 while the contribution of the epistemic weight of observed action (w_o) is positive when the perceived benefit of performing the action is large, w_o is negatively

correlated with the efficacy estimate when perceived benefit is low. The left panel of Figure 10 (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_o will thus decrease individuals' confidence that Δ is efficacious.

It is also worth pointing out how priors may interact with other parameters. Reassuringly, in all conditions stronger priors (large α_0/β_0) leads to higher efficacy estimate; however, even in cases where individuals may be skeptical of the technological practice ($\alpha_0/\beta_0 = 0.1$), 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 counter-intuitive divinatory practices (Boyer 2020). People in traditional societies may find some practices as odd as modern people do; it's just that the cultural information pre-modern 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 (Frazier, Gelman, and Wellman 2009; Chouinard 2007) and heavily rely on what they are told especially from familiar individuals (Corriveau et al. 2009; Harris et al. 2006) as children are often not in a epistemic position to evaluate the validity of culturally transmitted claims .

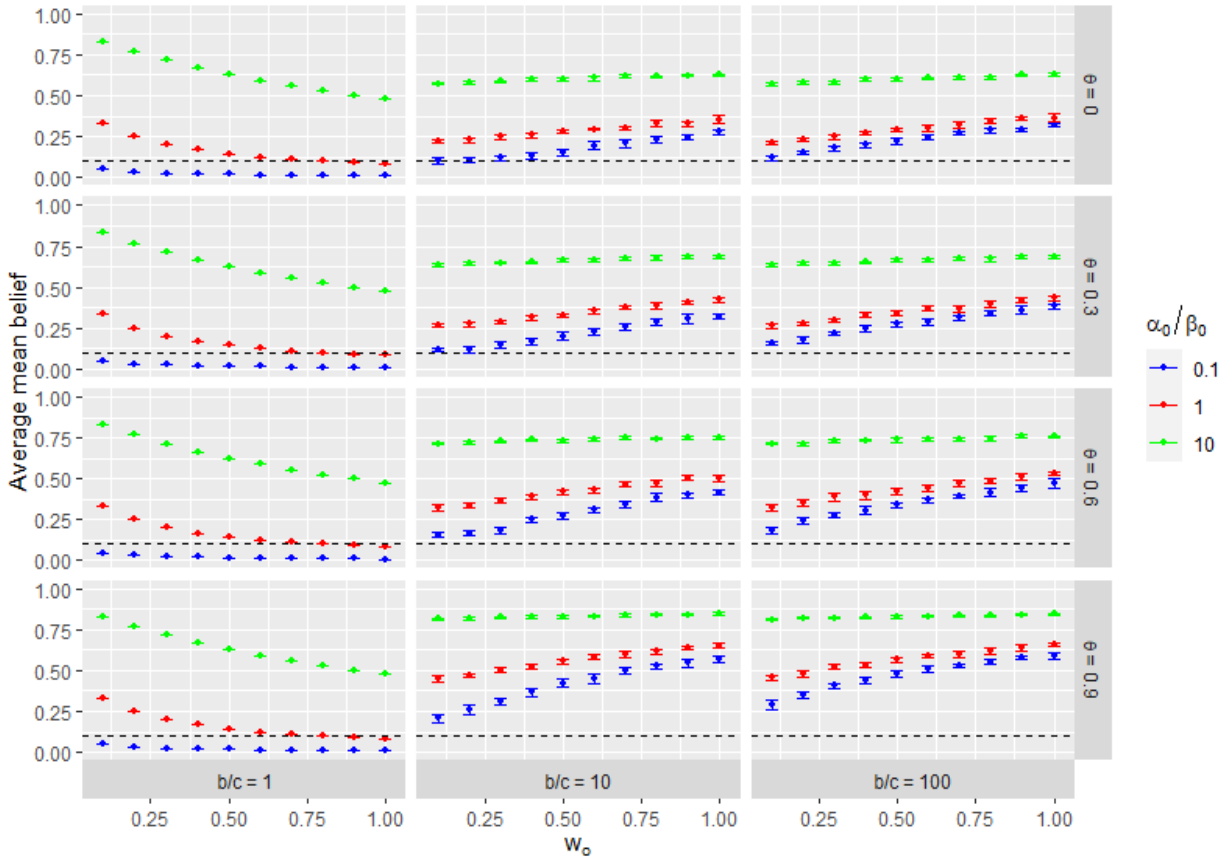

Figure 1.8. Exploration of parameter space in a combinatorial fashion. Each data point represents the population average of individual mean belief at equilibrium for a given parameter combination. Error bars represents 95% confidence interval for 10 independent simulation runs. Values of unspecified parameters are as in table 2. Horizontal dashed lines represent the true efficacy of technology (r = 0.1)

Our simulation has shown that a few factors, including strong priors, the under-reporting of negative evidence and high perceived benefit to cost ratios combined with the epistemic weight attached to observed actions could all bias individuals to over-estimate Δ's efficacy. People are most likely to believe in the efficacy of some technology when it is intuitively plausible, its negative instance under-reported, and its perceived benefit large, particularly in communities where people heavily rely on observed behavior to infer efficacy. In reality, these factors may all co-exist which could push 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, also may play important roles in affecting our evaluation of the efficacy of technologies.

4. Discussion

We have presented converging lines of evidence showing that many forms of divination can be 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 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 towards epistemic modernity.

4.1. Divination: just like any other technological practice?

Many authors have pointed out that viewing divination as a method or device to generate information are 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 practical meteorology that every reasonably intelligent person picks up during the course of life? (p. 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 (Rochberg 2004; Pankenier 2011; Huber and Swerdlow 2001). 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 (Field 1984; Boner 2008; Force and Popkin 1999); Kepler's fascination with astrology even led him to personally produce over 800 horoscopes (North and 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 (L. A. Raphals 2013), which in cognitive scientific terms would be a kind of similarity-based induction (Weber and Osherson 2010; Heit 1997). 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 19th century (Staum 1995; Greenblatt 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 therefore could 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).

4.2. Why Divination: Evolved Intuitions plus Cultural Transmission

This paper has emphasized the role of adaptive learning mechanisms in shaping individuals' belief and technological behavior at the population level. Of course, this is not to deny the importance of content-specific evolved 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. 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 presented a few scenarios where both biases (e.g. under-reporting of negative evidence) as well as learning and decision-making dynamics (e.g. mis-inferring belief from behavior in the presence of cost/benefit analysis) can lead to overestimating the efficacy. Humans everywhere – across historical/cultural space and time have been empiricists, in the sense that they incorporate sensory data obtained from their experience into their belief and subsequent decision-making. These data are often not sufficient or even available, in which case we necessarily have to rely on socially transmitted information which itself may be occasionally inaccurate.

In a Bayesian framework, the relative weight of different information sources becomes the 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 are important, open empirical questions that 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 towards an emphasis on experience over transmitted wisdom (Wootton 2016; Strevens 2020), and such transition may have induced a cascade of institutional and psychological changes regarding what individuals consider as legitimate ways of generating genuine knowledge (Henrich 2020).

4.3. Modernity, Science and the Evolution of Epistemic Norms

Modern societies differ from traditional societies in many ways. Here 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 produces a different kind of "prior" in post-enlightenment, contemporary societies. A person who live in such societies does not need data to be deeply suspicious of the claim that illnesses can be diagnosed by examining the holes from the chicken thigh bone and be cured by sacrificing domesticated animals to appease the spirit; our metaphysical theory about causality is materialistic, and it actively denies the causal relevance between events that do not have plausible physical connection. Second, modern societies have a larger division of labor in knowledge transmission: Scientists as the producer of knowledge and lay people as the consumer 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 under-reporting of negative evidence and other biases. Additionally, many lay people in such scientific 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 predicted her personality as evidence for the validity of astrology. In this way, scientists are able to generate accurate information and lay people, by de-valuing 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" (Shapin 2018; Beale and Hall 1956; Keller, Lindberg, and Westman 1993), and there has been no lack of speculation regarding why the rise of empirical science occurred in Europe (V. 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 (P. Richerson et al. 2016). One the one hand, the products of science – 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, Boyd, and Richerson 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-19th century (Hones and Endo 2006; Cheng and Waley 1960) and were overwhelmed by its technological superiority. The scholar of the late Edo period Sakuma Shozan famous 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 (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 and 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; it was overthrown in 1911 (Gao, Zhang, and Tian 2015). Soon after this, in 1919 there was a massive political-cultural movement (known as the May Fourth Movement) that 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 period (1912-1949), divination, along with a range of other traditional cultural practices came to be viewed as irrational superstitions that should eradicated (Zhiwei 2009). Note that both countries have sustained various kinds of divination and magic practices for millennia; it can be very difficult for societies to epistemically modernize on its own and such modernization often require 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 to our trust in scientific authorities (in the West at least) as reliable information sources, and people's attitude towards them is markedly different from that in pre-modern times. In fact, astrology and many kinds of fortune-telling in epistemically modern societies have transformed into a form of entertainment (Miller 2014; Johnston 2009; Šaknys 2015).

5. 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 though its 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.

Chapter 2.1. Empirical Case 1: Rainmaking

(Publication: Magic and Empiricism in Early Chinese Rainmaking – a Cultural Evolutionary Analysis, *Current Anthropology*, forthcoming)

In this chapter, we analyze the first empirical case – rainmaking in traditional China. We take advantage of the wealth of historical records available in China, and argue that rainmaking is best viewed as an instrumental, means-end activity, and that people have always placed strong emphasis on the outcomes of such activities. To account for persistence of rainmaking, we suggest that a commitment to a supernatural worldview (prior beliefs) provides theoretical support for the plausibility of various rainmaking methods, and people often over-estimate the efficacy of rainmaking technologies because of statistical artefacts (some methods appear effective simply by chance) and under-reporting of disconfirmatory evidence (failures of rainmaking not reported/transmitted).

1. Introduction

Ever since the advent of agriculture, rainfall has played a crucial role in people's lives (Rockström, Barron, and Fox 2009; Wahlquist 2009). Historically, rainfall was often a matter of life and death in any society that relied on farming or pasture for subsistence. Thus, a lack of rain in seasons when crops needed water posed a serious threat to farmers regarding their survival; in societies with complex political hierarchies, the stability of the state hinged on rain (De Châtel 2014; Jianyong Li et al. 2017; Kebbede and Jacob 1988; Chaney 2013). An influential hypothesis on Chinese dynastic change, for example, proposes that changes in Chinese dynastic powers may have been affected by a lack of precipitation mediated through popular unrest (P. Zhang et al. 2008)

Given the enormous importance of rainfall for subsistence, there have always been strong incentives to produce rain when needed. Societies across the world and throughout history attempted exactly this. In his masterpiece *The Golden Bough* (1890), James Frazer devotes an entire chapter to the magical control of the weather: the rain-making activities of the peasants in Russia, tribal farmers in New Guinea, the Omaha in North America, and many other traditional societies are all described in vivid detail. More recent ethnographic work further suggests the widespread nature of such efforts (Ruppert 2002; Schoeman 2006; Başgöz and Basgoz 1967).

The historical and cross-cultural recurrence of rainmaking itself is not puzzling. After all, when there is a problem, it is not surprising that people try to solve it. What is puzzling is that we as modern readers know that traditional[8] rainmaking attempts were *ineffective.* That is, assuming modern science is to be trusted, the ancients' rainmaking efforts did not exert any influence on

[8] To our knowledge, there has been no rainmaking effort that is scientifically plausible until the 19th century.

weather. The real question is thus this: why did people engage in a costly and time-consuming activity that objectively does not achieve its explicit aims? Anthropologists have been keenly aware of this problem, and there has been a long-standing debate regarding such seemingly ineffective actions and the implications for human rationality (Horton 1993a; Tambiah 1990). On the one hand, Tylor, Frazer, and their intellectual predecessors claim that magic shares the same fundamental goals as science: to explain, predict, and possibly control the natural world. On the other hand, many scholars have reacted against Tylor and Frazer's interpretation. Levy-Bruhl (1926), for example, suggests that "primitive" men have a fundamentally different thinking mode in which mental processes are powered by emotion rather than reason, and ritual activities are best described as "mystical participation" rather than "rational action". Durkheim (1912/2008) divides the world into two radically contrasted categories, the sacred and the profane, and posits that although the profane simply refers to the everyday ordinary, sacred objects and actions are characterized by a sense of awe and respect in virtue of their being symbols of societies. This distinction was later taken up by many thinkers such as Radcliff-Brown (1952) and Max Gluckman (1944) who suggest that the two categories require different kinds of interpretations: while the profane may be interpreted as "logical-empirical" through means-end decision calculus, the sacred requires a kind of sociological explanation. Malinowski, similarly, thinks that the indigenous people themselves recognize a distinction between the supernatural and rational (Malinowski, 1922/2002), and the great sociologist Talcott Parsons (1937) expanded this account by suggesting that there are certain actions that are "non-rational," that is, they have no pragmatic end other than the performance of the acts themselves. In short, the reaction against the Tylor-Frazer reading of ineffective actions in traditional societies is that the actions are not really trying to achieve their alleged goals—they are not instrumental. These actions are driven

by emotion, respect for tradition, power dynamics in the community, or other non-instrumental factors. Many anthropologists today still follow the reaction against Tylor and Frazer.

Let us step back and place rainmaking into this larger context. The Tylor-Frazer position on this would simply be that people engage in rainmaking activities to produce rain. For the symbolic-sociological proponents, the key issue is whether rainmaking may be viewed as a type of profane, instrumental activity. Wittgenstein famously thinks it may not (Wittgenstein 1967). For him, the native rainmaker does not really think he can make rain. In other words, he does not act out of "opinion" but rather "instinct", and his actions serve not as genuine instrumental effort but a kind of emotional discharge of anger and anxiety. Later authors also often emphasize the sociological and symbolic functions of rainmaking activities (Mbiti 1970; Ngara 2012), but rarely dismiss their instrumentality entirely. Surely, it would be very difficult to completely ignore the instrumental aspect of rainmaking; as will be shown, much historical evidence strongly suggests that various kinds of rainmaking were intended to be used as instruments to induce rain.

As a population with a long and continuous literary tradition, China provides an ideal case for a close examination of rainmaking. Due to the large amount of historical material, there have been many studies on Chinese rainmaking that focus on specific historical periods, and the recent advent of digitized databases of Chinese texts has enabled more quantitative assessment of elite history and culture (e.g., Sturgeon, 2006). Here we take advantage of such resources and offer a detailed analysis of rainmaking in China.

Our paper is organized as follows: In part one (section 2 and 3), we summarize major theories of rain in early China and the corresponding rain-inducing activities, arguing that the

majority of rainmaking activities are best understood as instrumental efforts. In part two (section 4), we focus on the pre-modern period (in particular the Tang and the Song dynasties, 618-1276 CE) and offer a cultural evolutionary analysis of various rainmaking methods by focusing on their perceived efficacy. We argue that there has always been a great deal of empiricism in rainmaking despite a prevailing supernatural worldview that sustains the plausibility of many methods, and propose a mechanism for how the same set of psychological learning mechanisms that produces adaptive cultural products and protocols nonetheless can generate and maintain maladaptive and costly actions like rainmaking. To preview, some methods will appear efficacious simply by chance even if one meticulously tracks their successes and failures, and under-reporting of rainmaking failures further contributes to the overestimation of various rainmaking methods' efficacy. In the final section (section 5) we offer an account of the disappearance of traditional rainmaking in China by attributing it to a shift in people's background worldview.

2. Folk theories of rain and rainmaking in early China

Like many traditional societies, pre-modern China had elaborate theories about meteorological phenomena such as precipitation and winds. For analytic convenience, we divide the theories into two large categories: "personal gods" and "impersonal forces". This distinction will help us better conceptually organize the myriad of theories and understand the associated actions to produce rain.

2.1. "Personal gods" theories of rain

Various kinds of "personal god" theories prevailed China during different periods of time. Generally, a personal god refers to an anthropomorphic, intentional agent that has human-like

dispositions and may respond to human desires and concerns (Boyer 2001; J. Bering 2012) as a result of our species' mentalizing capacity and other related cognitive intuitions such as dualism (Chudek et al. 2018; Frith and Frith 2012). This means that these gods can be pleaded with, manipulated, bribed and even coerced. Regarding rainmaking, the gods involved are often perceived to either be able to control weather phenomena or be the direct cause of rain. As such, to ask for rain is to negotiate with these gods. The corresponding rainmaking activities therefore become sensible if and only if we treat the underlying controlling or causative agents to be human-like entities with the capacity to make rain. In traditional China, these agents could be deceased ancestors, local deities (deceased famous individuals who serve as "protectors" of a geographic region), or supernatural beings such as dragons (detailed descriptions of these personalized gods can be found in Supplemental Information).

The key takeaway here is that the way people interact with these gods closely resembles human-human interactions. The most striking example is perhaps threat/coercion, as can be seen in the following quote from Taizu (1328-1398 CE), the first emperor of the Ming dynasty:

> The Deity lives off this soil, but it will not sympathize with my people. Now I make a covenant with the Deity that within three days it must rain. If it does not rain, then I will ruin the Deity's shrine. (*Ming Waishi*[9])

Here, the emperor is exercising his authority and treats the local deity as an inferior. Similar instances were recorded for lower officials as well; sometime between 1068 and 1083, a local magistrate brought an image of a deity to his office and vowed: "if it does not rain in three days,

[9] 明外史.

I will destroy your temple." (*Taizhou jinshilu*[10]). The recorded outcome of such threats varies; in the former case it was recorded that rain indeed came within three days (presumably due to the emperor's supreme authority) while in the latter the outcome was not specified. There were also occasions where the deities got angry at the threat and retaliated with natural disasters (Cohen 1978).

2.2. Impersonal Forces Theory of Rain

Alongside many beliefs about rain that involved human-like agents, there was also theorizing on the impersonal forces that produce rain. Generally, these "impersonal forces" theories of rain rely on principles of sympathy and correspondence, and the literati -- mostly Confucians -- tended to prefer this type of explanation to those based on personal gods. Note that these forces are not purely mechanistic in the modern sense but often appear mysterious in nature and may respond to human actions in rather moralistic ways (Ding 2009; Wong 2011). Thus, the distinction between personal and impersonal rainmaking agents can get murky, though this is common with regard to cosmic forces (Willard et al. 2020).

Broadly, these rainmaking theories involving impersonal forces can be divided into "Interactions Between Heaven and Mankind", a Confucian view of the causal structures of the universe (Wong 2011), and various sympathetic magic techniques to produce rain. "Interactions Between Heaven and Mankind" maintains that there is a resonance between Heaven and the actions of people, especially the political leaders as they are viewed as the representation of Heaven[11]. When the leaders err (usually in the form of bad governance), Heaven may send

[10] 台州金石录 (a record of inscriptions from Taizhou).
[11] Chinese emperors are often referred to as Tianzi (天子), literally, Son of Heaven.

disasters or portents (灾异). Sympathetic magic theories of rain in traditional China, on the other hand, operate based on the principle of "like stimulates like", as the early Han scholar Dong Zhongshu (179-104 BCE) explicitly theorizes:

> …the beautiful invokes the beautiful, the evil invokes the evil; [this is because] things of the same kind respond to each other. A horse neighs and other horse neigh; a cow moos and other cows moo. When kings and emperors rule well, there will appear beautiful and auspicious things; when their rule is about to end, there will appear monstrous spirits and ghosts. Therefore things of the same kind stimulates each other: as such, dragons cause rain, fans get rid of heat… (*Chunqiu Fanlu, chapter 57*)

We can see from the above quotation that the claim "dragon causes rain"[12] is situated in a larger sympathetic magical framework. More generally, Dong Zhongshu also discussed rainmaking vis-a-vis the *yin-yang*[13] principle. Because rain is considered *yin,* to induce it is to use its own kind -- things that are also *yin*. He therefore recommended rainmaking efforts[14] such as 1) women should appear in public places whereas men should remain in their house; 2) towns should close their southern gates[15] and open those on the north[16], or 3) the lighting of fires should be prohibited. As Bodde (1964) points out, the rainmaking efforts documented in *Chunqiu Fanlu* is more likely to be Dong's own scholastic formulation than an account of actual activities performed by the general populace. The core idea of employing sympathy to induce rain,

[12] Of course, this depends on the belief that dragon and rain are of the same kind.
[13] In traditional Chinese culture, *yin* and *yang* are a pair of complementary concepts and are perceived to be a fundamental attribute of any material objects. *Yin* usually refers to the feminine, negative, moist and cool, whereas *yang* refers to the masculine, positive, dry and hot.
[14] See Chunqiu Fanlu, chapter 74. Interestingly, Dong Zhongshu also talks about applying the same principle to stop rain, that is, to release or expose things that are *yang*, e.g. men or fire. See *Chunqiu Fanlu*, chapter 75.
[15] This very technique was used as late as 1892 (Snyder-Reinke 2020).
[16] In traditional Chinese culture, south is associated with *yang* and north is associated with *yin*

however, persisted throughout imperial China till as late as Qing dynasty (1644-1912) (Liu 2013).

Interestingly, the concept of "sincerity" 诚 often played an important role in rainmaking: in order for Heaven to grant rain, political leaders needed to be completely sincere when performing these rituals (Snyder-Reinke 2020). Consequently, rainmaking failures might be attributed to the insincerity of rainmakers. We suggest that this is an illustrative case of a more general phenomenon of "invoking auxiliary hypothesis to protect to core theories," in the language of the philosophy of science. It is common for people to invent reasons to explain (away) technological failures *post hoc* to prevent their theories from being falsified. However, there is ample historical and ethnographic evidence showing that people's subjective understanding of technological efficacy is probabilistic (Hong and Henrich 2021). That is to say, while people (under a particular worldview, see later sections) always believe that rainmaking can work *when properly conducted*, their estimation of the probability that the desired outcome (rain) would follow the technological action (rainmaking) will decrease in the face of empirical failures regardless of the excuses invoked. In other words, while the lack of sincerity may be used as an auxiliary hypothesis to protect confidence in supernatural rain-making techniques, people's confidence in any particular rainmaking protocol (all factors considered, including sincerity) is likely to be affected by observed failures. This is especially true when multiple methods are available, as in the case, for instance, where multiple deities were believed to be able to exert control over weather.

3. Rainmaking as an effort to produce rain

The above description of theories of rain and rainmaking methods already hints at the instrumental nature of rainmaking in early China. For the sake of completeness, we offer a few additional notes to bolster this claim.

3.1. Problem-solving style instructions on rainmaking

In most Chinese dynasties rainmaking was performed on both a regular and *ad hoc* basis (Snyder-Reinke 2020); that is, in addition to the annual rituals in which the emperors and officials pray for abundant harvest and good weather, rainmaking was also performed when there was a drought. This has resulted in a large corpus of transmitted "how-to" texts on rainmaking. These texts often have a distinctive problem-solving flavor: If it does not rain, do A; If it still does not rain; do B… For example, the following rainmaking instructions appear in the official dynastic record of Sui (隋书):

> If there is a drought after the fourth month of the year, then [one shall] pray for rain, and do the following seven things (policy-issues such as improving criminal justice and reducing taxation)…make the local officials bathe and fast for three days and pray for the state (*sheji* 社稷); if it does not rain after seven days, one needs to pray all over again. If it still does not rain after the three procedures, then pray to the local deities that often bring cloud and rain.

Such detailed instructions can also be found in popular rainmaking manuals such as *The Divine Farmer's Book of Praying for Rain* (*shennong qiuyu shu* 神农求雨书), which specifies the relevant rain-inducing action based on dates. Plan A is usually some kind of rain dance; if it fails

then plan B (closing southern gate of the town and place water outside[17]) is carried out; if it still fails then plan C (e.g., exposing shamans/spirit mediums under the sun) is carried out, and if plan C fails again there is plan D (piling up firewood on the sacred mountain and burning it). The stepwise style of these instructions is reminiscent of how modern mechanics or IT technicians fix a car or a computer. Like traditional rainmakers, these specialists have certain causal theories of how things normally work, and adopt a strategy of trying a series of potential solutions until the problem is fixed.

3.2. Willingness to try alternative methods

In traditional China, both government officials and commoners were willing to try a variety of methods in hopes of bringing rain, and their attitude towards various methods of rainmaking was anything but dogmatic. If rain did not arrive after praying to deity A they often switched to a different deity without hesitation (Hansen 2014). Such attitude is exemplified by the phrase in *Classic of Poetry* (诗经), complied over two thousand years ago, that "there are no deities not honored, no sacrifices withheld" in the context of dealing with a lasting drought.

Although state Confucianism provided more abstract, moralistic theories about the causes of natural calamities (that drought and other disasters are intimately linked with the ruler's politics), government officials were often quite willing to incorporate local beliefs and practices, experiment with occult technologies, and sometimes employ traveling rainmakers. Indeed, the extensive records of rainmaking leaves the overwhelming impression that these officials are willing to try anything to save their people (and their jobs). One particularly telling example

[17] This is clearly reminiscent of Dong Zhongshu's method.

occurred in the year 1004 CE[18], when Emperor Zhenzong (真宗) invited a western monk (胡僧) who successfully used dragon images to summon rain during a drought. After the success Zhenzong made the following comment: "although [the method] is unconventional, yet for saving people from drought, it is not to be avoided."[19] Although classically educated and presumably sharing the philosophical views of most Confucian scholars, the Emperor had an eminently practical view of rainmaking and was willing to try seemingly odd methods to obtain rain.

Lower officials were similarly likely to utilize a succession of different methods (including praying to different deities) until finally rain arrived. In the drought year of 1078, the famous essayist and historian Zeng Gong (曾巩), when serving as the governor of Fuzhou (福州), tried five different rainmaking methods from sympathetic magic to praying to local deities over a period of 20 days (L. Huang 2011). Ordinary people similarly asked a number of deities for rain, and the deities that "successfully"[20] produced rain were thanked, venerated and sometimes brought to other geographic regions by their worshippers (Hansen 2014).

3.3. Contemporaneous skepticism towards rainmaking

A central concern of any instrumental activity that claims to achieve specific goals is whether it indeed achieves those goals. For modern readers, we cannot help but wonder about the effectiveness of these exotic rainmaking methods: is it really true that natural phenomena are linked with the emperor's rule, or an image of a dragon would attract a real dragon that brings

[18] By this time Confucianism has firmed established as the state orthodox philosophy, and such sympathetic magic actions would certainly be deemed as illegitimate.
[19] Original text: 虽不经，然为民救旱, 亦无避也.See *Song Huiayo Jigao* 宋会要辑稿 *chapter 18*.
[20] In this context, "success" simply refers to the temporal contiguity of prayer/offerings and rain.

rain? We suggest the ancients had the same concerns, although skeptical comments were perhaps less likely to be recorded or transmitted in written texts.

The fact that people were willing to try many different rainmaking methods in a sequential fashion (as shown above) already indicates that some methods were trusted more than others. Naturally, one would try what one perceives to be the most effective methods first and then attempt alternative methods down the effectiveness scale while also taking costs into consideration. If a particular method repeatedly fails to bring rain then skepticism naturally arises. Such skepticism, however, rarely leads to a complete rejection of the underlying theory, as failures can be easily explained away by attributing it to accidental ritual errors or the incompetent or insincere practitioner. On the other hand, skepticism can also arise from theoretical plausibility even in the absence of empirical data.

More historical details of ancient skepticism towards rainmaking rituals can be found in the Supplemental Information, but for the sake of illustration let us note the views of the most famous early Chinese skeptic of religious rituals, the Confucian scholar Xunzi (310-235 BCE). In a broader essay exploring the proper attitude to have toward "Heaven" or "Nature" (*tian*), Xunzi notes:

> If we sacrifice and it rains, what does it mean? I say: it does not mean anything. It is the same as not sacrificing and having it rain. When the sun is eaten by the moon [i.e., when there is an eclipse], we [perform a ritual to] save it; when Heaven has a drought, we sacrifice; we engage in crackmaking and milfoil divination and only then decide a great event. But we do not thereby obtain what we seek – all of these practices are performed for their cultural (*wen* 文) value. Therefore, the gentlemen sees these rituals as cultural

> practices, even as the common people take them as having supernatural (*shen* 神) causality. To see them as cultural is auspicious; to see them as supernatural is inauspicious[21].

This is part of a larger argument that Xunzi makes for understanding religious ritual in a symbolic and functional sense, rather than literally efficacious techniques for bringing about desired outcomes in the world (Campany 1992). For Xunzi, sacrifice and other divinatory rituals are best seen as serving a social function: they bring people together, create a sense of community, and allow individuals to better understand where they fit into the social hierarchy. The scholar or intellectual, Xunzi's intended reader, should understand that we perform rituals for this social reason, not because there is any causal connection between human action and natural phenomena[22].

Xunzi's supernatural skepticism, however, is best seen as the exception that proves the rule. His agnostic or atheistic view of "Heaven" as simply an impersonal, blind process independent of human control (Machle 1976) remained a minority position, even among the elite, and—as the evidence cited above indicates—appeared to have little or no effect on very much practical and literal views of the efficacy of rain rituals. The fact that, even armed with a theoretical argument against rain-making magic, the Chinese, from elite down to the general

[21] *Xunzi*, Chapter *Tianlun*.

[22] Xunzi's larger point that rainmaking rituals may have political and social efficacy has been extensively addressed in the literature. Our main focus in this paper, however, is the *explicit* instrumental nature of rainmaking: i.e., rainmaking to induce rain. As we have previously argued (Hong and Henrich 2021), a ritual's social, religious, political functions depend on the public's belief that the ritual can indeed achieve its explicit purposes (bringing about rain, generating accurate information, etc.), which means that we still need to answer the question of why people believe in the explicit efficacy of rainmaking in the first place.

populace, continued to enthusiastically embrace such rituals makes their continued appeal even more puzzling.

4. The cultural evolution of rainmaking: all magic and no empiricism?

Like most other culturally transmitted practices, rainmaking protocols are subject to cultural selection processes that influence their differential spread (Fog 1999; Mesoudi 2005). The exact mechanism of this evolutionary process is still under some scholarly debate (Claidie, Scott-Phillips, and Sperber 2014; Claidière and Sperber 2007; J. Henrich and Boyd 2002), yet it is generally agreed that there are some basic principles that describe the transmission of cultural practices. For instrumental activities such as rainmaking, the probability of it being adopted by others in the community often depends on its perceived efficacy. Often, the focus of this literature is identifying recurrent features of ineffective instrumental practices that contribute to their plausibility. For example, repetition and the presence of religious icons are shown to increase perceived efficacy of rituals (Legare and Souza 2012); the form of bloodletting (co-location of cure and symptom and the act of removing blood from body) fit our folk physical and folk biological intuitions (Miton, Claidière, and Mercier 2015). More recently, Singh (2017) suggests that features like inhumanness – the physical appearance or behavioral habits that differ from normal humans -- contribute to the cultural success of many shamanistic practices. In sum, this line of research argues that certain practices are more likely to be adopted because they appear more plausible with regard to achieving people's goals, possibly due to some universal cognitive mechanisms. Many evolutionary minded anthropologists take a similar approach and offer adaptive accounts of why the human mind finds particular cultural representations

attractive (Boyer and Ramble 2001; Miton, Claidière, and Mercier 2015; Gervais, Norenzayan, and Henrich 2011; Henrich and Boyd 2002; Norenzayan et al. 2014).

This kind of explanation has been broadly applied to empirically ineffective technologies such as magic and divination. Indeed, one proposed defining feature of magic[23] is that it is "non-empirical" (Levy 1966) or seriously empirically inadequate (Nadel 1954), with the implication that people supposedly do not care much about whether the means employed really produced the desired ends. We suggest, however, that although it is certainly true that beliefs and cultural practices may spread successfully because they fit our psychological intuitions, there has always been a great deal of empiricism involved in any instrumental activity, and rainmaking is no exception. Specifically, outcomes of different rainmaking methods matter, and the same psychologies (e.g. payoff-biased cultural transmission as well as trial and error learning) that enable the spread of adaptive cultural practices are still at work when people evaluate different rainmaking methods.

This empiricist attitude towards rainmaking methods, however, does not guarantee optimal behavioral outcomes. Specifically, why did people not realize that rainmaking does not actually work and instead adopt rational inaction, a "do-nothing" strategy, given that rainmaking rituals often incur significant time, effort, and material cost? Research in cognitive psychology has proposed several accounts based on faulty information processing, and we shall discuss two main ones that are most relevant for the present study. First, classic studies have demonstrated the phenomenon of "illusion of control" where people erroneously attribute some observed

[23] Note that "magic" is a anthropologically problematic term that resists clear definition (Styers 2005). Here we are using it as a convenience shorthand to refer to cultural practices sustained by non-empirical components (primarily innate, evolved intuitions) as summarized in the previous paragraph. Below we use "magic/magical practices" to collectively refer to Frazerian sympathetic magic and practices that involve interacting with human-like entities.

outcome to their own actions (Rudski 2004; Langer 1975). Second, certain heuristics such as the availability heuristic (Tversky and Kahneman 1973; Schwarz et al. 1991; Tversky and Kahneman 2013) and the representativeness heuristic (Kahneman and Tversky 1972; Kahneman and Frederick 2012) may affect how we perceive frequency and probability. In the context of rainmaking, these biases mean that 1) we often subjectively feel that we have control over rainfall, especially when rain occasionally does occur after a ritual is performed; and 2) when we think about the frequency of rainmaking success, we tend to selectively recall cases where rain indeed fell after ritual being performed – arguably, these cases are more cognitively salient than rainmaking failures.

We think these accounts do fit the evidence, and they offer important explanatory insights on the persistence of rainmaking. However, these psychological accounts exclusively focus on individual cognition and largely ignores population-level processes in which beliefs are updated and transmitted over many generations. Previously, we have formally modeled how individuals' subjective perception[24] (from the perspective of the individuals themselves) of technological efficacy may be influenced by various factors, where objective efficacy (from the perspective of modern science) is an important input source (Hong and Henrich 2021). Here we offer two additional factors that contributes to the perceived efficacy of rainmaking from the empirical front by considering both how individuals form and update beliefs regarding the efficacy of rainmaking techniques and how these beliefs transmit in the population. Briefly, the efficacy of certain rainmaking methods may be overestimated due to 1) statistical artefacts (i.e., multiple culturally transmitted rainmaking methods being evaluated simultaneously causes some to

[24] Hereafter by "perceived efficacy", "beliefs about the efficacy…" and "estimation of the efficacy of…" we mean individuals' emic understandings (i.e., their subjective perceptions, beliefs and estimates).

appear efficacious by chance) and 2) underreporting of failed rainmaking attempts. Finally, we discuss the role of the background supernatural worldview which sustains the fundamental validity of traditional rainmaking, and the eventual decline of rainmaking in China as a result of a shift in worldview.

4.1. Payoff biased cultural transmission in rainmaking

The focus on the outcome of rainmaking, both at the individual level and state level, can be clearly seen from both primary historical records and secondary sources. Simply put, people paid serious attention to outcomes of rainmaking and preferentially adopted methods with more perceived success. This particular psychology is usually termed "payoff biased cultural transmission," and it plays an important role in adaptive cultural evolution (Boyd and Richerson 2009; Kendal, Giraldeau, and Laland 2009). In the context of rainmaking in early China, three aspects are particularly illustrative.

First, there was often competition among various methods. In medieval China (Tang and Song dynasty, 618-1276 CE) where a myriad of Buddhist, Daoist, and other local popular religious practices and beliefs co-existed, neither government officials nor ordinary folk had strong commitments to any single deity or religious doctrine, especially on practical matters such as rainmaking (Wang 2006). As a result, there existed a wide range of possible methods to choose from in times of drought, and these methods were often in a "market competition" situation where the efficacy of different methods and the competence of different specialists were compared (Wang 2016).

Second, the evaluation criteria for judging good from bad methods strongly depends on their outcomes, which always serve as good evidence for efficacy. In his extensive treatment of

medieval Chinese rainmaking, Capitanio (2008) describes a genre of literature known as "evidentiary miracles", which refers to a collection of successful rainmaking anecdotes. As the author suggests, these stories likely serve as rhetorical devices to convince people of the power of respective practitioners and/or their methods. Hansen (2014) similarly emphasize the importance of *ling* (efficacy[25] 灵) in individuals' decisions regarding which deity to whom to offer prayers. In evaluating the efficacy of various rainmaking methods people not only focused on the eventual outcomes but also on the timing of the rain. In other words, temporal contiguity matters: a method that is followed by immediate rainfall would be deemed more efficacious and credible than one with delayed rain. Many famous historical cases emphasize the immediacy of rain after the ritual is conducted. In official Chinese dynastic records, entries that involve rainmaking frequently mention the timeliness of rain with words like "the very day" (是日) and occasionally more dramatic stories where rain fell during the ritual or immediately after the ritual. Sometimes explicit time limits were placed on specialists who claim to have to power of inducing rain. For example, when emperor Daizong of the Tang dynasty ordered the Buddhist monk Amoghavarjra to make rain, he made the timing requirement very explicit: "If it rains within three days it will be due to your magic power. If it rains after three days, the credit will not be yours." (*Song Gaoseng Zhuan*[26]) In a sense, rainmakers are placing a dangerous bet when promising to induce rain, because although success can bring fame and fortune, failure often means severe punishment (sometimes death). During a drought in the Jin dynasty, a diviner reported to emperor Zhangzong (1200 CE) that she had been informed by someone in her dream

[25] *Ling* is sometimes translated as "supernatural efficacy". This is, however, imposing western categories on Chinese concepts. Although *ling* is most often used to describe the efficacy of what we would categorize as supernatural entities and technologies, it is also used to describe fully natural methods such as herbal medicine.
[26] 宋高僧传 (Biographies of eminent monks of Song)

that sufficient rain would fall in three days. Unfortunately, no rain occurred after three days, and the diviner pleaded guilty to the emperor[27].

Third, in some historical periods the state was directly involved in spreading rainmaking methods that were seen as having been proven successful by outcome, and the Song dynasty is a particularly illustrative example. During this time popular local deities were generally deemed illegitimate (淫祀) by the state, and people worshipping them could potentially be penalized; however, the government could also grant titles to these deities, which then accorded them legitimate status (正祀), allowing them to receive official endorsement and sometimes funding (for repairing temples, etc.) (Pi 2005). The criteria for granting titles to local deities seems to be primarily based on efficacy in terms of realized positive outcomes. Emperor Shenzhong's order in the year 1074 CE was very explicit: "for all deities and temples that are efficacious and responsive to prayers, if they are famous and do not have official titles yet, titles will be granted. Those that already have titles but not publicly praised should also be advertised to the public."[28] Hansen (2014)'s comprehensive study on Chinese medieval popular religion strongly supports this view with many historical details. What is particularly striking from Hansen's descriptions is that the title granting for local deities involved a lengthy verification process. Local people would request a particular deity to be officially recognized by making a request to the county magistrate who checked the power of the deity by sending local leaders and their deputies who would verify whether the claimed miracles really took place and examine the deity's history of responding to prayers. If the report on deity's miracles was favorable, the magistrate would petition a fiscal intendant who then reported to the central government and explained what steps

[27] Jin shi, chapter 101.
[28] *Song Huiyao, Li, chapter 20.*

had been taken to verify the deity's power. The final reports could be extremely detailed and sometimes even included the names of witnesses that the inspectors interviewed.

Aside from granting titles to deities with apparent records of success, the Song state also endorsed rainmaking approaches based on sympathetic relationships. A very popular method involved the use of lizards, because of their physical resemblance to the mythological dragon. This "lizard rainmaking method" (蜥蜴祈雨法) was mentioned to the emperor by an administrator who emphasized its efficacy by invoking his personal experience with its successful application (Qi 2018). A few years later, when a drought occurred the method was officially proposed. It was tried and "worked", and the government subsequently endorsed and promoted this method as an effective way to induce rain to be applied at local levels[29]. For some time this method was so popular that there was a shortage of regular lizards and people resorted to using geckos instead (Jiang 1981)—again relying on sympathetic relationships (geckos resemble lizards).

In other dynasties where rainmaking activities were less centrally organized, we observe instances of lower officials serving as disseminators of "effective" rainmaking methods. During the Qing dynasty, for example, local officials had a remarkable degree of freedom to choose from existing methods and revise them (Snyder-Reinke 2020). The rainmaking method invented by the mid-Qing scholar Ji Daqui serves as a typical example: Snyder-Reinke (2020) records multiple instances where local officials heard about the method, tried it and the method proved successful, and then decided to disseminate the method through textual instructions.

[29] *Xu Zizhitongjian Changbian, chapter 281*

From the above reviews we can see that if some method within the possibility space were indeed effective (hypothetically speaking), they would almost certainly have been identified by the Chinese. Given that none of the methods was effective, why did people, including highly educated elite, mistakenly perceive efficacy in certain rain rituals, and continue to pour significant material and temporal resources into pursuing such rituals? Why did individuals not adopt the obvious strategy of "doing nothing", which would have—as Xunzi pointed out in the 3rd century BCE—provided the same results without the effort or expense? Granted, while doing nothing in the face of drought is not as cognitively salient as the elaborative rainmaking rituals that are often performed and public, we have seen that scholars such as Xunzi did question the efficacy of these methods and certainly entertained the possibility that doing something is no better than doing nothing (See Supplemental Information). In the following sections we suggest two factors to help explain the persistence of ineffective rainmaking activities: some methods may appear effective purely by chance, and many rainmaking failures may have been under-reported.

4.2. Empirically successful rainmaking methods arising purely by chance

Statistics as a discipline was formulated and mathematized rather late in history (MacKenzie and Stigler 1988) and the concept of chance was poorly understood before the mid-seventeenth century (Hacking 2006). One aspect of rainmaking that many modern readers may fail to appreciate is that evaluating the efficacy of rainmaking methods is in fact a non-trivial statistical challenge which requires carefully controlled experimentation and analyses. Our scientific understanding of the world tells us that none of the ancient rainmaking methods work; people

without such theoretical commitments, however, were faced with an inferential problem similar to what is now referred to as "multiple testing" (Rupert 2012). Briefly, the problem is that when a large number of hypotheses were being considered simultaneously without controlled measure such as the Bonferroni correction (Armstrong 2014), some hypotheses may appear statistically significant simply due to chance.

In the context of rainmaking, this means that some rainmaking methods may appear to be effective because many different methods are available in the market and some happen to obtain a successful track record by chance. Note that as a cultural species, people's ideas about what might work is mostly culturally transmitted. This fact, combined with individuals' idiosyncratic local environments, creates a large number of available methods.

A little formalization may be useful to demonstrate this phenomenon and provide some numerical intuitions. Suppose there are *N* methods of rainmaking (identical in terms of their efficacy) under consideration. Each method is "experimented" *n* times with the probability of "success" being *p*. The probability density distribution of the total number of success of each method is a binomial distribution with parameter *p* and *n*. The expected number of methods with *k* out of *n* success (a success rate of *k/n*) is thus

$$\binom{n}{k} \cdot p^k \cdot (1-p)^{(n-k)} \cdot N$$

Figure 2.1.1 provides a graphical illustration of the above equation. If the probability of success of each method *p* is set to be the same as chance (as we would expect from a modern perspective when it comes to rain-making rituals), we observe that although most methods have a success rate lower or close to chance, there will be quite a few methods with success rate significantly higher than chance. For example, if the chance of rain is 0.3, among the 100 rainmaking methods

we expect ten with 50% success rate, four with 60% success rate, and one with 70% success rate merely as a result of randomness. Therefore, some rainmaking methods may appear very efficacious, not because they actually influence weather but merely because of chance. Of course, keep in mind that if a method with a solid track record suddenly fails, there are many potential explanations such as the incompetence or insincerity of a particular rainmaker.

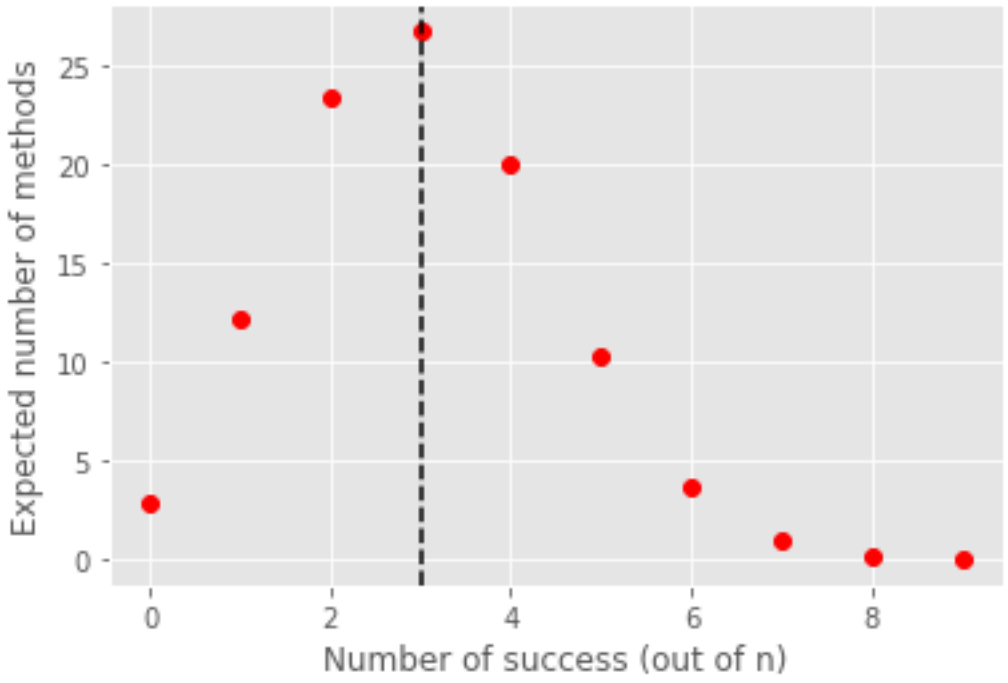

FIGURE 2.1.2. THE GRAPHICAL REPRESENTATION OF EQUATION (1) WITH ILLUSTRATIVE PARAMETER VALUES: N = 10, P = 0.3, N = 100. THE EXPECTED NUMBER OF SUCCESSES PURELY BY CHANCE (X = 3) IS DENOTED BY THE DASHED LINE.

4.3. Under-reporting of dis-confirmatory instances

A second reason why the efficacy of rainmaking protocols may be perceived to be higher than it actually is (chance) is that many of the rainmaking failures are not reported and thus not transmitted overtime. There is evidence that some people may have been aware of such under-reporting issues. For example, the Song historian and philosopher Lü Zuqian (1137-1181 CE) made the following statement when commenting on the Confucian text *Zuo Zhuan* (~500 BCE):

> Some people ask: "Zuo's record of crackmaking and milfoil divination cases were so amazing and spectacular; given such predictive accuracy, why are there so few [records] of them?" The answer: "from the Lord Yin till Lord Ai was a total of two hundred and twenty-two years. Kings, lords, dukes, the literati and the commoner perhaps made tens of thousands of divinations, and only tens of the efficacious cases were recorded in Zuo's book. These tens of the cases were collected in Zuo's book and therefore feel like a lot; if they were dispersed into the two hundred and twenty-two years it would feel extremely rare. If divination cases were of deceptive nature or had failed predictions, they would not have transmitted during their time and would not be recorded in the book. I do not know how many tens of thousands of them were missed. If we had all of them [recorded], they would not be so rare. (*Donglai Zuoshi Boyi*[30])

Similarly, the famous Ming politician Zhang Juzheng (1525-1582 CE), commented on the then popular practice of geomancy:

> Some people say: "Geomancers' words (predictions) often turn out to be true. If [they do] not [possess real abilities], how could they foresee what is going to happen in the future?" This statement is not true…Suppose there is a place here, let three geomancers predict [whether it is suitable for place a tomb]; one says it is auspicious, one says it is inauspicious, and the third says it is first auspicious followed by inauspiciousness… If it turns out auspicious people will say the first geomancer made accurate predictions; if it turns out inauspicious they will say the second geomancer made accurate predictions, and auspiciousness followed by inauspiciousness will be said to be predicted by the third

[30] 东莱左氏博议.

> geomancer. People transmit cases of accurate predictions and not cases of inaccurate predictions. That's why [predictive] failures are not heard and successes by chance stay/exist [in our society]. (*Zangdi lun*[31])

Although Lü Zuqian and Zhang Juzheng are talking about divination and geomancy, the same argument can be easily applied to other instrumental activities such as rainmaking. To obtain some quantitative information on the possible under-reporting of the rainmaking failures, we compiled a dataset using the digitized official Chinese dynastic records[32] (Twenty-Four Histories plus Draft History of Qing)[33] which are systematic records of important people and events of the previous dynasty written by professional historians of the later dynasty (Wilkinson 2012) from the Chinese Text Project (ctext.org). Specifically, we searched for keywords 祈 (to pray/request) and 祷 (to pray), collected all instances involving the prayer for rain/snow to occur or stop, and recorded whether an outcome was specified as well as the number of days it took from performing the ritual to the occurrence of the desired effect (e.g. rain, snow, or clear sky).

[31] 葬地论.

[32] Note that these recorded rainmaking instances are quite special in that they come from the official dynastic records which carry a certain authority. We suggest, however, that this sense of authority carried by transmitted texts are not unique to China: The authority of Aristotle in west, for example, has shaped our understanding of the causal structures of the world for thousands of years, and it was only rather recently (the scientific revolution in the 17th century) that we observe a profound shift in epistemology in Europe (Wootton, 2016). Galenic medical theory similarly shaped subsequent medical practices in Europe well until early modern times (Hankinson, 2009; Nutton, 1972).

[33] Books used for keyword search: Shiji (史记), Han shu(汉书), Houhan shu (后汉书), Sanguozhi (三国志), Jin shu (晋书), Nan shi (南史), Bei shi (北史), Sui shu (隋书), Jiu Tangshu (旧唐书), Xin tangshu (新唐书), Jiu Wudaishi (旧五代史), Xin Wudaishi (新五代史) Song shi (宋史), Jin shi (金史), Yuan shi (元史), Ming shi (明史), Qing shigao (清史稿).

Table 2.1.1: Rainmaking data from Chinese dynastic records

		Outcome & Accuracy				
Dynasty	*Date*	*Total ritual attempts*	*Rain ritual success*	*Rain ritual failure*	*Success rate*	*% outcome unreported*
Han (汉) and Pre-Han	*Before 220CE*	*17*	*15*	*0*	*88.2%*	*11.8%*
Jin (晋)	*266-420CE*	*2*	*2*	*0*	*100%*	*0*
N & S dynasties (南北朝)	*420-589CE*	*23*	*18*	*3*	*85.7%*	*13.8%*
Sui (隋)	*581-619CE*	*2*	*0*	*0*	*NA*	*100%*
Tang (唐)	*618-907CE*	*32*	*13*	*5*	*72.2%*	*43.8%*
Five Dynasties (五代)	*907-960CE*	*38*	*8*	*2*	*80.0%*	*73.7%*
Liao (辽)	*907-1125CE*	*10*	*3*	*0*	*100%*	*70%*
Song (宋)	*960-1279CE*	*179*	*37*	*2*	*94.9%*	*78.2%*
Jin (金)	*1115-1234CE*	*59*	*11*	*2*	*84.6%*	*78.0%*
Yuan (元)	*1271-1368CE*	*25*	*18*	*1*	*94.7%*	*24%*
Ming (明)	*1368-1644CE*	*54*	*11*	*5*	*68.8%*	*70.4%*
Qing (清)	*1636-1912CE*	*146*	*54*	*2*	*96.4%*	*61.6%*

Total	*497*	*144*	*17*	*89.4%*	*65.1%*

Table 2.1.1 summarizes the results. One clear trend here is that there are very few recorded failures and as a result many more successes, relatively speaking. What is particularly conspicuous is that a substantial proportion of the rainmaking outcomes are not reported. While we do not necessarily need to know the details of every rainmaking attempt, we are interested in whether failures are more likely to go unreported than successes, and there are a few reasons to think that this was the case. First, successful rainmaking was often viewed as a kind of achievement, and many rainmakers took pride in it (Snyder-Reinke 2020). These rainmakers were thus more likely to advertise their own success. Second, a suspicious pattern can be observed when we consider the days it took for an outcome to occur: there are many more rainmaking successes that occur shortly after (0~1 days) the rainmaking ritual than those with a longer delay. The phrase 是日 (on this very day) is often used which gives an impression of immediate weather response. In the Qing dynasty where we have rather detailed records of the time for rainmaking efforts to take effect: 42.2% of the rainmaking successes occur on the same day the ritual is performed, and the distribution has a rather long tail, with the number of day before rain/snow/clear sky occurs ranging from 1 to 30 (Figure 2.1.2). This suggests that while cases of immediate success were unambiguously reported, the lack of immediate success was not interpreted and reported as failure; indeed, there is quite some room in attributing later rain to earlier rainmaking. On the extreme end, we see that a delay as much as 30 days could still be said to be due to previous rainmaking efforts.

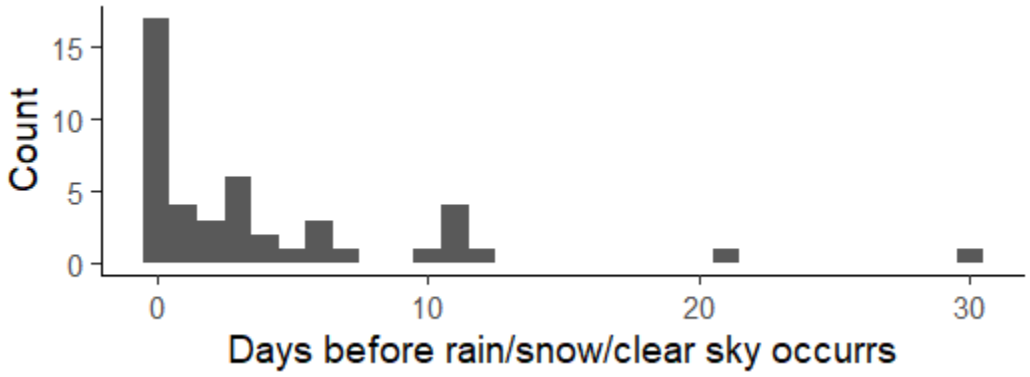

FIGURE 2.1.3. THE NUMBER OF DAYS IT TOOK BEFORE THE DESIRED WEATHER OCCURRED, AS RECORDED IN THE DRAFT HISTORY OF QING.

Such under-reporting may arise for a number of reasons, including confirmation bias (Nickerson 1998; D. K. Johnson 2017) and the aforementioned availability and representativeness heuristics. Regardless of the initial cause, the consequence of under-reporting is that naïve individuals (readers of the dynastic histories) may erroneously conclude that rainmaking is highly effective even if they do not possess the cognitive biases. In other words, the tendency to under-report disconfirmatory instances creates a feedback loop in which the belief in the perceived efficacy of rainmaking (or any other technology) may be recursively boosted.

4.4. In the background: a supernatural worldview

We should keep in mind that despite the sporadic skeptics (whose views were never very popular), most ordinary people in pre-modern China held a worldview in which spiritual agencies can respond to human requests and objects may stimulate each other based on sympathetic principles. This meta-understanding of the world created strong content bias (Henrich and McElreath 2003) regarding the *a priori* plausibility of various kinds of rainmaking protocols. With the theoretical commitment of the existence of human-like agencies, failures to

bring about rain are more likely to be attributed to unpersuasive negotiations with the divine or too much attention to the wrong deity.

This supernatural worldview is closely related to the literature that focuses on the intrinsic plausibility of cultural practices discussed in the beginning of section 4. To reiterate, this literature within evolutionary psychology and anthropology have treated the content-specific biases regarding why we find particular cultural practices plausible as largely a result of genetically evolved causal intuitions (Boyer 2020; M. Singh 2017; Miton, Claidière, and Mercier 2015). We would like to point out that although such a supernatural worldview is certainly supported by innate intuitions, it is also subject to systematic cultural input, and may change as a result of cultural influence. As we will show, this was exactly what happened during the turn of the twentieth century: the replacement of the supernatural worldview with the scientific-mechanistic finally led to the full rejection of ineffective rainmaking rituals. It was not the case that the Chinese suddenly had good data to distinguish ineffective from effective rainmaking methods. Rather, a mechanistic understanding of the world that categorically denied their plausibility increasingly supplanted earlier worldviews.

5. The disappearance of rainmaking: a rejection based on theory

The persistence of various rainmaking methods throughout Chinese history and across the world is remarkable and has been extensively studied. Yet, their relatively sudden decline has received much less scholarly attention[34]. This is unfortunate since the conditions under which many

[34] Note that strictly speaking, traditional rainmaking still *exists* in both China and elsewhere in the world, just as astrology and other "superstitious" practices still have their market. In any society with sufficiently large population and complex social structures, there are going to be people who commit to different epistemologies and practice non-mainstream practices. In the US, for example, a small yet often vocal minority hold beliefs to the contrary of scientific consensus (e.g., anti-vaccination beliefs) despite the spectacular scientific and technological advances the US has experienced during the past few centuries. However, if we look at the larger picture, there is a genuine,

people came to no longer believe in these objectively ineffective methods provide crucial insights into the psychological and sociological mechanisms that had sustained them for millennia (e.g., Table 2.1.1). On the surface, the disappearance of ancient rainmaking and other magical practices took place in the late nineteenth and early twentieth century as China gradually modernized under Western cultural influences. Rainmaking, along with many other ancient practices was deemed "superstitious" and replaced with modern technologies that, unlike magic and divination, often had both materialist theoretical explanations and systematic empirical grounding.

This account is largely accurate, but it misses some key information regarding the social dynamics during this cultural transition. How did China modernize and what exactly happened to the ancient beliefs and practices? We suggest that the disappearance of traditional rainmaking was ultimately due to the rejection of traditional theories of rain at the elite level, who then disseminated modern scientific theories of weather phenomena through institutional channels such as mass education. In other words, it was not the case that people somehow realized that various traditional rainmaking efforts did not perform any better than chance based on *data*, but rather that the imposition of a different worldview made the traditional theories behind these rainmaking efforts seem implausible.

From the late Qing to the early Nationalist era Western scientific ideas had been spreading quite rapidly, as people were impressed by the superiority of Western technological and scientific achievements (Cheng and Waley 1960). During the same era students were sent to

qualitative difference between the public understanding and practice of rainmaking in traditional China and modern China precisely because of a worldview shift. Even in the case of Taiwan, where traditional rainmaking (praying to deities) is more frequent and sometimes attended by public officials, surveys show that the only a minority expect the rainmaking ritual to be "efficacious," and there is often public pressure from intellectuals that discourage high level government officials to attend these "superstitious" rituals (T. Wu 2021).

the US and Europe to study science and applied technology (Deng 1995; Xiu-li 2008); most of them returned to China and many held important positions in the subsequent Nationalist government (Wei 2008). Regarding rainmaking, many Western-educated Chinese scholars either publicly or anonymously voiced their criticism by emphasizing the implausibility of weather being controlled by gods and deities, and often offered alternative, more naturalistic theories of rain. For example, in 1908, the influential early modern intellectual Hu Shi made the following comment on traditional rainmaking methods:

> When there is a drought, people want to pray for rain; but who do they pray to? Maybe praying to Heaven and Earth 天地? Yet heaven is but a puff of air, and earth is but a globe. Maybe to the Jade Emperor? To the Dragon King? Yet, the Jade Emperor and Dragon King are made of wood and mud and they know nothing [about weather]. (Six pieces of bad tradition, *Dian Huabao, Issue 5, 1908)*

Others explicitly articulated alternative, scientific theories of rain. In 1926, Harvard educated geologist and meteorologist Zhu Kezhen published an article repudiating the traditional rainmaking practices and explaining the natural causes of rain – that is the current scientific take on rain:

> Rain comes from the water vapor in the air. All air that is close to the Earth contains water vapor; not only air above the sea, but also air above the desert. Whether it rains or not depends on the condensation of water vapor into water. The lower the temperature of the air is, the less it contains water vapor… Therefore low air temperature is the necessary condition for rain. (On the prohibition of butchering for rainmaking and drought, *Dongfang Zazhi, issue 13*)

A particularly telling example occurred during a severe drought in southeastern China in 1934. The long-lasting drought caused much desperation, and many traditional rainmaking practices were conducted in various localities (Ai 2010). In Shanghai, philanthropists, entrepreneurs, and some local activists organized a fundraising event and invited the "Heaven's Master Zhang" 张天师 to perform a rainmaking ritual. The ritual was in fact a "success": rain indeed came afterwards (Hu 2017a). In traditional China, this would no doubt be touted as proof of the rainmaker's capacity to induce rain and the effectiveness of the rainmaking method. The reaction from many Western educated intellectuals at the time, however, was one of criticism, ridicule, and sarcasm (Hu 2017b). The following derisive comment in the leading newspaper at the time, *Shun Pao*, exemplified a common attitude:

> During the drought this year, the Soviet Union spent such time and money to invent artificial rainmaking; our 63rd generation Heaven's Master just needed to step onto the podium and exercise his magical power, didn't heavy rain fall as well? But it is told that Heaven's Master Zhang for some reason has attempted suicide five times; I hope that he passes all his magical apparatus to the 64th generation before he dies. (East, West, South, and North, *Shun Pao, issue 21, 1934*)

By this time, although uneducated lay people still maintained some of the traditional beliefs, the educated elites had rejected them on theoretical grounds. Therefore, any observed success could only be incidental and not due to the causal influence of rainmakers. A keyword search of "praying for rain" (求雨) in the Shanghai Library Chinese Periodical Full-text Database shows that in the year 1934, 44% of the articles expressed obvious negative attitude towards traditional rainmaking activities out of a total of 66 occurrences, and among the disapproving

articles the vast majority (90%) did not mention any actual rainmaking failures. Rather, many of the articles explicitly label traditional rainmaking as "superstition" (迷信), and those peasants who believe in it "stupid people" (愚民). How was the elite-level skepticism during this time different from the sporadic skeptics of earlier eras? We suggest two key differences. First, the shock of Western superiority that hit China was so profound that it fundamentally rattled many people's faith in traditional Chinese culture in general. Thus many intellectual elites adopted entire sets of cultural beliefs and value systems from the West, which led to a total rejection of the theoretical core of traditional Chinese divination, rainmaking and other magical practices (Spence 1982) — a case of prestige-biased transmission (Henrich and Gil-White 2001). Second, these elites—given the power of the Chinese state — were in a position to quickly and efficiently spread new worldviews thorough institutions such as modern schools, universities and government agencies.

The elimination of ineffective rainmaking methods and the realization of the superiority of the "do-nothing" strategy, therefore, should be viewed as the result of a group-level process. That is, it was caused by the spread of the materialistic and scientific worldview from Western Europe to other parts of the world. Within-group cultural evolutionary forces such as payoff biased transmission often fail to pick up the "do-nothing" among many "do-something" strategies. This is because the "do-nothing" strategy does not benefit from the under-reporting of disconfirmatory evidence (in fact, in this case *positive* instances are likely to go under-reported as they are less likely to be noticed), and as a single strategy with low salience it is unlikely to appear "efficacious" by chance. Again, people do care about outcomes, but the empiricism in traditional societies work better when the optimal variant is of a "do-something" nature.

One of the prominent features of modern science, we argue, is that it denies the causal relevance of magical action and alleged outcome, thus making the "do-nothing" strategy the only scientifically-defensible alternative. However, it is worth noting that the "do-something" bias is so powerful that we can still see it skewing behavior in modern societies: as a recent newspaper article notes, the modern version of rainmaking, seeding clouds with chemicals to induce precipitation,[35] is practiced quite widely across modern China. This is despite evidence that it is only efficacious in, at best, very specific circumstances, and that overall the costs of the practice appear to greatly outweigh the benefits. ("Cloud-Seeding Will Not Solve China's Water Shortages" 2021). If an ineffective "do-something" strategy can prevail in modern China, even with the benefit of detailed data gathering and modern scientific models, the longevity of traditional rain making practices is not at all surprising.

In fact, rejection of a set of previously accepted practices due to a shift in worldview was likely a general feature in the evolution of ineffective instrumental practices. In his most celebrated book *Religion and the Decline of Magic,* Keith Thomas (1971/2003) penetratingly concludes that

> …once their initial premises are accepted, no subsequent discovery will shake the believer's faith, for he can explain it away in terms of the existing system. Neither will his convictions be weakened by the failure of some accepted ritual to accomplish its desired end, for this too can be accounted for…The reaction against magic could thus

[35] In contrast with traditional rainmaking that involves praying to deities and/or sympathetic magic, cloud seeding, whatever its actual efficacy, is distinctive from them in being theoretically plausible within the modern scientific, mechanistic worldview.

never come from the cumulative resentment of disappointed clients. It had to arise from outside of the system altogether. (Keith Thomas, *Religion and the Decline of Magic*)

Subsequent work in history of science largely corroborates this claim. Astrology in the 17th century England, for example, was suggested to be rejected on non-empirical grounds, as what it would take to test the core tenets of astrology was simply unavailable at the time (Kemp 2003). Similarly, the decline of alchemy was attributed to change in the larger socio-cultural context rather than its empirical inadequacies (Clements 2017). As in the case of rainmaking, a mechanistic worldview renders such traditional practices implausible.

6. Conclusion

In this paper, we focus on the nature of rainmaking rituals in traditional China and argued that they have always been understood as instrumental activities to induce rain, as strongly supported by the extensive historical records and the extant studies on Chinese rainmaking. We further argue that despite the existence of payoff-biased transmission which usually produces adaptive cultural practices, certain psychological and social factors nonetheless can maintain such ineffective technologies as people fail to realize the superiority of the "do-nothing" strategy while under a supernatural worldview. Thus, the disappearance of ineffective rainmaking requires a rejection of the underlying theories of rain. In China, although anti-supernatural, mechanistic theories of the world were available to elites as early as the third century BCE, widespread theoretical rejection had to wait over two millennia until contact with the West. It is worth exploring in more detail the economic, political and cultural factors that finally allowed the successful diffusion of a mechanistic/materialistic worldview of natural phenomena at this

point in Chinese history, but our view is that prestige-biased transmission played an important role.

Although we have exclusively focused on rainmaking in pre-modern China, our proposed cultural evolutionary explanations for the persistence of rainmaking rituals hold for ineffective technologies in general. Shang oracle bones, for example, contain many rain-related predictions (whether it will rain on a certain day) and sometimes have "verifications" (whether it indeed rained on that day), and the vast majority of the recorded outcomes are confirmatory (Keightley 1985). More generally, whenever there is a need to achieve some desirable outcome or to avoid an undesirable one, there will be an incentive to perform some (costly) technology or practice, and potentially many technologies or practices deemed plausible under some larger worldview. Furthermore, when the outcome is probabilistic, people may over-estimate the efficacy of these technology either due to chance or because many of the disconformatory instances were omitted and lost during cultural transmission. Fetal sex prognostication[36], traditional healing (appeasing ghosts/spirits to cure illness), and many other forms of magic prevail largely for these reasons. Note that the two proposed factors that bias efficacy perception -- statistical artefacts and under-reporting of failures -- are but two features (among many others) of the underlying cultural evolutionary processes (Hong and Henrich 2021), and a complete understanding of ineffective technologies, past and present, would require an understanding of the evolved intuitions, the population dynamics of information transmission, and the larger social context in which such transmission occurs.

[36] Gender-related divination was also common in China (Jian Li 2015); once the gender of the baby is believed to be revealed, one can decide whether to keep it (in the case of boy) or to abort to (in the case of girl).

Chapter 2.2. Empirical Case 2: Dream Divination

(Publication: Dream interpretation from a cognitive and cultural evolutionary perspective: the case of oneiromancy in traditional China, *Cognitive Science*, 46: e13088.)

In this chapter, I present the second case, dreaming divination, using historical data from imperial China. Similar to the rainmaking case, I show that there is significant selective reporting: predictively accurate cases are much more likely to be reported in dynastic records. I additionally analyze the idiosyncratic features of dream divination, including the possibility of false memory and retrospective inference, as well as a brief historical investigation of the rise in popularity of dream divination during the Southern-Northern Dynasties period (420-589 CE) and the subsequent decline.

1. Introduction

Dreams have fascinated humankind since antiquity; the story-like events experienced during sleep have inspired countless efforts to make sense of their meaning. Oneiromancy[37], the interpretation of dreams in order to foretell the future, has featured prominently in virtually all ancient civilizations as well as contemporary small-scale, traditional societies (Kessels 1969; Hughes 2000).

The universality of dreaming itself is not surprising. Contemporary research in neuroscience has shed light on the neurological mechanisms of dreaming (Siclari et al. 2017; Nir and Tononi 2010) and psychologists have proposed adaptive, evolutionary explanations for its occurrence (Revonsuo 2000; Franklin and Zyphur 2005). Anthropologically, considerable effort has been devoted to identifying universal features in dream content (Garfield 2009; Nielsen et al. 2003; Griffith, Miyagi, and Tago 1958). Of course, the interpretation of dreams is almost certainly a culturally mediated practice (Lincoln 2003). That is, how specific signs (what appears in one's dream) correspond to meaning (what the dream reveals about reality) is often heavily dependent on the cultural contexts (Kracke 1992).

What is perhaps more noteworthy is the ubiquity of using dreams as a valid source of information. Oneiromancy has been well-documented in the ethnographic literature (Lincoln 1935; Grunebaum, Caillois, and others 1966), and the cultural significance of dreaming has been thoroughly explored by anthropologists (Bourguignon 1972; Hollan 1989). Existing research, however, leaves an important and obvious question inadequately addressed: why do people believe in the validity of oneiromancy when modern neuroscience has shown that dreams do not

necessarily have any bearings on future events (Nir and Tononi 2010; D. Barrett and McNamara 2007)? Typically, oneiromancy, like many other divinatory practices, is explained from functional perspectives which emphasize its social, political, and religious role in a society (Annus 2010). It is undeniable that oneiromancy certainly serves these functions; for example, a general in a battleground may fabricate auspicious dreams to boost his troops' morale (Wenying Liu 1989) and a king may make up dreams to legitimize his political power (Fang 2015). But the effectiveness of such deceptive techniques depends on the audience's confidence in the prophetic power of dreams. Therefore, we still need an account to explain why people believe in the validity of dreams in the first place.

Historically, the art of dream interpretation was often viewed as a form of magic which has been subject to extensive anthropological theorizing (Tylor 1871; Frazer 1890). Briefly, early thinkers tend to treat magic as ineffective technology: that is, what we (modern readers) consider as "magical" activities were really instrumental efforts to achieve some desirable outcomes. As such, the "magicness" of these efforts stems from their ineffectiveness (Tambiah 1990). Why would people engage in these ineffective activities? According to some early anthropological theories, this is because people in certain societies reason in a faulty fashion. Tylor (1871), for example, offers some possible factors that lead to faulty reasoning of people in traditional[38] societies, such as successful outcome by natural means (chance), vague diagnosis, and under-appreciation of negative evidence. More recently, Horton (1967, 1993) has taken up this line of argument by suggesting that while traditional magic practices and western science share the same fundamental goals of explaining, predicting, and controlling worldly events, individuals in traditional societies differ from those in the West in their reasoning habits; specifically, when

[38] The word "primitive" was often used to denote these societies in early anthropological writings.

evaluating the effectiveness of some technology, people in traditional societies do not readily entertain alternative possibilities (e.g. the technology does not work) and do not engage in much reflective thinking.

The above view has gone out of fashion for quite some time, as later scholars in anthropology tended to focus on the symbolic function of magical, ritualistic activities (Tedlock 2006). In the field of psychology and cognitive science, however, there has been a revival of interest in understanding these seemingly irrational beliefs and actions. Vyse (1997), for instance, offers an excellent review of the psychological and cognitive explanations of why people hold irrational beliefs and engage in ineffective actions. The psychological literature on contemporary superstition and traditional divination/magic has grown substantially in recent years; in general, psychological theories tend to attribute these irrational beliefs and actions to some type of *intuition*. In other words, factually incorrect beliefs are held as a result of intuitive reasoning (Risen 2016; Shenhav, Rand, and Greene 2012), and ineffective technologies are practiced because they are intuitively plausible with regard to achieving the alleged goals. In particular, cognitive psychologists and anthropologists often attribute the cultural success of certain magic/divination practices to their specific features that increases their perceived efficacy, and much progress has been made on this front. For example, Legare & Souza (2012) experimentally show that procedural features such as repetition and the presence of religious icons enhance the perceived efficacy of rituals; Nemeroff & Rozin (2010, 1990) suggest that magical principles of sympathy and contagion are intuitively attractive and speculated the adaptive benefits it may have conferred in our evolutionary past (e.g. pathogen avoidance); Miton et al. (2015) contend that the popularity of bloodletting is due to the match between its form (releasing blood from the body) and folk intuitions on the nature of illness and how the

body works; Singh (2017) proposes that specific aspects of shamanism such as inhumanness increases the plausibility of shamanistic practices which culturally evolved as a result of a selective retention process; Barrett (2001, 2008) and Boyer (2001) have argued that concepts (and by extension, cultural practices) that are "minimally counter-intuitive" are more memorable and enjoys an advantage in the transmission process.

There is no doubt that intuitive plausibility contributes to the overall explanation of the persistence of ineffective technologies such as oneiromancy. However, evolved intuitions are unlikely to provide the full story. Previously, we have offered extensive ethnographic and historical evidence showing that people often entertain considerable uncertainty regarding their efficacy in achieving explicit goals and at the same time often care a lot about whether technological practices indeed achieve the promised outcomes or not (Hong and Henrich 2021). In other words, the empirical side of magic/divination matters as well; though occasionally failures can be explained away rather easily (Annus 2010), frequent failures would likely lead to a certain level of skepticism[39]. Indeed, despite the documented biases and errors in human reasoning and decision making (Korn et al. 2014; Sharot 2011; Henrich 2002), humans do probabilistically modify their beliefs and consequently actions as evidence accumulates (Ambuehl and Li 2018; Shah et al. 2016).

Given such probabilistic understanding of the efficacy of technological practice, it may be useful to explore factors that contribute to the estimation of technological efficacy. In addition to individual trial and error learning (more generally, reinforcement learning) (Dayan and Balleine 2002; Dayan and Daw 2008; Niv 2009), humans obtain a tremendous amount of

[39] Although as I emphatically point out in (Hong, Slingerland & Henrich, forthcoming) and will later discuss in the paper, such skepticism rarely lead to a complete rejection of the validity of some technological practice.

information culturally (P. J. Richerson and Boyd 2005). As such, psychological and social factors may create population dynamics in which over-estimation of efficacy occurs. In Hong and Henrich (2021), we have formally modeled the interaction between individual cognition and social processes where individuals update their belief regarding the efficacy of some technology in a Bayesian fashion, and through biased information transmission individuals may end up believing the technology to be substantially more efficacious than it actually is. One key prediction of the model is that overestimation of the efficacy of some technology may be caused by a reporting bias which I have found in other magical activities such as rainmaking (Hong, Slingerland & Henrich, forthcoming) and fetal sex prognostication (Hong, unpublished). In this paper, I aim to place the persistence of oneiromancy in a cultural evolutionary framework and examine the extent to which dream divination failures are under-reported as well as other psychological and social factors that may lead to the over-estimation of the predictive accuracy of dreams in a cultural evolutionary process.

A large literature in psychology and cognitive science has shown that many of our beliefs, attitudes, and behaviors are transmitted culturally rather than through individual learning (Joseph Henrich and McElreath 2003; P. J. Richerson and Boyd 2005; Csibra and Gergely 2009). Often, the anthropological studies on dreams implicitly presume the role of cultural transmission but rarely discuss it explicitly. In an obvious sense, the way people treat and interpret dreams is influenced by others in the community. In most small-scale societies, the meaning of dreams is passed on through word of mouth (Tedlock 1987), and in literate societies such as ancient Greece and ancient China, as written texts (Fu 2017; Price 1986). The importance of cultural transmission, however, extends beyond dream oneiromancy manuals. In addition to how to interpret dreams, people also culturally obtain actual cases of dreams accurately (or not)

predicting future events, which affect their confidence in the validity of dreams as a reliable information source. This latter point is important because ample research in cognitive science and evolutionary anthropology has shown that humans possess some level of "epistemic vigilance" and do not accept transmitted information uncritically (Mercier 2020; Sperber et al. 2010). Predictively accurate dreams thus serve as "data" to corroborate the "theory" that dreams are indeed prognosticative of future events.

The rest of the paper is organized as follows. Section 2 provides the essential background information of theories of dreams in ancient China, and section 3 shows the results of a comprehensive quantitative analysis of dream occurrences in Chinese historical records and offers a cultural evolutionary account of the persistence of dream interpretation. Additionally, I present tentative evidence that although oneiromancy has always been considered a valid technique throughout Chinese history, the extent to which dreams were taken seriously may have declined over time. In the final section, I discuss the applicability and limitations of this account as well as the implications for divination/magic in modern societies. To preview, I argue that a theoretical commitment to the spiritual world, deliberate fabrication/retrospective inference of successful dream predictions, and the under-reporting of failed predictions collectively contribute to the persistence of oneiromancy. While the first factor can be largely attributed to evolved intuitions, the latter two factors crucially depend on our species' reliance on social learning, as our evaluation of the efficacy of some technology is often significantly affected by the testimonies, opinions, and behaviors of others in the community. The declining importance of oneiromancy over time, on the other hand, may be attributed to the uniqueness of oneiromancy compared to other divination and magic practices, i.e. dreams are by nature subjective to

manipulation, cannot be readily produced to solve practical problems, and may be explained by naturalistic (psychological) causes.

2. The cultural background: dream interpretation in traditional China

2.1. Theories of dream interpretations: a supernatural worldview

Like most traditional societies, beliefs in ghosts, spirits, and life after death is prevalent in pre-modern China. Such a supernatural worldview makes certain beliefs appear more plausible; for example, someone with the assumption that people's souls can survive their death is much more likely to believe that deceased individuals may "visit" them in a dream and potentially offer useful information compared to someone with a more materialistic worldview. Although to my knowledge no evolutionary explanation has been proposed for why specific kinds of dream interpretations may be intuitively attractive, evolutionary psychology has proposed evolved intuitions such as life after death (Stewart-Williams, 2018) and the existence of god (Boyer and Ramble 2001; Boyer 2001) that contribute to the plausibility of oneiromancy as a truth-revealing technique. Moreover, research in psychology and cognitive science has shown that our mind is psychologically predisposed to extract meaning from sensory data, and may occasionally detect patterns when there isn't one (Ayton and Fischer 2004). Therefore, *how* dreams should be interpreted may be up for debate, but *that* dreams can be decoded to extract and reveal meaning is usually not questioned. This is not to say that people never suspect whether specific dreams

have predictive power or not; in fact, certain kinds of dreams were thought to be uninterpretable, such as dreams due to over-thinking during the day[40].

It should be noted that while the above arguments bear resemblance to the aforementioned psychological and cognitive literature that focuses on intuition, it differs from previous accounts in two ways. First, most research that invokes intuition to explain supernatural beliefs and practices emphasizes the innateness of our intuitions (with regard to religious beliefs, humans are sometimes described as "born believers" (Rottman 2013)); these intuitions presumably are "hard-wired" in our genes as a result of millions of years of evolution. In my account, although the "supernatural worldview" certainly has (presumably genetically evolved) intuitive support, it also has a significant cultural component. The early anthropologist, Margaret Mead (1932), for example, showed that among the Manus in Papua New Guinea, it was often the adults rather than the children who were more prone to magical thinking and supernatural beliefs. Some recent work in psychology also show that there is no detectable correlation between intuitive thinking and supernatural beliefs (Farias et al. 2017), and people in certain religious societies may even be described as "moving toward magical thinking" as a result of cultural transmission (Harris 2012). The takeaway here is that while debate on the exact role of intuition in supernatural beliefs remains, the role of cultural input should be better appreciated by psychologists and cognitive scientists.

A second difference between the "supernatural worldview" and evolved intuition is that the plausibility of specific beliefs (e.g. dead people may transmit information in dreams) is a downstream consequence of some higher level theoretical commitment (e.g. some form of life

[40] See *Meng Zhan Yi Zhi*, by Chen Shiyuan (1516-1597).

beyond death). As such, once the high-level theoretical commitment is gone or radically altered, the downstream practices that rely on the original theoretical justification lose their plausibility immediately. In a different paper we have argued that rainmaking practices in traditional China suffers exactly from this fate (Hong, Slingerland & Henrich, forthcoming).

2.2. Dream as signs vs. dream as messages

In contemporary Western societies, dreams are often grouped into different categories based on their cognitive functions or the underlying brain activities (C. K. C. Yu 2016; Blagrove 1992; Revonsuo 2000). In contrast, the Chinese, like some other ancient civilizations (Kessels 1969) ,have long classified dreams by how they should be interpreted (Wenying Liu 1989; Hughes 2000). For example, "straight dreams" (直梦) refer to dreams that that are prophetic of reality in a straightforward way, e.g., dreaming of X's death and X dying in reality. "Opposite dreams" (反梦) on the other hand, refer to dreams that are in some sense "opposite" to reality[41].

Since this paper focuses on why people believe in the validity of oneiromancy, I propose to classify dreams by their epistemological status. Specifically, dreams as signs that usually need to be interpreted (often with professional expertise) and dreams as messages transmitted by other humans or human-like agents. This distinction is useful because it highlights how the perceived plausibility of the two kinds of dreams may be affected by one's larger theoretical commitment[42]. The famous Eastern Han skeptical thinker, Wang Chong (27 CE-97 CE), for example, denies the possibility of message dreams but would entertain the possibility of certain sign dreams (Yueqing He 2011). It is also worth noting that there are instances where message

[41] Obviously, "opposition to reality" is a vague term and there is a lot of ways dreams can be said to be "opposite".
[42] This way of classifying dreams resembles Plato's distinction between "technical" and "possession" divination, where "technical divination" refers to the interpretation of signs that appear in dreams whereas "possession divination" refers to messages from the gods conveyed by humans in some altered conscious state (Flower 2008).

dreams nonetheless require great interpretive effort; for example, when the information sender offers a riddle with hidden meaning.

2.3. The cultural transmission of oneiromancy instructions and cases

Because of the indispensability of interpretation in sign dreams, there is often an interest and demand for instructions on how to correctly interpret of the content of dreams. In ancient China, there was a rich tradition in collecting and compiling dreams and their associated meanings (Fu 2017; Wenying Liu 1989), and some of the most popular compilations such as *The Duke of Zhou's Explanations of Dreams* can still be purchased in bookstores today (Yun 2013). As mentioned, the other aspect of cultural transmission of oneiromancy, the transmission of actual oneiromancy cases and the associated predictive outcomes (whether the prediction was successful or not), is also important; intuitively, one would not take dreams very seriously if all she hears about oneiromancy are failed predictions. In China, oneiromancy cases were recorded in historical records, philosophical writings, and a wide range of literary forms (fiction, drama, poetry, etc.) (Wenying Liu 1989). During later dynasties, compilations of oneiromancy cases in the form of encyclopedias became popular with improved printing technology and the expansion of book publishing and distribution (Vance 2012). These encyclopedias often contained both dream prognostic instructions as well as actual cases; in an extensive analysis of an oneiromancy encyclopedia, *Forest of Dreams* compiled in 1636 CE, for example, Vance (2012) shows that it contained not only instructions on how to interpret dreams but also many case descriptions of predictive dreams.

3. Analysis of historical data in a cultural evolutionary framework

3.1. General description of dream collection and the dataset

Although many anthropological and psychological studies on dreams have utilized quantitative approaches, most of them lack a historical dimension. In this section I take advantage of the rich textual record of Chinese dynastic histories to systematically examine the content and context of dream occurrences and how they are interpreted. Specifically, I compiled all dream occurrences by searching the key word "dream/to dream" (梦) in the *Twenty-Four Histories* and *Draft History of Qing*, as well as two well-known pre-Qin historical texts, *Zhuo Zhuan* and *Guo Yu* on ctext.org, a digital database of Chinese textual records. The *Twenty-Four Histories* are the official historical books that record important historical figures and events from mythic times (~ 2600 BCE) to the end of Ming dynasty (1644 CE). The *Draft History of Qing* follows the same format as *Twenty-Four Histories* and is the draft of the official history of the Qing dynasty[43], and *Zhuo Zhuan* and *Guo Yu* are chronical narrative histories covering a period from 722 to 468 BCE. The latter two books are usually attributed to Zuo Qiuming, a historian of Lu during the Spring and Autumn era (770 -476 BCE), though debates remain regarding their authorship (Plaks & Nylan, 2016). Collectively, these records provide a comprehensive coverage of Chinese history, and given their orthodox status, we can have a good sense of the mainstream depiction of dreams in terms of how they were interpreted and the general attitude toward oneiromancy. My choice of using the official historical records for textual analysis is deliberate: although there are

[43] The *Draft History of Qing* was written during the Beiyang government period (1912-1928 AD) but was not completed due to a lack of funding.

perhaps more mentionings of dreams and oneiromancy in non-historical writings, it is unclear the extent to which oneiromancy cases in these literary forms were viewed by the general public as real, recorded story or artistic creations. Dynastic histories, on the other hand, are supposed to consist of only factual information[44]. Of course, as modern historiography points out, the subjective biases in history writing is more or less inevitable (Lustick 1996; Tucker 2009; A. C. Yu 1988), yet we can at least be certain that what is recorded in these officially approved historical documents was deemed realistic and plausible at the time of their writing.

In total, I collected 793 dream occurrences and recorded information regarding the type of dreams, the dreamer, the interpreter, the interpretation of dream and the predictive accuracy of dream interpretation whenever possible (see Supplemental Material for details). To ensure reliability of the coding scheme, two independent coders were invited to code a randomly selected sample (133 out of a total of 793 dreams) based on written instructions (See Supplemental Material for details). I then performed an inter-rater reliability test with *kappam.light* method of the *irr* package in *R* and achieved moderate to substantial reliability (0.548, 0.622, and 0.674 for dream type, interpretation, and outcome accuracy respectively) (Landis and Koch 1977).

We see cultural transmission in action: among the 793 dreams, a significant proportion (15%) are either individuals in later times referencing dreams/dream interpretation of earlier people or historians recording oneiromancy cases that already appeared in earlier texts. Figure 2.2.1 shows the breakdown of the types of dreams across Chinese history. There is a consistent pattern that the majority of sign dreams are symbolic and thus require interpretation. No obvious

[44] The classical Chinese conception of history has been that it is a *record* of events, free of interpretations (Dubs 1946)

temporal trend is observed in the relative frequency of these different types of dreams, and the ratio between message dreams and sign dream in most historical periods is roughly 1:2.

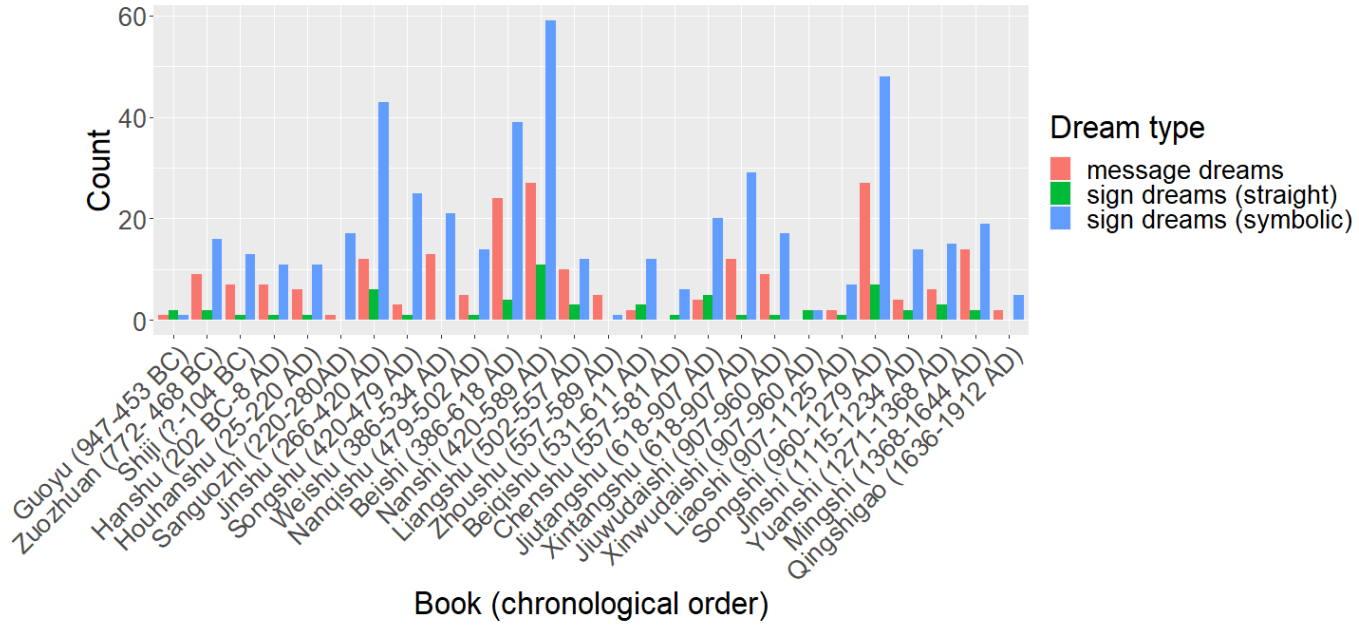

FIGURE 2.2.4. THE BREAKDOWN OF THE DREAM TYPES ACROSS CHINESE HISTORY. THE X-AXIS REPRESENTS THE INDIVIDUAL DYNASTIC RECORDS ORDERED CHRONOLOGICALLY BY THE TIME PERIODS THAT THEY COVER, AND THE Y-AXIS REPRESENT THE RAW COUNTS OF DREAM OCCURRENCES IN EACH TEXT.

Figure 2.2.2 shows the breakdown of the types of dream interpretations across all sources. These dream interpretations cover a wide range of topics, many of which are difficult to classify. Overall, we observe that a large proportion of dream interpretations were related to pregnancy, followed by disaster, death, career, and politics. Many of the dreams are non-predictive; they are mostly dreams of deceased friends or relatives paying visits, offering "thank-you" messages when the dreamer had done something nice to their living family members or refurbished their grave. Consistent with previous anthropological studies of dreams

(Bourguignon 1972; Wallace 1959), my dataset shows that dreams can have therapeutic significance; one may dream of some deity offering to cure either one's own illness or the illness of her close relatives or friends. A final noteworthy type of dreams is that one could gain some ability either through a symbolic dream, where a person or a deity gives the dreamer an object with magic power (e.g. a five-colored pen 五色笔) or a message dream, where one is explicitly taught or trained by some spiritual agent. The exact criteria for categorizing dreams and a more detailed description and can be found in the Supplemental Material.

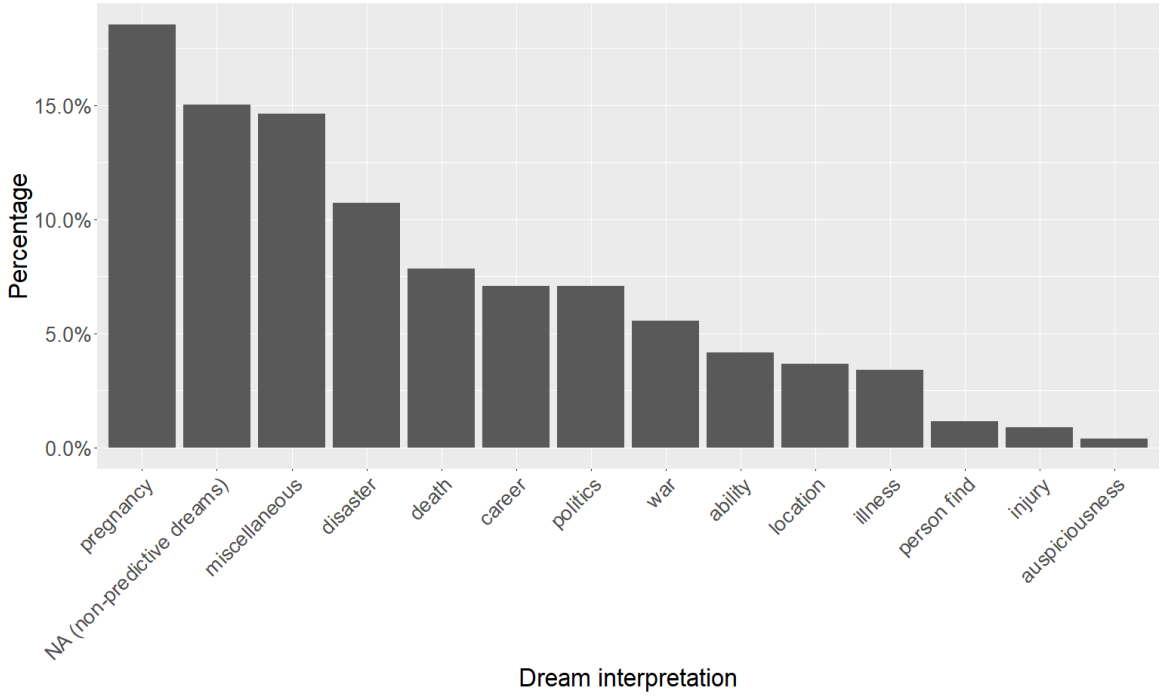

FIGURE 2.2.5. THE BREAKDOWN OF DIFFERENT TYPES OF DREAM INTERPRETATIONS, ORDERED BY THEIR RELATIVE FREQUENCY.

3.2. Fabrication and retrospective inference of prophetic dreams: a look at pregnancy dreams

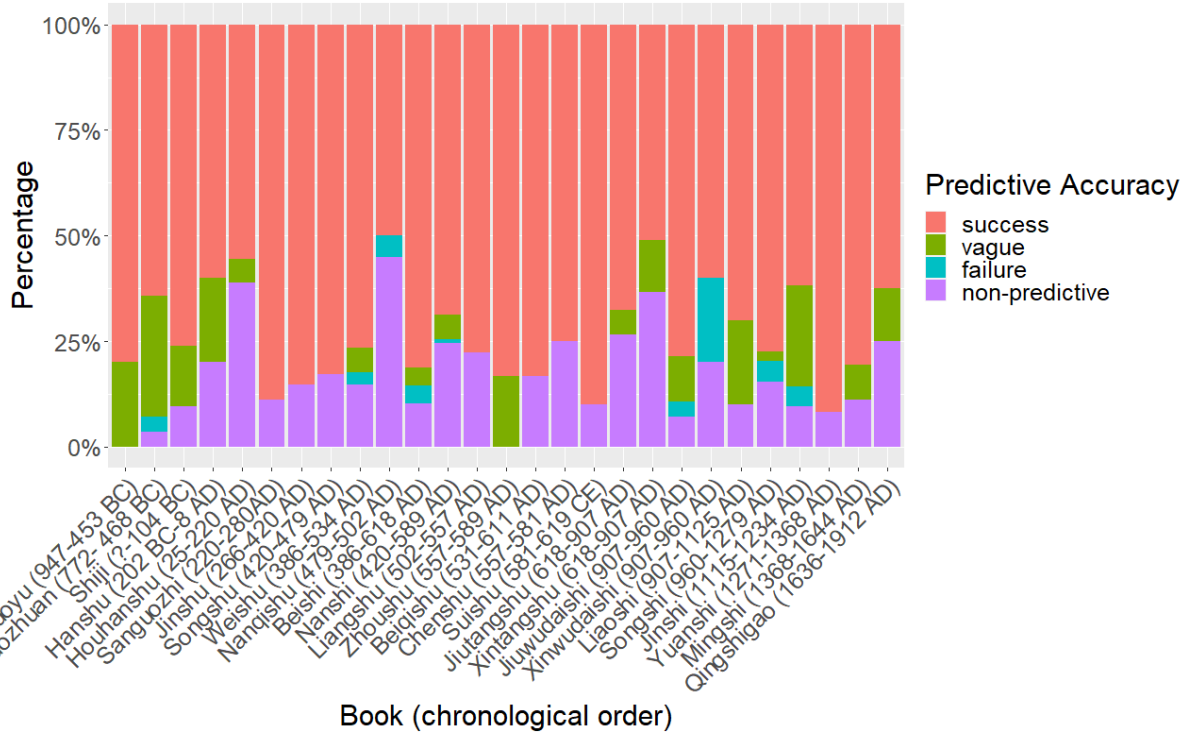

FIGURE 2.2.6. RELATIVE PROPORTION OF DREAMS OF DIFFERENT ACCURACY TYPES AS OCCURRED IN OFFICIAL DYNASTIC RECORDS BY CHRONOLOGICAL ORDER.

With this dataset, I now address the question regarding the persistence of oneiromancy by focusing its empirical component. My basic argument is that predictively accurate dreams strengthen people's confidence in the validity of dreams, and the large number of successful oneiromancy cases that were recorded and transmitted were not an accurate representation of the statistical reality of prophetic dreams. Figure 2.2.3 shows the relative proportion of dreams in terms of their predictive accuracy over historical time, and what is immediately obvious is that most dream occurrences are prophetic and have an associated confirmatory outcome. That is,

whenever dreams are mentioned in these official historical records, the readers can expect that they are predictive of some later outcome which is usually verified. How come oneiromancy as practiced in ancient China appear to have such a high rate of success? First, I address the possibility that many of these dreams and their associated predictions may be deliberately fabricated by focusing on the largest category of dream interpretations (see Figure 2), pregnancy dreams.

Typically, the mother (occasionally the father) of some famous individual would dream of strange things or events which is said to have "induced" (感) the pregnancy. Because official dynastic histories are essentially biographies of famous individuals, pregnancy dreams were often mentioned, partly to demonstrate the extraordinariness of these individuals. In the case of emperors, dragons and suns were usually dreamt by their mothers, and it is probably not a coincidence that both dragons and suns symbolize imperial power. In fact, it is very likely that either historians or people who first reported these stories retrospectively fabricated pregnancy dreams of emperors' mothers to justify the emperors' political power of their own dynasty[45] (Fang 2015). To what extent were these stories believed? Historical texts do not offer straightforward answers, but we can nonetheless get some indirect clues. The famous skeptic during the Eastern Han dynasty, Wang Chong (27-97 CE) made the following comment on the story that the mother of the first Han emperor dreamed of a dragon which presumably induced the pregnancy:

[45] In addition to writing histories of the previous dynasty, official court historians also were responsible for recording individuals and events of their own dynasty, which often served as raw materials for historians of later dynasties (Qu 2020; Xu 2012).

> From the chronical of Gaozu (the later founding emperor of the Han dynasty) we learn that dame Liu (mother of Gaozu) was reposing on the banks of a large lake. In her dream she met with a spirit. At the time there was a tempest with thunder and lightning and a great darkness. Taigong (Gaozu's father) went near, and perceived a dragon above her. She became enceinte and was delivered of Gaozu. These instances of the supernatural action of spirits are not only narrated, but also written down, and all the savants of the day swear by them. (*Lun Heng*, Chapter 26, Forke (1907)'s translation)

Thus the story goes that Gaozu's mother met with a spirit (and presumably had sexual intercourse with it) whose earthly manifestation was a dragon. According to Wang Chong, all the savants believed the veracity of the story, and he felt compelled to make a case against it. Of course, we do not know for sure whether the savants at the time genuinely believed in it or were merely pretending for political reasons. I suggest that some, perhaps many of them were genuine believers; even Wang Chong himself who argued against this kind of supernatural pregnancy believed that when great men are born, there will be signs occurring either in reality or dreams; he just doesn't believe that non-human species such as dragons can have sexual intercourse with humans[46]. This belief in supernatural pregnancy is perhaps not all that shocking considering that 73% of contemporary Americans believe in Jesus' virgin birth according to Pew Research Center[47]. In a way, the Chinese were more justified in believing the plausibility of spiritual impregnation of emperors' mothers as there were more data supporting it!

[46] Later in the text, Wang Chong seems to have entertained the possibility that different kinds/species may have intercourse with each other, but he insists that their offspring are unprincipled and mischievous as opposed to virtuous and king-like.

[47] Pew Research Center. (2013). Celebrating Christmas and the Holidays, Then and Now. Accessed on 01/20/2021 from https://www.pewforum.org/2013/12/18/celebrating-christmas-and-the-holidays-then-and-now/

Intentional fabrication of dreams for political reasons is likely a prevalent phenomenon in these dynastic histories. Besides pregnancy dreams, we occasionally observe individuals themselves use dreams to justify their own political power. For example, the founding father of Eastern Han Dynasty, Guangwu emperor, said the following to one of his generals as Guangwu is achieving tremendous military success yet has not officially declared himself the emperor:

> "Last night I dreamed of myself riding a red dragon flying into the sky; when I woke up, my heart beat real fast." Feng Yi (the general) said: "This is your soul induced/moved by the Heavenly Mandate (天命). The unrest in your heart is due to your habitual prudence."
>
> Then he started to discuss with other generals on officially proposing Guangwu to be the emperor. (*Hou Hanshu, chapter 17*)

We do not know for sure whether Guangwu indeed dreamed of himself riding a dragon, but even it he made it up (and he had good incentive to do so), few would question its validity especially given that he indeed became an emperor later. As long as dreams are perceived to be a permissible information channel, historians and laypeople alike at the time have very little incentive to challenge the dream claim. To get a better sense of the amount of such "political justification" dreams, I computed the percentage of such dreams[48] out of total number of dreams in different historical periods (Table 1).

Table 1. Percentage of dreams that could be used for justifying political power in different time periods.

[48] Dreams that depicts the extra-ordinariness of kings, queens, and emperors, excluding repeated dreams.

TABLE 2.2.1. PERCENTAGE OF DREAMS THAT COULD BE USED FOR JUSTIFYING POLITICAL POWER IN DIFFERENT TIME PERIODS.

Time Period	*Total number of dream occurrences*	*Number of political justification dreams*	*% of political justification dreams*
pre S-N (before 420 CE)	*171*	*27*	*15.8*
S-N (420 -589 CE)	*323*	*33*	*10.2*
post S-N (after 589CE)	*309*	*29*	*9.4*

From Table 2.2.1 we can clearly see that in all three historical periods (The reason for using Southern-Northern Dynasties as the dividing period will be made clear in section 3.4) non-trivial proportion of recorded dreams are of such type. The percentage of dreams that could be used to justify political power is slightly higher in the pre Southern-Northern Dynasties period and remains roughly constant in the later two periods.

In addition to intentional fabrication, some dreams may be "false memories"; that is, individuals may falsely remember and report dreams that they never experienced if these dreams were expected in the community. Recent psychological research on dreams has suggested that the encoding of memories of dreams may share the same neurocognitive basis as autobiographical memory and thus be subject to false memory (Beaulieu-Prévost and Zadra 2015). Psychologists have long known that subjective dream reports are often unreliable (Schwitzgebel 2011), and both theoretical accounts and empirical studies (Beaulieu-Prévost and Zadra 2015) have suggested that false memories may occur quite often in dreams (Rosen 2013).

In particular, Rosen (2013) points out there's often significant memory loss in dream recall which may lead to a "fill in the blanks" process.

While the dreamer may fabricate or falsely remember their dreams, the observer could also *infer* dreams retrospectively. Historians in ancient China often have a "if there is an outcome, then there must be a sign" mentality (W. Zheng 2014) when recording events that were supposed be predicted by divination. Similarly, Vance (2012) in her extensive treatment of dream interpretation of the Ming dynasty argues that written and transmitted dreams often reveal not what the dreamer actually dreamed of but what the recorder believed about the dreams. In my dataset, a substantial proportion of the dreams (11%) were described in a retrospective and explanatory manner, marked by the phrase "in the beginning" (*chu*). This way of writing gives the impression that the authors were trying to find signs that had already foretold the fate of individuals in order to create a coherent narrative.

Therefore, it is likely that the retelling and recording of dreams involves an imaginative and inferential process. Li (1999) points out that in early Chinese historical writings authors may present cases where multiple individuals shared the same dream to prove its objective veracity. In my dataset, 1.3% of total dreams were reported to have multiple dreamers, and in the most extreme case hundreds of people were said to have dreamed of the same thing[49]. Although this is not statistically impossible, we can safely conclude (unless we seriously entertain the possibility of ghosts and spirits) that there was either some serious fabrication or false inference.

[49] *Nan Shi*, chapter 63.

3.3. Under-reporting of failed dream predictions/wrong dream interpretations

In addition to the fabrication/retrospective inference of oneiromancy cases, under-reporting of failed predictions very likely existed to a substantial extent. The Song historian and philosopher Lü Zuqian (1137-1181 CE) made the following statement when commenting on the Confucian text *Zuo Zhuan* (~500 BCE) regarding the accuracy of divination predictions:

> Some people ask: "Zuo's record of crackmaking and milfoil divination cases were so amazing and spectacular; given such predictive accuracy, why are there so few [records] of them?" The answer: "from the Lord Yin till Lord Ai was a total of two hundred and twenty-two years. Kings, lords, dukes, the literati and the commoner perhaps made tens of thousands of divinations, and only tens of the efficacious cases were recorded in Zuo's book. These tens of the cases were collected in Zuo's book and therefore feel like a lot; if they were dispersed into the two hundred and twenty-two years it would feel extremely rare. If divination cases were of deceptive nature or had failed predictions, they would not have transmitted during their time and not be recorded in the book. I do not know how many tens of thousands of them were missed. If we had all of them [recorded], they would not be so rare. (*Donglai Zuoshi Boyi*[50])

The early Qing scholar Xiong Bolong (1616-1669 CE) commented on using dream signs to predict the gender of the fetus more specifically[51]:

[50] 东莱左史博议.

[51] Interestingly, Xiong Bolong does think that what appears in the mother's dream *statistically* predicts the fetus's gender by offering a justification of using the yin-yang theory.

> It is not the case that all pregnant women have the same type of dreams, and it is not the case that if [she] dreams of certain signs she must give birth to son or daughter. There are also instances where one dreams of a bear[52] yet gives birth to a daughter, and instances where one dreams of a snake and gives birth to a son. The poets [diviners] tell the cases where their predictions are fulfilled and not talk about the cases where their predictions failed. (*Wuhe Ji*[53])

Passages like this shows that even in pre-modern times some people were aware that failed predictions may have been missed or intentionally ignored in transmitted texts. There are a few reasons why people might preferentially report dreams whose predictions turn out to be accurate: first, a large literature on confirmation bias has shown that humans have a tendency to search for, interpret, and recall information that supports one's prior beliefs (D. K. Johnson 2017; Nickerson 1998); second, research on norm psychology suggests that one of the most fundamental human psychological disposition is to observe, internalize, and follow rules (Chudek and Henrich 2011). Thus, if the community norm is to use dreams for predictive purposes then people may have an incentive to avoid revealing predictive failures. Lastly, my own fieldwork in southwest China among the Yi shows that many people are unwilling to reveal the divination or healing ritual failures of local shamans because these shamans are often friends and neighbors of the clients and there is the concern that spreading "accidental" failures may taint their reputation (Hong, unpublished).

[52] The association between dreaming of bear and giving birth to son (as well as dreaming of snake and giving birth to daughter) originally comes from *Classic of Poetry, Xiaoya.*
[53] 无何集.

Therefore, if the prevailing belief is that dreams indeed contain hidden information that could be decoded and interpreted, dreams with failed predictions are not as likely to be recorded and transmitted as predictively accurate dreams. This may create a population level process where these predictively accurate dreams were taken as data for the validity of oneiromancy by naïve individuals (See Hong and Henrich (2021) for a formal analysis of this process, and De Barra (2017), De Barra et al. (2014) and Ioannidis (2017) for additional analysis in the medical literature). In most dynasties, predictively accurate dreams constitute over 50 percent of total recorded dream occurrences, and this percentage will be even higher if we discount non-predictive dreams. Deliberate fabrication and retrospective inference alone are unlikely to account for such a high proportion of predictively accurate dreams; after all, these dynastic records were written by serious historians and the fabrication of facts was generally discouraged in Chinese historical writing.

With the above analysis in mind, let's take a closer look at Figure 3. Notice that there is a non-trivial amount of dreams (5-20%) with vague predictive outcomes in most dynastic records. These dreams were mostly cases where the dream content was clearly described but does not have a definitive confirmation or disconfirmation of the dream's significance or prophetic power. It is likely that many of these dreams were in fact predictive failures, as otherwise historians would have recorded the verifications given that dreams were generally viewed as a legitimate information source. Will a naïve reader realize that these dreams with unclear predictive outcomes may in fact be predictive failures? We do not know for sure, but I suggest it is very likely that people with a strong background belief in the validity of oneiromancy will take these dreams signs as meaningful and prognosticative, and that the predicted outcomes of these dreams

in fact occurred but happened to be omitted for idiosyncratic reasons. Further historical and anthropological work may shed light on this interesting possibility.

As we have argued elsewhere, under-reporting of failed predictions may be a prevalent feature of divination in ancient societies (Hong and Henrich 2021). By selectively omitting failed predictions these transmitted texts give a false impression that dream interpretations are overwhelmingly accurate, which, along with fabrication and *ad hoc* inference of predictive dreams, serves as a powerful mechanism to empirically sustain the validity of oneiromancy.

3.4. The declining significance of oneiromancy over time: evidence from its frequency of occurrence

So far, I have discussed factors that contribute to people's confidence in oneiromancy, with the premise being that oneiromancy was viewed as a legitimate prediction technique throughout Chinese history. Indeed, Figure 2.2.3 shows that the success rate of dream interpretation does not change much over time, and there is not a definitive trend in the number of dream occurrences over time based on Figure 2.2.2. However, later texts were often lengthier than earlier ones; could there be a temporal pattern in the relative frequency of dream occurrences? To investigate this, I obtained the number of total characters in each of the Twenty Four Histories from the Corpus of Chinese Dynastic Histories[54] (Zinin and Xu 2020), and calculated the relative frequency of dream occurrence (number of dreams divided by number of total characters) in each dynastic record. Figure 2.2.4 shows the relationship between the middle year of each dynastic record's coverage and the relative frequency of dream occurrence, with 95% confidence intervals

[54] *Zuo Zhuan*, *Guoyu*, and *Draft History of Qing* from the published versions by Zhonghua Book Company (中华书局)

calculated assuming the number of dreams recorded in a particular history follows a Poisson distribution. Although there is not a definitive linear temporal trend, we nonetheless observe some interesting patterns. Most notably, there appears a sudden spike at around 500 CE. The dynastic history *nanshi* (*南史, The History of the Southern Dynasties*), for example, has a frequency of 0.15 per thousand characters as many of the temporally nearby dynastic histories such as *nanqishu (南齐书, The History of Nanqi), beishi (北史, The History of the Northern Dynasties), liangshu (梁书, The History of Liang)* and *beiqishu (北齐书, The History of Beiqi).*

What is special about this particular time period? Traditionally, the period between 420 CE and 589 CE is referred to as The Southern and Northern dynasties (Zhi'An and Henderson 2014) and is a particularly turbulent time of civil war and political chaos. Yet the same period also witnessed great cultural and religious transformations, most notably the rapid spread of Buddhism. According to some authors, the bitter wartime suffering turned many laypeople and elites alike towards religion and placed their hopes into the promised afterlife often in the form of Karma and reincarnation (Y. Duan and Zhang 2020). Though the real cause of Buddhism spreading is most likely complex and multi-faceted, there is no doubt that Buddhist values and beliefs was vastly popular during this time period yet such popularity gradually waned in later dynasties (Sato 1955; Ch'en and Ch'en 1972; Whalen 2013). I suggest that the heightened religious interest during the Southern and Northern Dynasty contributed to people's belief in dream as this religion greatly increases the theoretical plausibility of dreams being predictive devices. My dataset supports this possibility: in this short time period, we observe 12 dreams with explicit mentioning of either the Budda (佛) or other Buddhist deities out of a total of 20 Buddhism themed dreams throughout the entire dynastic histories.

After the Southern and Northern dynasties, however, the frequency of dream occurrence visibly declines (see Figure 2.2.5 for a comparison of the dream frequency in the three time periods), with a downward trend particularly noticeable in later dynasties. This means that although oneiromancy cases were still described as accurate whenever they are mentioned, the total amount of their mentioning seems to have decreased over time. The *Draft History of Qing*, for example, covers nearly 300 hundred years of history (1636-1912 CE) and has the greatest number of characters (4,514,000), but only mentions dreams eight times. Of course, because the *Draft History of Qing* was written between 1914 and 1928 when the radical social and cultural transformation was taking place, it is possible that its authors were influenced by the scientific thinking from the West and thus their omission of oneiromancy cases does not reflect attitudes towards oneiromancy during the Qing dynasty. To obtain additional evidence, I turn to non-supernatural fictions in the Ming and Qing dynasties for their depiction of dreams and dream interpretations. Obviously, we need to bear in mind the aforementioned caveat that dream stories in these literal works may be artistic creations and may be thought of as unrealistic even by their contemporaneous readers. In the following analysis, I thus excluded fictions with explicit supernatural themes and only focused on historical and realistic fictions in the Ming-Qing era (1368-1912 CE).

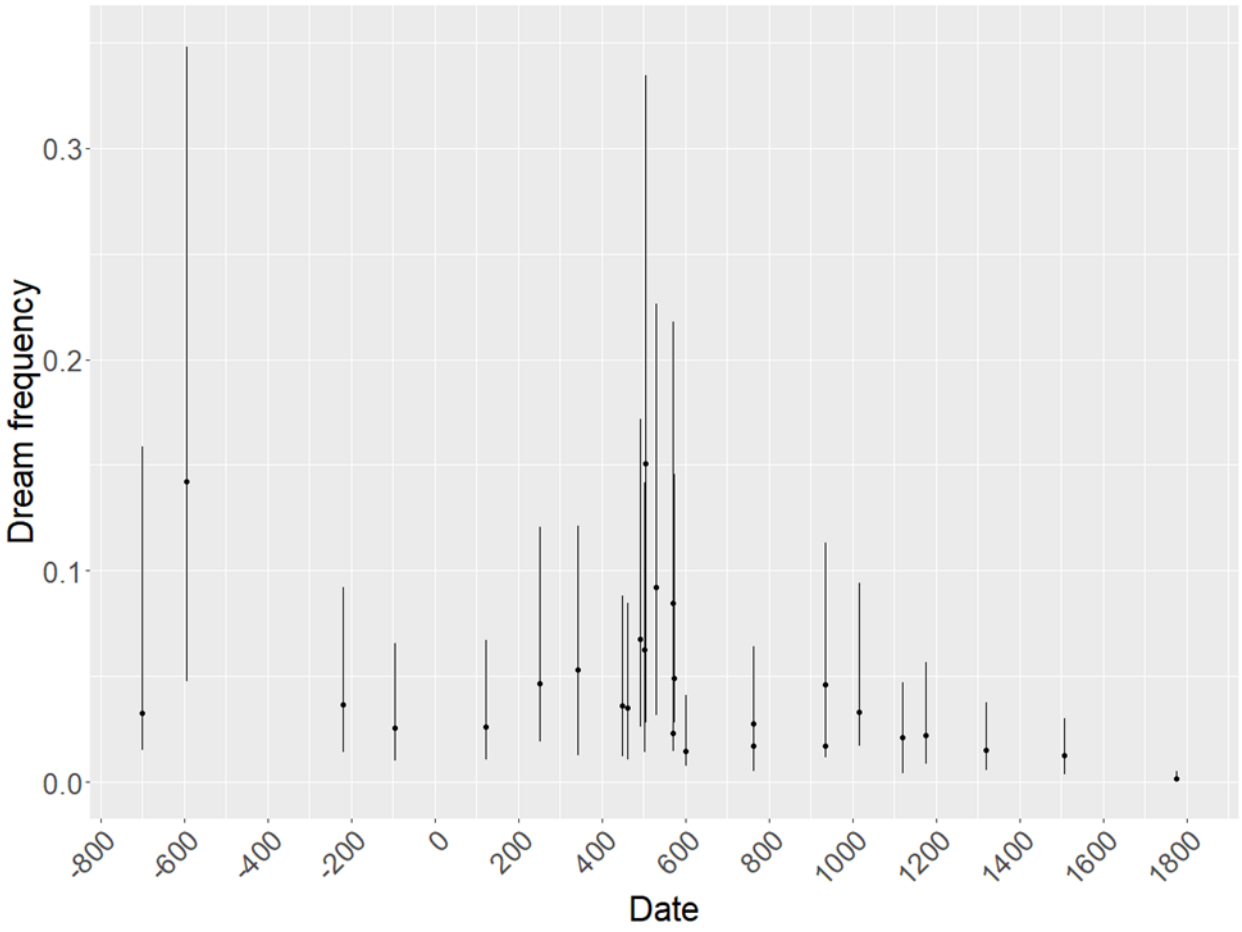

FIGURE 2.2.7. DREAM FREQUENCY (OCCURRENCE PER THOUSAND WORDS) VS. YEAR. EACH DATA POINT REPRESENTS THE MIDDLE YEAR OF THE HISTORICAL PERIOD THAT EACH HISTORICAL RECORD COVERS. ERROR BARS REPRESENT 95% CONFIDENCE INTERVAL FOR POISSON DISTRIBUTION.

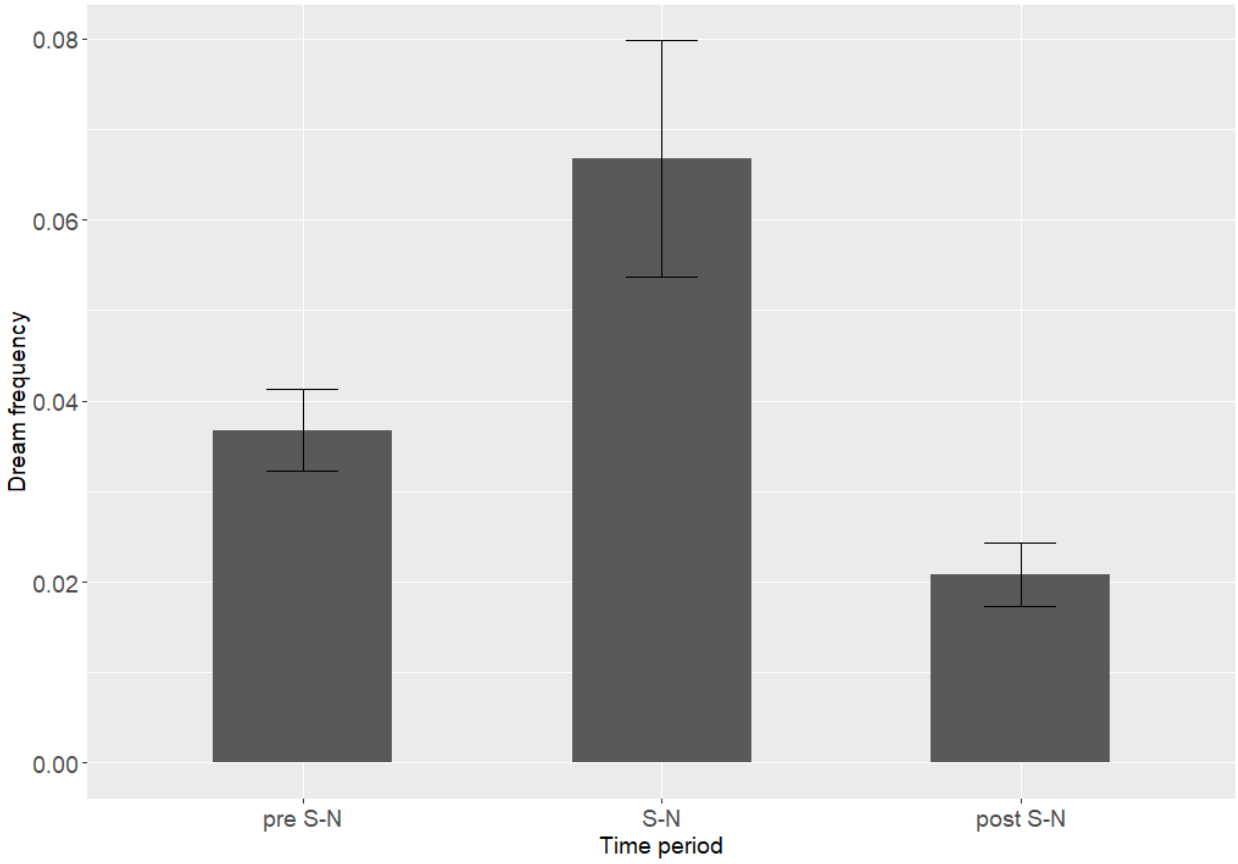

FIGURE 2.2.8. DREAM FREQUENCY DURING DIFFERENT TIME PERIODS. S-N REPRESENTS SOUTHERN-NORTHERN DYNASTIES (420-589 CE).

Table 2.2.2 shows the summary statistics of dream occurrences in the five most famous non-supernatural classic fictions[55] written between the 14th and 18th century (Plaks, 2015). We can see that the frequencies of dream occurrence in these fictions are comparable with those in official historical records (though they fall on the low end of the spectrum), but in later fictions the percentage of accurate dreams showed a marked decline. Another interesting observation is that in later fictions dreams were often offered psychological explanations; that is, dreams were not attributed to external reality but subjective feelings, emotions, and desires. In *Unofficial*

[55] *Journey to the West* is excluded from this analysis due to the supernatural nature of its stories.

History of the Scholars (written in 18th century), for example, we see the following description of dreams:

> Ever since you went with the guest, my body has felt uneasy for over a year! One night I dreamed of you falling into water, and I found myself wake up crying; another night I dreamed that you hurt your leg; another night I dreamed that you had a large tumor on your face… I told your father about these dreams, and your father said I miss you so much that I'm losing my mind (想痴了). (*Unofficial History of the Scholars, chapter 16*)

Here is a story of a woman dreaming of her lover and was told that the reason she had such a dream was because she missed him too much. This type of psychological explanation occurs similarly in *Dream of the Red Chamber* (written in 18th century):

> Sister Feng said: "…last night I had a dream which is kind of funny. I dreamed of a person who looks nice, yet I do not know his name; he told me that he was sent by a royal madam (娘娘) to ask for a hundred pieces of silk. I asked which madam, he said she's not our madam. I therefore did not want to give him [the silk], and he came to grab it by force. I woke up as he was grabbing it." The person from Wang Er family smiled and said: "this is because you manage and organize housework with too much concentration during the day, thinking about the imperial palace." (*Dream of the Red Chamber, Chapter 72*)

Again, we see a dream being attributed to one's over-thinking during the day. Additionally, in these later fictions we also see occasional skepticism towards the use of dreams for foretelling future events:

> Jia Yun said: "…yesterday there was a person saying that a nun in her temple had a dream in which Miao Yu was killed." The crowd laughed: "dream talk does not count!" (*Dream of the Red Chamber, Chapter 72*)

Although in the fiction whether Miao Yu was indeed killed was never revealed, it is clear that the significance of a dream was dismissed quite casually in this scenario. In Table 2.2.2, although there are only 5 data points, we do observe a temporal increase in the psychological explanation of dreams and skepticism towards dream interpretation.

TABLE 2.2.2. SUMMARY STATISTICS OF FIVE NON-SUPERNATURAL FICTIONS FROM THE 14TH TO THE 18TH CENTURY

Book	*Century*	*Number of dream occurrences*	*Dream per thousand characters*	*% inaccurate dreams*	*% vague dreams*	*% accurate dreams*	*% non-predictive dreams*	*% psychological explanation & skepticism*
Outlaws of the Marsh	*14th*	*24*	*0.025*	*0*	*4.2*	*95.8*	*0*	*0*
Romance of the Three Kingdoms	*14th*	*21*	*0.035*	*14.3*	*23.8*	*57.1*	*4.8*	*9.5*
The Golden Lotus	*16th-17th*	*15*	*0.015*	*0*	*33.3*	*60*	*6.67*	*26.7*

Unofficial History of the Scholars	*18th*	*7*	*0.020*	*0*	*28.6*	*57.2*	*14.3*	*28.6*
Dream of the Red Chamber	*18th*	*17*	*0.022*	*0*	*35.3*	*35.3*	*29.4*	*17.6*

Together, the decreased frequency of dream occurrence in dynastic records and increased psychological explanations/skepticism of dreams in fictions suggest that the predictive value of dreams was perhaps not taken as seriously in later times. Of course, this does not mean that oneiromancy was definitively rejected in any way; as long as spirits and ghosts are believed to exist, dreams always serve as a plausible channel for the transmission of messages and signs. Indeed, literary researchers maintain that works on dreams (prognostication manuals, dream encyclopedias, treatise on dreams, and fiction) were valued as a legitimate source of human knowledge during the Ming and well into the Qing dynasty (Zeitlin 1993). What I want to emphasize here is a comparative difference: although oneiromancy has always existed throughout Chinese history, its relative importance has diminished in later dynasties. The Ming scholar Zhang Fengyi (1527-1613 CE), for example, made the following comment about the early oneiromancy instruction manual *The Duke of Zhou's Explanations of Dreams*:

> Verily, there was no better mantic art than dream [interpretation]. During the Wei-Jin period (220-589 CE), each generation still had its famous specialists. In Song-Yuan times

> (961-1368 CE), however, people had lost so much interest in it that some crafty ones in the book market appropriated the name "Duke of Zhou" (Ong (1981)'s translation).

There are two interesting points here. First, Zhang Fengyi himself obviously takes oneiromancy seriously as he laments the loss of public interest in dream interpretation. Second, he suggests a temporal decline of the popularity of oneiromancy by providing a rough timeline. Zhang's claim echoes well with the quantitative analysis in Figure 3; most of the texts with the highest dream frequency are from 300 CE to 600 CE, and there is a marked decline in dream frequency after 1000 CE.

Another worth-noting point is the decline of official court oneiromancy during Chinese history. The interpretation of dreams was viewed as a very important divination technique during the Zhou dynasty (1046 BCE-256 BCE), and oneiromancers often have official government appointments (Yang, 1993). According to official dynastic record of the Han dynasty[56], "different divination techniques do not yield the same result, and oneiromancy is the main method [should take precedence over other methods]. That's why the Zhou dynasty had an official position of oneiromancer." Liu (1989) in his extensive analysis of the history of Chinese oneiromancy points out that official oneiromancy entirely disappeared in transmitted texts after the Five Dynasties (907-960 CE). The Song scholar Hong Mai (1123-1202 CE) commented on the disappearance of official oneiromancy:

> [Official oneiromancy] still existed sparingly in Wei-Jin times; people (the literati) today don't pay much attention to it anymore. Although [dream interpretation has become] a lowly street art (市井妄术) and was practiced by a few, none of them called themselves

[56] *Han Shu*, Yiwenzhi (Treatise on Literature)

an oneiromancer (无以占梦者自居). This technique has indeed disappeared. (*Rong Zhai Sui Bi*)

Of course, Hong Mai is exaggerating a little bit here as the technique itself never disappeared. Nonetheless, the relegation of oneiromancy to a "lowly street art" deserves attention. Contemporary Chinese researchers have attributed the decline of oneiromancy to its inflexibility; that is, because the sign-outcome association in some early oneiromancy manuals tends to be straightforward and unsophisticated, it leaves little room for oneiromancers to explain away failed predictions and was therefore outcompeted by other divination techniques (Fang, 2015; Yang, 2002). This explanation is inadequate because although it is true that some oneiromancy manuals are overly simplistic (i.e. if dreaming of X, then Y, where Y is a very specific outcome), there is no reason why oneiromancers cannot be flexible in offering their predictions (i.e. dreaming of X means general auspiciousness or disaster) as other divination techniques (Wenying Liu and Cao 2003). I suggest that the decline of oneiromancy is primarily due to three reasons. First, what appears in one's dream is, for the most part, an involuntary phenomenon[57]. Therefore, it cannot be readily used to solve practical problems in the same way that other divinatory techniques can be used whenever necessary, such as to identify the spirit that causes illness, the whereabouts of some lost item, or the best location of one's grave. This means that it is probably not as frequently used as other divination techniques, and thus less likely to be observed and copied. Since observing others performing some technology (Hong and Henrich 2021) often contributes to one's subjective belief in the efficacy of the technology, the infrequent

[57] Though Ong (1981) mentions dream incubation (efforts to produced specific types of dreams for problem solving) in China, it never became a mainstream practice and never appeared in official dynastic records.

use of oneiromancy means its efficacy is not believed as much as other divination and magic practices that are more frequently performed and observed.

Second, dreams are by their nature a private phenomenon, i.e., what appears in one's dream is only directly accessible by the dreamer. As such, dream interpretation by a third party necessarily relies on the subjective report of the dreamer. This creates a possibility for the dreamer to fabricate his dream content to provide strategic misinformation to the interpreter or the audience. Boyer (2020) suggests that the cultural success of many divination techniques may be attributed to their "ostensive detachment"; that is, the signs or messages of successful divinations are usually produced in a process which is perceived to not be influenced by the intentions and interests of the interpreter (the diviner). In oneiromancy, the suspiciousness comes from the provider of the sign, the dreamer herself. The deceptive use of dreams was even recorded in orthodox histories:

> Wang Shichong wanted to take the chance to start a war against him (Li Mi, a general during the Tang dynasty), but is afraid of a lack of confidence from his soldiers. Therefore, he utilized omens from ghosts and spirits by saying that he has dreamt of the Duke of Zhou. He then built a temple for the Duke of Zhou by the Luo River, and let the shamans announce that the Duke of Zhou had ordered a war against Li Mi, and if war is not fought then all soldiers will die of disease. Wang's soldiers were mostly from Chu 楚 with the tradition of believing in the strange and the supernatural, and all [soldiers] requested to fight. (*Jiu Tangshu, chapter 54*)

This instance happened in year 618 CE and echoes the previous point that manipulation of dreams depends on the belief of the audience. The more obvious takeaway here, however, is it

shows how easily dreams can be used for deceptive purposes, especially this type of message dream where one is free to make up whatever message he wants to influence others. In this aspect, dream interpretation suffers a disadvantage compared to other divination techniques that appear more "objective". Here we see that fabrication may have the opposite effects on efficacy estimation; on the one hand, fabricated successes may trick naïve individuals into believing that oneiromancy is more effective than it actually is; on the other hand, the possibility of fabrication may raise suspicion and thus lowers the efficacy estimate.

Lastly, the perceived predictive power of dreams could be diminished due to having a rather straightforward explanation caused by present anxieties, desires, and emotions. Such explanations already existed in early Han philosophical writings; the Confucian scholar Wang Fu (102-167 CE), commented that sometimes "what one thinks during the day, one dreams at night"[58]. Similarly, as we see in later fictions, dreams were often explained as a product of psychological states which diminishes their significance in presaging future events. Yet, it is important to note that the decline of oneiromancy does not mean its disappearance; like other divinatory and magic practices, oneiromancy survived well into the Qing dynasty, and was only truly rejected[59] with the introduction of western science based on theoretical grounds.

What about other divination techniques? If oneiromancy's decline in popularity was indeed due to its uniqueness, we would expect less of a decline in popularity of other divinatory techniques, especially the ones whose signs are public and can be readily utilized to solve practical problems. I thus examined two common divinatory techniques, siting (geomancy) and

[58] *Qian fu lun, Meng lie* (潜夫论·梦列).

[59] Of course, the use of dreams for prognosticative purpose still exists in China, especially in rural areas. But, as I have argued in Hong and Henrich (2021), there is a qualitative difference between rejection based on theoretical grounds due to a culturally imposed mechanistic worldview and the mere declining popularity of one type of divination relative to others.

date selection (Figure 2.2.6). Siting, now known as Fengshui, is the technique for picking a location for various purposes such as burial or home construction (Kory 2016). Date selection refers to the calculation of auspicious dates for holding important events such as religious ceremonies, marriage, and opening a business (L. Li 2007). Figure 6 shows the frequency of occurrence of these two types of divinatory techniques over time. Here, intuitive visual inspection does not reveal a definitive trend, and formal statistical tests show that there is not significant correlation between and the frequency of these two divination techniques and time (Pearson's correlation test, p=0.136 and 0.439 for Siting and date selection respectively). Unlike oneiromancy, the frequency of Siting and date selection remained substantial in later dynasties and both techniques played important roles in people's everyday life. Even in the late Qing dynasty, Siting concerns were invoked to prevent the construction of railways by foreign powers (as the "earth vein" would be disrupted) (Brown 2017). Therefore, the decline in popularity of oneiromancy is more likely due to its idiosyncratic characteristics rather than some overall shift the in zeitgeist with regard to divination and magic in Chinese society.

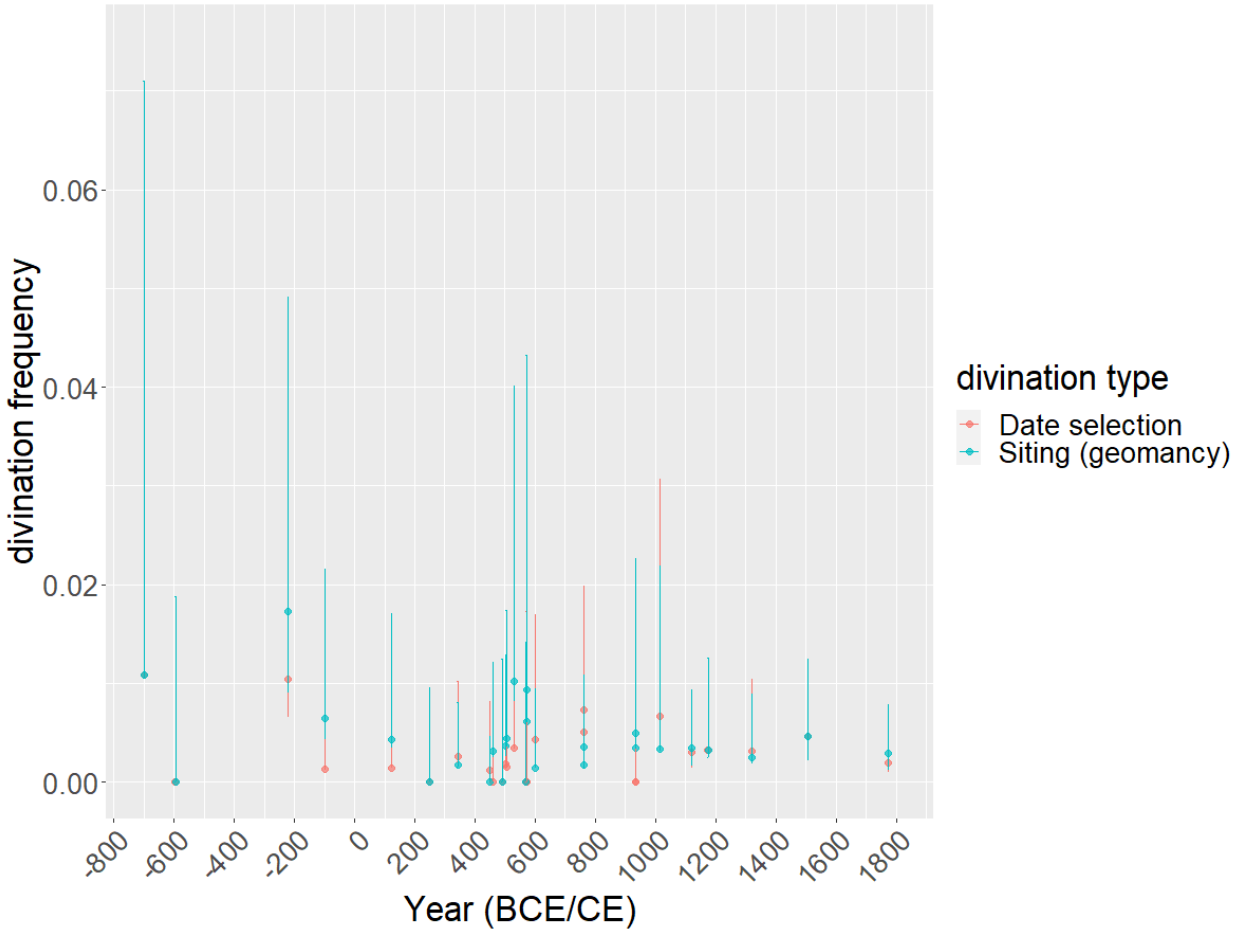

FIGURE 2.2.9. THE FREQUENCY (OCCURRENCE PER THOUSAND CHARACTERS) OF SITING AND DATE SELECTION VS. TIME. EACH DATA POINT REPRESENTS THE MIDDLE YEAR OF THE HISTORICAL PERIOD THAT EACH HISTORICAL RECORD COVERS. KEYWORD SEARCHES WERE PERFORMED ON "卜宅/卜居/卜葬/卜地/卜筑" FOR SITING, AND "卜吉/卜日" FOR DATE SELECTION. ERROR BARS REPRESENT 95% CONFIDENCE INTERVAL FOR POISSON DISTRIBUTION.

4. Discussion

4.1. Why oneiromancy? The puzzle from a cognitive perspective

Given that much anthropological research has focused on the functional aspect of dream interpretation, it is necessary to reassert the cognitive aspect of oneiromancy and ask why humans everywhere believed what one experiences during sleep has genuine meaning and is often prognosticative of future events, when many dream predictions assuredly must have turned out to be wrong. In this paper, I suggest that people in pre-modern societies have both theoretical (supernatural worldview) and empirical reasons (successful oneiromancy cases) to believe in the validity of oneiromancy. Through a comprehensive analysis of the Chinese dynastic history, I show that the impressive success of recorded dream predictions may largely be a result of deliberate fabrication, retrospective inference, and under-reporting of predictive failures. These recorded predictively successful dreams then get transmitted over generations and serve as raw input data for naïve individuals and increased their confidence in the predictive power of oneiromancy. Such psychological and social factors may also apply to other divination/magic practices: for example, some astrological omens recorded in Han Shu are almost certainly fabrications for political purposes (Eberhard 1957), and many rainmaking failures were ignored in Chinese dynastic records (Hong, Slingerland & Henrich, forthcoming). In fact, this belief-reinforcing process may be a general feature of many instrumental practices and may result in a feedback loop (Hong and Henrich 2021). Consequently, some rather ineffective practices can nonetheless be perceived as highly effective and persist in the population.

In terms of theoretical plausibility, oneiromancy enjoys the same level of support from a supernatural worldview as many other divination and magic practices. What is perhaps unique

about oneiromancy is that it does have an alternative explanation. After all, it is not all that difficult to realize the association between one's waking thoughts and dream contents, and from historical sources we do see this type of psychological explanation appearing in later Chinese dynasties. Oneiromancy suffers from two additional issues: its usage is quite limited because it cannot be voluntarily produced, and the private nature of its sign makes it susceptible to skepticism and suspicion more than other divinatory practices where the sign is more public. These factors potentially contributed to its declining popularity in China. The possibility of fabrication in oneiromancy is particularly interesting because its effect is double-edged: on the one hand, fabrication increases the number of predictively accurate oneiromancy cases which are recorded and transmitted; on the other hand, the fact that it can be easily fabricated triggers epistemic vigilance and generates suspicion. Which effect dominates may be determined by the cultural context (for example, whether falsely reporting dream incurs supernatural punishment, etc.).

We thus see that it may be challenging to come up with a unified theory of divination or magic in general, as each kind of divination/magic practice has its own idiosyncratic characteristics that affect the extent to which they are believed and used. Research on "why divination/magic" is thus largely an effort to identify one or several factors that increase the perceived efficacy of some (large) set of divinatory/magic practices. We need to keep in mind, however, that in reality the subjectively perceived efficacy of any instrumental action is certainly a function of many factors. Given the complexity of human cognition and behavior, it may be more useful to assess the relative importance of factors that collectively contribute to the cultural success of some practice.

4.2. The inadequacy of individual intuition in explaining oneiromancy

Of course, it is rather banal to make the uninformative claim that "everything matters". In what follows I shall offer a few suggestive arguments for why dream interpretation, along with many other ancient forms of divination and magic, has some characteristics that make explanations primarily relying on intuitions inadequate. First, while there certainly exist intuitive elements in the overarching worldview that provide theoretical support of oneiromancy, the specific dream interpretation techniques often require great interpretive effort and expertise, and are not intuitive in any obvious sense. For example, glyphomancy, a type of fortune telling by dissecting and analyzing a Chinese character, was frequently used in deciphering the meaning of dreams (Vance 2012). The basic idea is that what appears in dreams is extracted and represented by their corresponding written characters, and these characters are either dissected or assembled into other characters whose meanings are then interpreted. In a rather extreme case, a court official during the Jin dynasty (266 – 420 CE) is said to have correctly deduced a murderer's name by analyzing the signs of a suspect's dream using glyphomancy.[60] For most illiterate people at the time (which was the vast majority of the population), glyphomancy probably did not make much intuitive sense.

Second, interpreting the meaning of dreams using specific techniques was often a very deliberative process. The good dream diviner, according to the famous dream encyclopedia *Guidelines for Dreams and Dream Interpretation* (梦占逸旨) written in the 16th century, needs to carefully examine the context of dream occurrence, such as the timing of the dream (what season it occurs), the *yin-yang* situation of the place of dreaming, and in particular the psycho-

[60] This story is recorded in the official dynastic history of Jin 晋书 (266 -420 CE), Chapter 114.

physiological state of the dreamer; for example, dreams are not interpretable if the dreamer has excessive impure thoughts (妄虑) during the day, or if the dreamer wakes up in the middle of a dream. Indeed, in ancient China, the level of oneiromancy theorizing was so great that it is reminiscent of doctors theorizing the nature of illness and the appropriate treatments. In this sense, people resorting to specific interpretation techniques to decipher hidden messages from their dreams is rather different from people avoiding walking under ladders, which has been attributed to the failures of deliberate reasoning to correct or override intuitive reasoning in a dual-processing account (Risen 2016)

Finally, an exclusive focus on the intuition at the individual level ignores the fact that there often exists significant division of cognitive labor in technological practices that require expertise. Surely, the extent to which experts and lay people find some practice intuitively plausible would be very different. As in the case of glyphomancy, while the literati may find it an attractive way of deciphering dreams, lay people most likely find it much less intuitive, and their confidence in its validity is probably a combination of the aforementioned psycho-social factors (fabrication, retrospective inference, under-reporting of negative evidence) and their trust in oneiromancers, who, like astrologers, geomancers and healers, are the possessors and practitioners of specialized skills. Such differential possession of knowledge means that these professionals often serve as epistemic authorities with regard to solving specific problems (Pierson 1994; Majdik and Keith 2011), and to better understand the beliefs and practices of ordinary individuals we need to focus instead on the production and dissemination of knowledge.

4.3. The decline of oneiromancy: then and now

Many human practices are inherited and passed on over generations. Not all practices are equally successful, and in a cultural evolutionary process the frequency of some practices in the population may change via a number of mechanisms (Boyd and Richerson 1985; Henrich and McElreath 2003). For example, context biases such as prestige bias (Henrich and Gil-White 2001) and payoff bias (Kendal, Giraldeau, and Laland 2009) often lead to the selective retention of adaptive cultural variants. While in simplistic cultural evolutionary models the probability of a certain cultural variant being transmitted largely depends on it being "possessed" (or, in the case of behavioral variants, "practiced") by individuals, in reality the belief in the plausibility of some technology may last regardless of its actual usage frequency in the population. That is, the use of some technology may be rare in a population due to fear of deception, charlatans, or other factors, the beliefs that it can achieve its presumed purpose when *properly performed* may nonetheless remain in the population.

In this final section I wish to point out that the decline of oneiromancy in later Chinese dynasties exemplifies this type of situation and as such was qualitatively different from the marginalization of divination and magic in contemporary modern societies. As previously alluded to, the declining popularity of oneiromancy in pre-modern China was not due to a rejection of the underlying theory, but rather because in everyday situations it was not perceived as reliable an information source as some other divinatory techniques for the aforementioned reasons. Therefore, despite its relegation to a "lowly street art", the extraction of meaning from dreams remains theoretically plausible. This is why in later dynasties we often observed scholarly efforts to rediscover the lost art of oneiromancy.

The situation in modern societies is very different. Most notably, modern science and technology has generated a materialistic/mechanistic worldview in which ghosts and spirits have no place. This worldview is largely imposed on the population through mass education and state media that creates a radically different understanding of the nature of dreams. Therefore, if a person in late Qing dynasty was asked why he (who, by the way, mostly likely believed in astrology, geomancy, and a number of other divination techniques) doesn't believe in oneiromancy, he would probably have answered "the art has been lost and those on the streets are just quacks" (Wenying Liu and Cao 2003) whereas if a modern person is asked the same question he would probably offer a materialistic explanation of the dreams and why it has no causal association with future events. In fact, the significance of dreams has diminished to such as a degree that most contemporary Americans rarely remember their dreams (Kracke 1992).

A final note on the particularities of modernity: modern societies have epistemic institutions such as universities and research agencies where the use of data to inform theory is regulated. Fabrication of data is straightforwardly discouraged; theories and hypotheses are carefully tested in controlled experimental settings, and important discoveries are replicated to rule out the possibility of statistic artefacts. Under-reporting of predictive failures (known as the publication bias in the scientific literature) was perhaps not adequately dealt with as much in the social and medical sciences, but recent progress in pre-registration (Nosek et al. 2018; 2019; L. Haven and Van Grootel 2019) and the encouragement of publishing negative results (Trivers 2010; Mehta 2019) have been proposed to address the issue. Of course, this is not to say that superstitions such as horoscopes and fortune telling completely ceased to exist in our societies. They are, however, definitively out of the mainstream as a credible information source and people who believe in them are often frowned upon. I think it would be a mistake to deny the

drastic difference between the traditional and the modern: as long as our epistemic institutions survive, thrive, and are trusted by the public, we have good reasons to believe that the technologies we utilize today are genuinely effective, and that we generally live in a much more epistemically secure society.

Chapter 2.3. Empirical Case 3: Fetal Sex Prognostication

(Publication: in preparation)

This chapter presents the last empirical case analysis. Here I focus on a folk technology that has particular significance in patriarchal societies: fetal sex prognostication. Compared to rainmaking and dream divination, fetal sex prognostication is especially informative in that we know the true probability of giving birth to boys/girls is roughly 50%, and as such we can use 50% as a reference benchmark to examine possible biases in folk perception and statistical inference. As expected, I found that the reported successful (i.e., predictively accurate) cases vastly outnumber reported failures. Additionally, I compile some historical evidence showing that people indeed entertained uncertainty in the efficacy of various fetal sex prognostication methods and sometimes explicitly express their uncertainty in quantitative forms such as “eight or nine out of ten”.

1. Introduction

Throughout history and across societies, humans have been fascinated by the possibility of knowing the future, both out of curiosity (Kahlos 2018; Fatma, Rosa, and Zurmailis 2020) and practical needs (Hong and Henrich 2021; Bennett 2012). Among the many things that humans wish to know about, the sex of the fetus is perhaps not the most urgent compared to the outcome of war or the timing of rainfall, yet the incentive to know whether the unborn is male or female have always existed. Contemporary western women may purchase baby gender[61] prediction kit for fun, but in traditional societies where the sexual division of labor and the associated social, economic and political consequences are emphasized, there is often great interest in knowing whether the fetus will be a boy or a girl. On the extreme end, sex-selective abortion or infanticide may be practiced due to a strong cultural preference for either sex (almost always boys) (Goodkind 2015; Lamichhane et al. 2011). In China and India, the pervasive sex-selective abortion has led to government policies that prohibit medical doctors from revealing the sex of fetuses precisely to prevent the selective abortion of girls (Nie 2010; Westley 1995).

Given the strong demand, it is not surprising that fetal sex prognostication[62] is found in many historic cultures as well as contemporary small-scale societies. Ancient Egyptians, for example, predicted whether a woman would give birth to a boy or a girl by having her urinate on both wheat and spelt seeds and examining which would grow[63] (Dawson 1929); the ancient

[61] Throughout this paper "gender" and "sex" will be used interchangeably, where the term "gender" is used in more traditional context of "born sex".
[62] In the literature, the term "divination" is sometimes used, though in this paper we will avoid this term as a general description of the practice because it implies some kind of divine of mystical revelation. In fact, many sex prediction methods are completely mundane and involves nothing "divine"; for example, the Tepoztlán in Mexico predict the sex of the baby by its position in the womb: if it is to one side near the hip, it will be a boy; if it is in the middle, then it will be a girl (Lewis 1951).
[63] Note that this method is mentioned in a medical context.

Greek physician Hippocrates thought that the coloration of the eye and the relative size of the breast of the pregnant woman indicates fetal sex (Forbes 1959); in Europe, the medieval text *Distaff Gospels* provides multiple advices on predicting the sex of the fetus, including examining which foot the women walks with first[64] (Garay and Jeay 2007). written records of fetal sex prognostication remain scant in small-scale societies, yet ethnographers have documented plenty of folk methods of predicting the sex of the baby (Popov 1946; Naik 1956).

Definitely, all these practices respond to some social demand, but it is only a part of the story; to fully explain the recurrence and persistence of sex prognostication we also need to consider the cognitive aspect: why people have (at least some) confidence in the efficacy of these prognostication methods? Given that fetal sex prognostication is unmistakably a goal-oriented behavior, people would not engage in sex prediction if they think that it has no chance of correctly predicting the sex of the fetus. The obvious question is thus this: are pre-modern fetal sex prognostication methods effective?

Unlike many divinatory/magical activities that explicitly invokes supernatural entities, certain fetal prognostication methods are biologically plausible and may indeed work (Perry, DiPietro, and Costigan 1999), meaning that they may have a higher than chance probability of correctly predicting fetal sex. Many of the documented methods are quite naturalistic and do not fundamentally contradict the mechanistic worldview of western science. In fact, there has been plenty of research efforts in trying to evaluate the efficacy of folk fetal sex prognostication methods (Ghalioungui, Khalil, and Ammar 1963; O'Shea 2003; Ostler and Sun 1999; Rosengarten and Bebbington 1995; McKenna et al. 2005; Perry, DiPietro, and Costigan 1999;

[64] The theory there is that if the woman is pregnant with a boy then she will walk with her right foot first, and a girl if she walks with her left foot first.

Zare and Sekhavat 2013). To our knowledge, however, none of the folk methods examined significantly outperforms chance by a substantial margin.

Besides, the overwhelming negative result in the literature is prevalent despite the publication bias: surely, verification of some "ancient wisdom" would be more newsworthy. It should be acknowledged that there are some studies showing that certain physiological such as morning sickness (Rashid et al. 2012) and hypertension (Y. Liu et al. 2019) are statistically associated with fetal sex[65]. However, the effect sizes of these studies are without exception tiny: for example, Liu et al. (2019)'s large cohort study (N=205,605) that presumably shows an association between gestational hypertension and fetal sex reports male delivery rates of 51.1% and 52.0% in women with and without hypertension respectively. Even if we grant the statistical significance in these studies, such methods that barely outperform chance would be useless in practice.

The universal presence of folk fetal sex prognostication methods in human societies, therefore, presents a puzzle in two aspects: evolutionarily, such ineffective technologies often incur a material cost which is often associated with genetic fitness (Durham 1991; Hong and Henrich 2021); cognitively, these technologies must have frequently failed to produce desirable outcomes (accurate prediction in the case of fetal sex prognostication) and therefore should be disfavored by reinforcement learning. Previously, we have presented a general framework for understanding the persistence of ineffective technologies in human societies (Hong & Henrich, 2021; Hong, forthcoming): our evolved capacity for obtaining information from conspecifics generally facilitates the spread of adaptive culture (Boyd and Richerson 1985; Joseph Henrich

[65] Some of the positive finding yield contradictory results; for example, Zare & Sekhavat (2013) show that women with morning sickness are more likely to give birth to boys, while (Rashid et al. 2012) find the opposite pattern.

2016), yet at the same time such cultural capacity enables the spread of nonadaptive, or even maladaptive cultural practices (P. J. Richerson and Boyd 2005).

Specifically, we argue that a number of psychological and social biases contribute to individuals' confidence in the efficacy of ineffective technologies during the process of cultural transmission, and formally model how individuals construct their belief regarding the efficacy of some epistemic technology and the cultural evolutionary dynamics that may give rise to an overestimation of its efficacy (Hong and Henrich 2021). In the model, individuals' expectation of some technology yielding successful outcomes (accurate information) is probabilistic, and their belief updating regarding its efficacy[66] is based on various types of information sources, with testimony from others being a crucial input. In plain language, one does not expect an epistemic technology to "work" every single time, and positive reports from other people increases their confidence that the technology may work in a particular instance.

One key parameter in the above model that biases individuals' estimation of technological efficacy is the relative amount of reported confirmatory and dis-confirmatory evidence. Intuitively, the more testimonies (i.e., instances of technological actions with outcomes specified) are confirmatory, the higher individuals will subjectively perceive the (probabilistic) efficacy to be. In Hong & Henrich (2021), we suggest that such psychological bias and information transmission dynamics may be a general feature of human societies that help explain the persistence of ineffective technologies. Note that the over-representation of confirmatory stories may be due to a number of social and psychological reasons, such as selective reporting

[66] Here "efficacy" refers to the probability that a technological action being followed by the putative outcome. Throughout this paper "efficacy" takes this specific definition and is therefore a real number between 0 and 1 (inclusive).

(failures are less likely to be reported than successes), deliberate fabrication (making up successful stories) and retrospective inference (falsely infer the existence of sign based on outcome) (Hong, forthcoming).

In two previous studies, we have analyzed rainmaking and oneiromancy in traditional China and showed that transmitted historical records were likely to have been significantly influenced by under-reporting of failures as well as deliberate fabrication (Hong, Slingerland, & Henrich, forthcoming; Hong, forthcoming). In this paper, we intend to add to this line of empirical research by examining the extent to which fetal sex prognostication is also subject to these biasing factors.

Unlike oneiromancy and rainmaking, however, we know the "chance efficacy" of fetal sex prognostication is roughly 50% given that human sex ratio at birth does not deviate much from 1:1 (Orzack et al. 2015; Jacobsen, Møller, and Mouritsen 1999). Therefore, if the success record of objectively ineffective sex prognostication methods is substantially higher than 50%, then we can be certain that the observed reporting pattern is due to some of the above biases which may give the readers the impression that fetal sex prognostication is more effective than chance.

Given our previous theoretical reasoning (Hong and Henrich 2021) and empirical evidence (Hong, Slingerland & Henrich, forthcoming; Hong, forthcoming), we expect that 1) people would treat technological efficacy as probabilistic rather than deterministic; that is, they would acknowledge the uncertainty involved in these technological practices and not expect it to "work" 100% of the time, and 2) people would under-report[67] predictive failures and/or fabricate

[67] Here, we take "report" to mean the general process where individuals reveal information in some medium which is taken up by other individuals.

success stories. Here, we take advantage of the extensive historical record and offer a detail examination of fetal sex prognostication in traditional China to see if it provides further support to our previous conclusions. The analysis of historical records also allows us to understand how the folk methods of prognostication functioned in a traditional society which was not yet affected by the modern medical perspective. As we will show below, even the arrival of modern prognostication methods does not completely eliminate these folk traditional in China. As such, Chinese historical records present an invaluable source of knowledge about the functioning of these methods in the past.

We will first provide a brief overview of the tradition of fetal sex prognostication in China, including evidences of doubts and uncertainty in prognostication outcomes, and then proceed to analyze sex prognostication data as recorded in historical texts, in particular the relative frequency of predictive success and failures of prognostication methods. Finally, we discuss the broader implications of such psychological bias and information transmission dynamics and how they influence the cultural evolution of technology in general.

2. A brief overview of fetal sex prognostication in China

The full history of sex prognostication is necessarily beyond the scope of this paper; therefore, we simply highlight some historical moments in its trajectory from the earliest times to the modern period. The prognostication of fetal sex had been a matter of royal interest and reported in the oracle bone records of the Shang dynasty (ca. 1554-1045 BCE) where the sex of the fetus was divined and recorded, where the unborn was predicted to be a girl and therefore "inauspicious" (De Bary and Lufrano 1999). There have been many predictive methods documented in transmitted texts. These methods were not confined to literature on divination;

even in texts devoting to mathematics we see such methods recorded. For example, in *Sunzi suanjing* (ca. 3rd – 5th century CE), a text that primarily consists of practical mathematical problems and their solutions, the following way of the predicting fetal sex is presented in problem 36 at the end of the third book (Ang and Lam 2004):

> A woman aged 29 has been nine months pregnant. What is the sex of her future baby?
>
> Answer: male.
>
> Method: Set down 49, add the gestation period and subtract the age [of the woman]. From the remainder take away 1 [the number of the] heaven, 2 that of earth, 3 the man, 4 the four seasons, 5 the five phases, 6 the six pitchpipes, 7 the seven stars [*of Ursa Major*], 8 the eight winds and 9 the nine territories [of China under Yu the Great]. If the remainder is odd, the infant will be a male, if even, a female.

The fact that this method of fetal sex prognostication appears in a serious mathematical treatise suggests that knowing the sex of the unborn baby was one of the standard calculation tasks in the society and therefore a matter of great interest both for the lay people and the elite literati class. In a society that is highly patriarchal like traditional China, the sex of a yet-to-be-born fetus is not only a matter of curiosity but also of significant pragmatic importance, as such information is often very valuable and can be used for strategic purposes (e.g. whether to attempt a female-to-male transformation[68] (转女为男) or in the extreme case, abortion).

[68] In traditional China, a great deal of effort was devoted to manipulation the sex of the baby (X. Wang, 2008). In the famous medical treatise *Essential Prescriptions Worth a Thousand in Gold for Every Emergency* by the renowned physician Sun Simiao (618-907 CE), for example, a number of methods for "turning the fetus from female to male" are included along with other gynecology treatment recipes.

Among the many methods of fetal sex prognostication include birth timing during the day (Cook and Luo 2017), Zhouyi trigrams (Cook and Lu 2017), numerology (Zhou 2020), physiognomy (J. Wang 2013), dreams (Hong, submitted), pregnant women's cravings [69], the breast (whether there is a swelling on left or right breast) of the pregnant women's *husband* (Cao 2000), and pulse diagnosis (Zhou 2020). For a modern reader, some of these methods may appear plausible while others mere superstitions due to her mechanistic worldview, but we need to keep in mind that all of these methods had some degree of plausibility for pre-modern readers (Hong & Henrich, 2021). The seemingly ridiculous method of telling the sex of fetus by what's on the breast of the husband, for example, has been repeatedly recorded in later medical texts[70] since it was first proposed in the *Pulse Classic* by Wang Shuhe in the 3rd century.

Throughout the history of China the popularity of various fetal sex prognostication techniques may have changed, yet the overall effort of attempting to identify the sex of the unborn undoubtedly persisted. As late as the Qing dynasty (1636 – 1911 CE) people still extensively used traditional methods to predict fetal sex. The Qing Palace Table (清宫图), for example, is a famous look-up table (allegedly used by the royal family to control the sex of royal offspring) where one can identify fetus sex by the month of pregnancy and the age of the pregnant women. Even today, people often exhibit interest (though they don't necessarily believe in it) in the predictive accuracy of the Qing Palace Table (Hong, unpublished). To quantitatively evaluate the popularity of this method, we used Baidu Index (The Chinese equivalent of Google Trend) to examine the daily count of internet search queries for "Qing Palace Table" in mainland

[69] See *nv ke wanjin fang* 女科万金方 by Xu Guyu 薛古愚.

[70] See *Chan Jian 产鉴* by Wang Huazhen and *Chongding Chanyun Ji 重订产孕集* by Zhang Yaosun, and *Lenglu Yihua 冷庐医话* by Lu Yitian. Interestingly, in some of the texts the original method of checking the husband's breast was mis-transmitted as checking the pregnant woman's breast.

China, with the modern medical equivalent, ultrasonography (B 超) and the general term for geomancy *feng shui* (风水) also shown for comparison purposes (Figure 2.3.1). From the graph we can easily see that the folk method Qing Palace Table has consistently been a more popular search query than ultrasonography[71] in the past seven years, and perhaps surprisingly its search count also outnumbers the much-studied Chinese mantic art of geomancy. In fact, the popularity of using the Chinese lunar calendar to predict fetal sex has led researchers to perform rigorous statistical examinations which found that it is no better than a random coin-flip (Ostler and Sun 1999; O'Shea 2003; D. Katz and Wylie 2009).

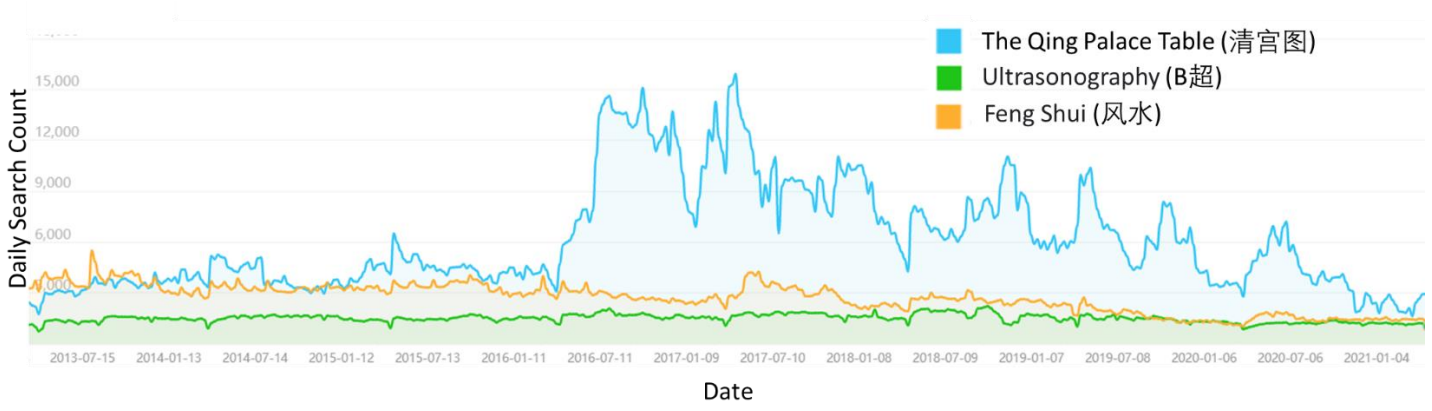

FIGURE 2.3.10. THE DAILY COUNT OF INTERNET SEARCH QUERIES FOR "THE QING PALACE TABLE", "ULTRASONOGRAPHY", AND "FENG SHUI" FROM 2013 TO 2021.

3. Analysis of fetal sex prognostication from Chinese historical records

3.1. Awareness of uncertainty in fetal sex prognostication in transmitted texts

Previously, we have suggested that the intrinsic uncertainty involved in divination (indeed, any predictive methods) is generally acknowledged in contemporary, small-scale societies (Hong &

[71] In mainland China, it is currently illegal to use ultrasonography to identify fetal sex due to selective abortion of girls.

Henrich, 2021). Although transmitted texts rarely explicitly discuss uncertainty as an independent scholarly topic, we can often infer such probabilistic understanding from texts indirectly. For example, the early Qing scholar Xiong Bolong (1616-1669 CE) commented on prediction of the gender of the fetus, using allusion to dream signs from a classic poem from the Shijing[72]:

> It is not the case that all pregnant women have the same type of dreams, and it is not the case that if [she] dream of certain signs she must give birth to son or daughter. There are also instances where one dreams of a bear[73] yet gives birth to a daughter, and instances where one dreams of a snake and gives birth to a son.[74]

Here, on the issue of the efficacy of dream divination, Xiong addresses the transmitted belief that dreaming of bear would lead to the birth of girls, and snake the birth of boys, which originally comes from the poem *Sigan* in the Confucian classic, the *Classic of Poetry* (11th -7th BCE). Note that here although Xiong endorses the association between one's dreams and fetal sex (he later in

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[72] The Shijing, section *Xiaoya, ode Si Gan (189)*
…大人占之。
維熊維羆、男子之祥。
維虺維蛇、女子之祥。

The chief diviner will divine them.
The bears and grisly bears,
Are the auspicious intimations of sons.
The cobras and [other] serpents,
Are the auspicious intimations of daughters.

Legge, James (1871). The She king, or the Lessons from the States. The Chinese Classics. 4. Part 1, Part 2. rpt. Hong Kong: Hong Kong University Press (1960). P.303.

[73] The association between dreaming of bear and giving birth to son (as well as dreaming of snake and giving birth to daughter) originally comes from *Classic of Poetry, Xiaoya.*

[74] 熊伯龙 《无何集》 中华书局 1979 年版, quot. by [Meng yu Zhongguo wenhua (梦与中国文化)/ Liu Wenying (刘文英), Cao Tianyu zhu (曹田玉) Beijing : Ren min chu ban she, 2003. 北京 : 人民出版社, 2003..
] p.333.

the text justifies it with the *yin-yang* theory); he nonetheless does not think using dreams to predict fetal gender works every single time.

On the very same topic of pregnancy dreams and the sex of fetus, we find interesting discussions of it in local gazetteers, also alluding to the Shijing:

> …the poem says bear signifies males and snake signifies females, and the explanation was that snake represent *yin*. Yet a local diviner's prediction is rather different from this: every time a pregnant woman dreams of a snake she would give birth to a boy, and the accuracy is eight or nine out of ten.
>
> --Gazetteer of Xianning county (Qianlong Period)[75]

In evaluating the accuracy of local diviner's prediction (though the exact opposite of the original *Classic of Poetry*!), the gazetteer author explicitly invokes a probabilistic assessment "eight or nine out of ten" (十中八九) .

Likewise in the medical literature, we also observe acknowledged uncertainty in the discussion of transmitted prognostication methods. In *Shenshi Nvke Jiyao* (1764), the Qing medical theorist Wang Mengying explicitly deals with the issue of uncertainty in fetal sex prognostication using pulse diagnosis:

> Different schools of thought [on how to tell fetal sex by check pulse] all have their reasons, and all offer accurate predictions sometimes and inaccurate predictions other times. I've been studying these methods since I was a child. Over three decades, I've seen

[75] Gazetteer of Qianlong Xianning County in Qianlong Period / (Qing) Han Zongxiu; (Qing) Zhu Xia, etc. [乾隆建寧縣志二十八卷卷首一卷:29/ (清)韓踪修;(清), 朱霞等墓 清乾隆 24 年(1759), ch. 28, p.13. Digitazied by Eastview Information Services, China Comprehensive Gazetteers.

> many cases…What ancient scholars talk about is originally their personal opinions, and the diagnosis of idiosyncratic individuals cannot be constrained by these fixed methods…[76]

By emphasizing that fixed methods cannot be rigidly applied to idiosyncratic individuals, Wang makes it rather clear that if such methods are rigidly applied predictive failures are bound to happen, as he has experienced in his medical career. Even texts that purport to affirm the efficacy of some prognostication method leave room for potential failures. In *Lizheng Anmo Yaoshu (1888)*, the Qing scholar Zhang Xiaozhu provides another numerological method of telling fetal sex based on parity:

> …write a character in the middle of the paper. On the top write the character "horse" (马); keeping writing the same character along a circle until the full circle is completed. Give the incantation (the paper) to the relatives of the pregnant woman…when you write the incantation you will know whether a boy or a girl will be born: count the number of character "horse"; if it is odd then a boy will be born; if it is even then a girl will be born. [The method] is most accurate (最为应验) when you write the characters mindlessly (i.e. not consciously thinking/worrying about the parity of numbers). [77]

In this text, by specifying the conditions under which the method is "most accurate", the author is implicitly acknowledging the possibility of failed predictions. As such, individual cases of failed predictions rarely definitively invalidate a particular prognostication method. They do,

[76] 沈尧封（又彭) Shen Yaofeng (Youpeng) 王孟英 Wang Mengying (comm.) 闫纯玺 Yan Chunxi 沈氏女科辑要胎产心法 Shenshi Nvke Jiyao Tāi chǎn xīn fǎ Renmin weishengchubanshe 1988, p.40

[77] Zhāng Zhènyún (張振鋆). Lízhèng ànmó yàoshù (厘正按摩要术). Beijing : Renmin weisheng chubanshe (人民卫生出版社) : Xinhua shudian Beijing faxing suo faxing 新华书店北京发行所发行, 1990. P. 56

however, reduce people's confidence in its efficacy. As we have shown in the case of traditional rainmaking, although no rainmaking methods were definitively rejected, people care very much about their perceived efficacy (e.g. whether prayers were successfully answered or not) and would preferentially worship deities that are responsive and deities that "work" (Hong, Slingerland, & Henrich, forthcoming).

Therefore, although people do not necessarily reason in a perfect Bayesian fashion, historical evidence suggests that individuals in the past nonetheless have a quasi-probabilistic understanding of the efficacy of technological practices. This is particularly true for fetal sex prognostication methods, because the outcome of predicting fetal sex is binary and unambiguous, leaving very little room in interpreting failures as successes.

3.2. Reporting bias in fetal sex prognostication from historical records

To examine the extent to which predictive successes appear more often than chance in the historical records, we used texts of three different genres: official dynastic histories which are systematic records of events of the previous dynasty, its customs and institutions, as well as biographies of the most prominent personalities written by professional historians of the later dynasty (Wilkinson 2012); officially compiled encyclopedia (leishu 类书) which include quotations, citations, and excerpts of earlier textual sources categorized in an encyclopedia manner (Zurndorfer 2013) and gazetteers (difangzhi,地方志) which are official records of history, economy, geography, and cultural traditions of specifical localities. For official dynastic histories, we used the fully digitized Twenty-Four Histories (二十四史) plus Zuo Zhuan (左传) , compiled as an open-source resource for the project of provided by Zinin & Xu (2020). For encyclopedia, we used *Taiping Guangji* (太平广记) and *Taiping Yulan* (太平御览) from the

Chinese Text Project (Sturgeon 2006), both compiled during the Song dynasty and freely available online, with consecutive verification of results by printed editions. Finally for the gazetteers, we used Erudition's proprietary comprehensive local gazetteer collection (http://er07.com/).

It should be noted that while some of the recorded cases were real historical episodes confirmed by reliable sources, many are not. Particularly, *Taiping Guangji* is a collection of stories whose themes are mainly ghosts, spirits, and other supernatural events, and both the Twenty-Four Histories and local gazetteers include, especially in biographies, much fictionalized material from a western scientific perspective. Therefore, these events should be considered to be historically-reported occurrences of fetal sex prognostication. Whether these reported events are fictional or real, however, is not critical for the key argument in this paper: as long as they were perceived (by literate public) as reports of real events, people's evaluation of the efficacy of various fetal sex prognostication methods will be affected. As will be argued later in the paper, these reports played an instrumental role in corroborating and propagating ineffective practices to the extent that it influences the readers' confidence in the efficacy of fetal sex prognostication.

The quantitative data on the reported fetal sex prognostication instances were obtained by retrieving information in the above-mentioned three genres of texts through keyword searches. The historical description of such cases could be stylistically and semantically vague, and this required the creation of a dedicated semantic keyword dataset. In this article, the dataset include the following keyword combinations to ensure maximum coverage: *nv* 女 (female) or *nan* 男 (male) and *yun* 孕 (pregnant); *nv* or *nan* and *bu* 卜 (to divine); *nv* or *nan* and *zhan* 占 (to divine); *shengnan* 生男 (give birth to boy) or *shengyinan* 生一男(give birth to a boy) or *shengnv* 生女

(give birth to girl) or *shengyinv* 生一女 (give birth to a girl). Application of this keyword dataset allowed extraction of a total of 98 fetal sex prognostication occurrences. All hits and recorded cases of fetal sex prognostication were analyzed with a special focus on the methods and recorded outcomes.

Figure 2.3.2 shows the relative percentage of predicted sex, broken down by accuracy and genre. Two patterns become immediately noticeable: first, boys are predicted more often than girls in all three genres. This is perhaps not very surprising given that China has always been a patriarchal society with a strong preference for male descendants; most actors in historical and fictional narratives are men, and therefore predicting a boy is a rhetoric method of introducing another male actor, where the fact of successful prediction of his being born male is stressing his predestination for his activities and demonstration of luck[78]. The concept of predestination is supported by the fact that the most commonly used prognostication method is dream (see Figure 2.3.3 for a full breakdown of prognostication methods), which could be considered, in the framework of Chinese culture of portents, as a legitimizing portent which conveys the will of Heaven (e.g. a concubine who dreamed of the Sun and later gave birth to an emperor, see Hong (forthcoming)).

[78] In one of the earliest oracle bone records, the King of the Shang dynasty divined that his wife Fuhao will give birth to a girl, which was taken as an inauspicious sign (Keightley 1985).

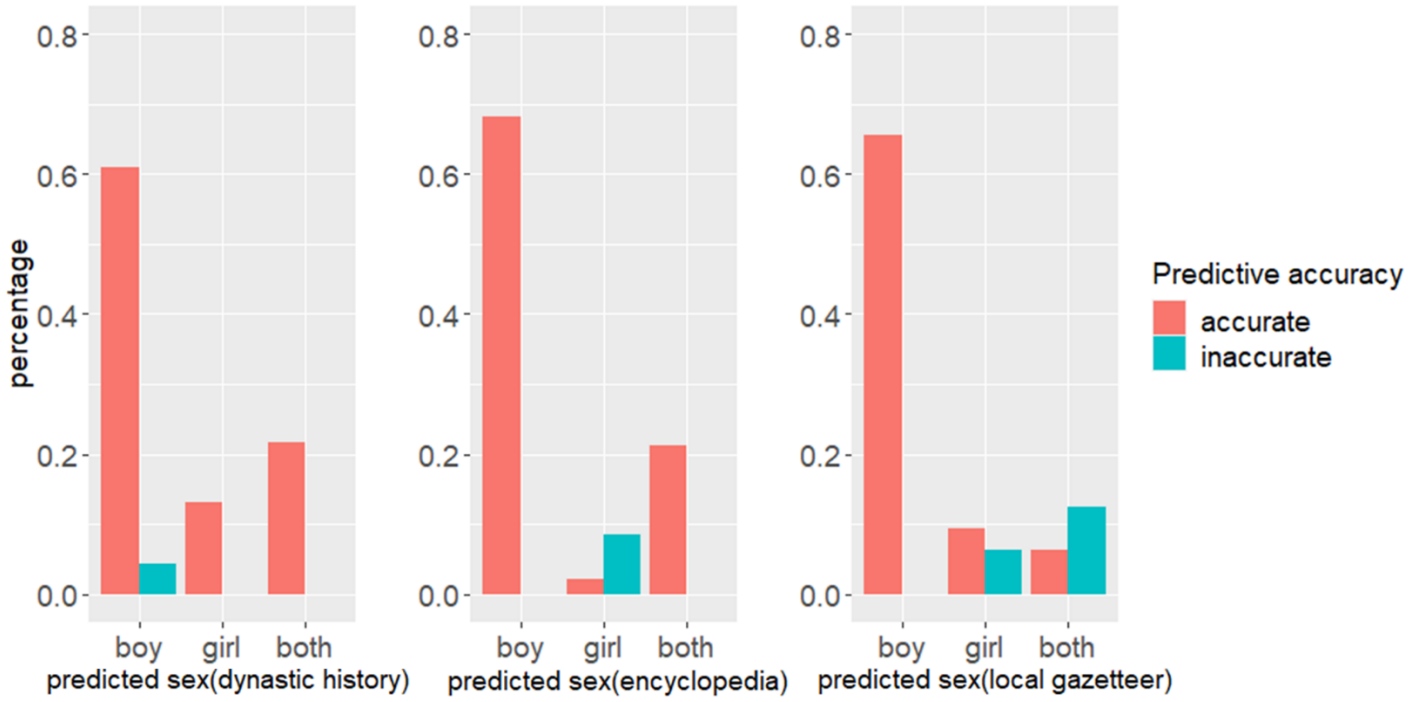

FIGURE 2.3.2.PERCENTAGE OF PREDICTED SEX BROKEN DOWN BY ACCURACY AND GENRE. N=23,47, AND 32 FOR HISTORICAL TEXTS, ENCYCLOPEDIA AND LOCAL GAZETTEERS RESPECTIVELY. THE X-AXIS DENOTES THE PREDICTED GENDER; "BOTH" MEANS THAT THERE WERE MULTIPLE BIRTHS AND PROGNOSTICATOR PREDICTED BOTH SEXES. IN THIS CASE IF ONE PREDICTION FAILS, THE ENTIRE EPISODE IS CLASSIFIED AS "INACCURATE".

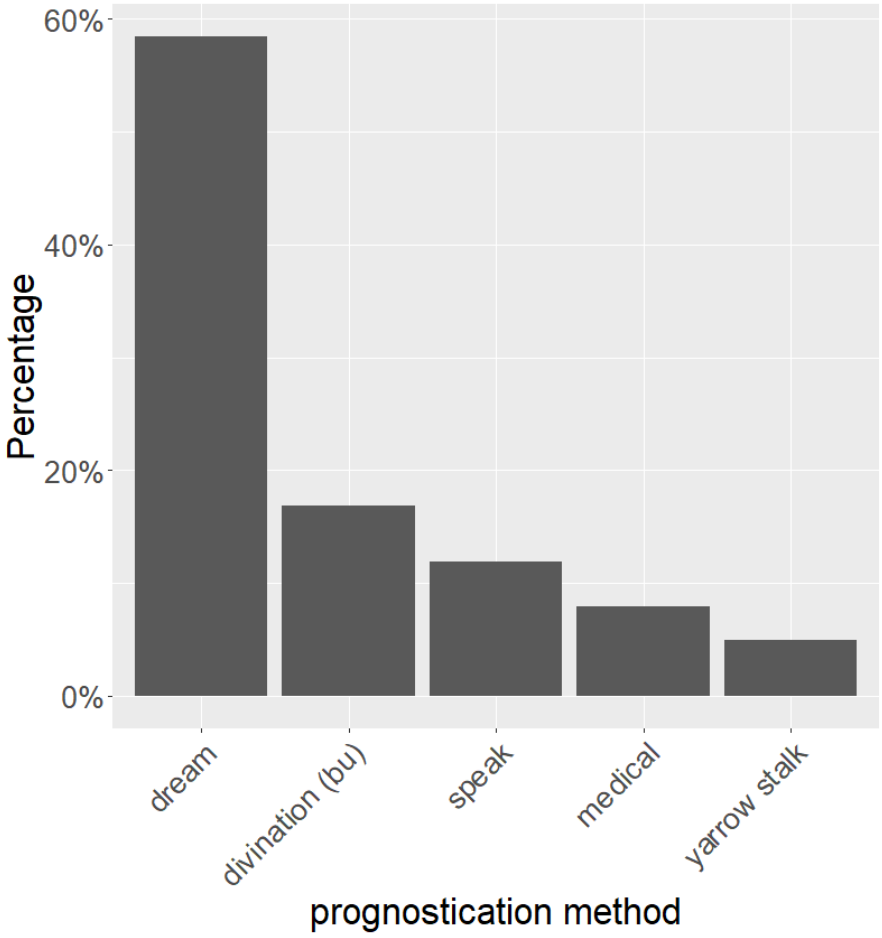

FIGURE 2.3.3. PERCENTAGE OF METHODS USED FOR FETAL SEX PROGNOSTICATION IN ALL SOURCES COMBINED. OVER 50% OF THE RECORDED FETAL SEX PREDICTION INSTANCES INVOLVE THE USE OF DREAMS, FOLLOWED BY GENERAL DIVINATION (BU) 卜 WHERE THE EXACT DIVINATORY METHOD IS USUALLY NOT SPECIFIED. "SPEAK" REFERS TO CASES WHERE THE PROGNOSTICATOR (OFTEN NOT A PROFESSIONAL) ANNOUNCES THE SEX OF THE FETUS VERBALLY; "MEDICAL" REFERS TO CASES WHERE MEDICAL METHODS BASED ON TRADITIONAL CHINESE YIN-YANG THEORY ARE USED; FINALLY, "YARROW STALK" REFERS TO A VERY SPECIFIC DIVINATION METHOD (SHI)筮 AND ACCOUNTS FOR LESS THAN 5% OF THE TOTAL CASES.

Second, we observe the overwhelming pattern that the vast majority of fetal sex prognostication cases were recorded as accurate. As mentioned, this may be attributed to under-reporting of predictive failures, as in the case of rainmaking (Hong, Slingerland & Henrich, forthcoming) and/or fabrication of success stories, as in the case of dream divination (Hong, forthcoming). Note that the degree of the reporting bias is rather large in fetal sex

prognostication: assuming the birth rate of boys and girls are roughly equal (Jacobsen, Møller, and Mouritsen 1999), the over 90% predictive accuracy as appears in transmitted texts means about 90% of the predictive failures are not recorded or fabricated as successes.

Of course, both official dynastic histories and encyclopedia (and to a lesser extent local gazetteers) serve political purposes; historians in the past did not write or compile them in order for later readers to objectively evaluate the accuracy of fetal sex prognostication (or any technological practice). These predictively accurate stories do, however, give the reader two possible impressions:

1) Fetal sex prognostication is generally accurate.

2) Fetal sex *can be* accurately predicted by the right people with the right method.

Note that these two impressions are not necessarily exclusive: in fact, the second impression may be viewed as a special case of the first one. It is worth emphasizing that fetal sex prognostication differs from other types of technological practices in that correctly predicting the sex of the unborn is not in itself a surprising event (by chance it should occur 50% of the time), and people must have been aware of the possibility of lucky guesses[79]. A careful examination of these prognostication methods reveals that the prognosticator is sometimes portrayed as possessing extra-ordinary abilities and the fact that he/she correctly foretells the sex of the fetus can be in no way due to chance. This is usually done by attributing a series of predictions (including fetal sex) to the prognosticator and emphasizing that *all* predictions were fulfilled. For example, *Houhanshu* (*Book of the Later Han*) records the following story:

[79] In traditional Chinese, this type of "success by chance" is referred to as ouhe 偶合(coincidence).

> In the beginning, Huan was the prefect of Wuwei. [One day] his wife was pregnant and dreamt of climbing a high terrace building with Huan's sealed ribbon[80] and singing. A diviner is consulted and said: "[the unborn] must be a boy; [he] will govern this place as well, and will die on this very terrace." Later Zhang Meng was born and was appointed as the prefect of Wuwei during the Jian'an period; he killed the governor Han Danshang and was surrounded and attacked by troops. Zhang Meng was ashamed of being captured, and climbed the terrace and burned himself just as the diviner said.[81]

Here, the diviner not only correctly predicts that a boy will be born but also his life trajectory, in particular how he dies, highlighting the diviner's extra-ordinary predictive ability as well as creating a sense of fatalism.

In cases where both sexes were predicted, an emphasis is usually placed on the prognosticator's ability to offer correct predictions repeatedly, as seen in phrases like "none that is different from his prediction" (无不如占), "no failed predictions using yarrow stalks" (筮无不中) and "all as he (the diviner) predicted". Other prognostication cases are more mundane, and the context offered is no more than a single fetal sex prediction and the outcome. We suspect that a naïve reader may get a bit of both impressions from reading the overwhelmingly predictively successful (sometimes spectacularly so) stories, and even a skeptical reader[82] would seriously entertain the possibility of accurate fetal sex prognostication.

[80] An item representing the official status in Chinese bureaucracy.
[81] Hou Han shu 后汉书 [Book of the Later Han dynasty] (Beijing: Zhonghua shuju, 1965), vol. 8, ch. 65 皇甫張段列傳 (Huángfǔ zhāng duàn lièzhuàn), p.2144.

Although we cannot be fully certain about the veracity of recorded historical events, it is highly likely that miraculous stories like this were made up to emphasize the idea of pre-destination, karma, the will of Heaven and possibly to serve some other social, cultural and political purposes. Correctly predicting the sex of a fetus and his destiny, for example, is often presented as a part of a larger narrative such as the demonstration of predestination. As for other more mundane stories, failed prognostications may simply be ignored and not talked about. Early scholars have explicitly pointed out this possibility; the aforementioned Qing scholar Xiong Bolong comments the following immediately after pointing the out uncertainty involved in fetal sex prognostication using dreams:

> The poets [diviners] tell the cases where their predictions are fulfilled and not talk about the cases where their predictions failed.[83]

Similarly, The Song scholar Lü Zuqian (1137-1181 CE) makes a more general comment on under-reporting of failures in divination:

> Some people ask: "Zuo's record of crackmaking and milfoil divination cases were so amazing and spectacular; given such predictive accuracy, why are there so few [records] of them?" The answer: "from the Lord Yin till Lord Ai was a total of two hundred and twenty-two years. Kings, lords, dukes, the literati and the commoner perhaps made tens of thousands of divinations, and only tens of the efficacious cases were recorded in Zuo's book. These tens of the cases were collected in Zuo's book and therefore feel like a lot; if they were dispersed into the two hundred and twenty-two years it would feel extremely

[83] 熊伯龙 《无何集》 中华书局 1979 年版, quot. by [Meng yu Zhongguo wenhua (梦与中国文化)/ Liu Wenying (刘文英), Cao Tianyu zhu (曹田玉) Beijing : Ren min chu ban she, 2003. 北京 : 人民出版社, 2003..
] p.333.

> rare. If divination cases were of deceptive nature or had failed predictions, they would not have transmitted during their time and not be recorded in the book. I do not know how many tens of thousands of them were missed. If we had all of them [recorded], they would not be so rare.[84]

Note that these commenters are more concerned about underreporting than fabrication. In reality, of course, both factors likely contributed to the overwhelming successes of fetal sex prognostication as seen in transmitted texts.

An important question here, then, is the extent to which people realize that failures are under-reported and success stories fabricated, and take such reporting bias into consideration when forming a belief regarding the efficacy of some technology. Although it may not be possible to find definitive answers from the historical record, we can nonetheless make some reasonable inferences. To start with, the validity of various divination and magic practices was generally unchallenged in traditional China, and in the rare case of skepticism the skeptics almost always questions their theoretical plausibility rather than empirical inadequacies (Hong, Slingerland & Henrich, forthcoming). There were indeed scholars who would point out the underreporting of failures (discussed in section 3.2.), yet they were a minority among the literati, and the way their discourses were presented was usually in the form of answering a question or rebutting some existing prevalent opinion, suggesting that most people readily believed the plausibility of these culturally transmitted technologies (Hong, Slingerland & Henrich, forthcoming). Additionally, if people take under-reporting into consideration and perform the necessary calculations when they update their belief, then stories of diviners who has correctly

[84] See Lǚ Zǔqiān quánjí: Zuǒ shì bó yì, zuǒ chuán lèi biān (吕祖謙全集: 左氏博議, 左傳類編). Zhèjiāng gǔjí chū bǎn shè (浙江古籍出版社) vol.6, ch.8, p.181

predicted every single case would lose credibility, as surely they must have given some failed predictions. This is however not what we see in transmitted texts: the reputation of certain diviners often persisted for very long periods of time (Zhao 2015).

On the possibility of fabrication, one may wonder to what extent people at the time took these recorded prognostication instances seriously: in particular, whether they treated them as factual cases or made-up stories. This issue is especially concerning for encyclopedia like *Taiping Guangji* as many of its stories are of supernatural nature by modern standards. There are good reasons, however, to think that people at that time generally expected what's recorded in these texts to be true.

First, due to the lack of a central, organized religious institution as in medieval Europe, various local religious/superstitious activities and folk beliefs were prevalent in traditional China (Hansen 2014), and stories that involve what we would consider supernatural entities such as ghosts and spirits have level of theoretical plausibility.

Second, the distinction between fiction and history came rather late in Chinese history[85] (Jianguo Li 2011), and "fiction" in the modern sense that involves an implicit contract of "make-believe" between the author and the reader (Mortensen and Agapitos 2012) probably never occurred. Although some contemporary literary researchers have pointed out that fiction (xiaoshuo, 小说) started to become "self-aware" (i.e. people are intentionally creating stories that are not necessarily true) in the Tang dynasty (618-907 CE) (Guo 2010), the emergence of fiction as an independent genre was a very gradual process. As late as the Qing dynasty there were still

[85] Interestingly, the lack of distinction between fiction and history has also been suggested for western literature (Mortensen and Agapitos 2012; Ashe 2015)

authors who tried to convince their readers of the veracity of the stories that involve ghosts and spirits (H. Wu 2019).

For encyclopedia compilations such as Taiping Guangji (originally published in 978 CE), most of its editors served as historians and participated in the writing of the official dynastic history of the Tang (Xiong 2017), and the chief editor Li Fang emphasized that stories to be included in *Taiping Guangji* must have "evidence" 稽 to back it up.[86] Because its original intended audience was the emperor Taizong, books like *Taiping Guangji* was compiled with the intention of categorizing knowledge rather than making up stories (Yuan 2020). As such, the vast majority of the stories recorded in *Taiping Guangji* have their original sources clearly indicated.

Therefore, these stories serve as "evidence" for the efficacy of various fetal sex prognostication methods from the perspective of individual cognition. For readers of these texts in traditional China, these recorded instances of predictive success quite "sensibly" reinforce their belief that fetal sex could be accurately predicted.

4. Discussion

Like many culturally transmitted technologies, traditional methods for fetal sex prognostication do not "work" in the sense that they do not outperform chance. Unlike most magic and divination practices which are often offered functional explanations (Flad 2008; Burkert 1985; Struck 2016), fetal sex prognostication is unmistakably instrumental. In this paper, we have offered a thorough examination of the fetal sex prognostication practices in pre-modern China and show that 1) people clearly understood that methods for predicting fetal sex do not work

[86] See See *Jiong Yuan; Yi Yuan(袁褧. 袁褧) Feng chuang xiao du 楓窗小牘《楓窗小牘》商務印書館 1937 年版 Changsha.*

every single time, and 2) there are many more predictive successes recorded in transmitted texts which contributes to the over-estimation of the efficacy of fetal sex prognostication. As mentioned, the fact that predictive successes vastly outnumber failures in historical records could be the result of various social, cultural, and psychological factors. What we wish to emphasize in the paper is that regardless of the exact causes of such biased reporting, a reader of these historical records would very likely to be impressed by the overwhelming predictive success of fetal sex prognostication and form an erroneous belief that these prognostication methods "work". Again, this is because readers of these historical texts (mostly educated literati) may not necessarily be aware of the incentives behind reporting these stories; indeed, inferring belief from behavioral observation is often a psychologically difficult task (Cushman 2019; Hong and Henrich 2021).

One may reasonably worry that transmitted texts may be quite different from other types of transmission (e.g., face to face) and given that textual records are largely absent in illiterate, small-scale societies, the generalizability of our argument may be quite limited. To this we have two responses. First, the reporting bias likely has some firm psychological basis. A large literature in psychology shows that people have a tendency to search, recall, and interpret evidence that fits their pre-existing beliefs (Nickerson 1998; D. K. Johnson 2017). Therefore, for people who already believe in the plausibility of fetal sex prognostication, it is very natural for them to record predictive successes rather than failures. Second, there is evidence that such reporting biases exist in societies without writing. During our fieldwork among the Yi people[87] (small-scale agriculturalists in southwest China), we discovered that local individuals are also

[87] Strictly speaking, the Yi do have writing (in their own language); though only a very small proportion of the population are literate and the writings are almost exclusively mnemonic devices for ritual performance.

much more likely to report predictive successes when asked to recall instances of fetal sex prognostication. Amazingly, the overall percentage of reported success rate is also roughly 90%, with dreams being the most frequent used method (Hong, submitted)! In-depth interviews with our local informants reveal that there is very likely a memory bias in recall, and while people sometimes are aware of their own memory bias, they rarely consciously take such bias into consideration when processing transmitted information. Of course, in complex societies such as ancient China the literary tradition and folk tradition of fetal sex prognostication may differ and interact in various ways. Yet given the instrumental nature of this practice and the pan-human psychological and cognitive mechanisms for information processing, we expect the insights provided in this paper to be valuable for both anthropologists who are interested in folk culture and historians whose research focuses more on the literati class.

It should be reiterated that although the reporting bias is likely to be a general feature of information transmission in human societies, it is only one of the many factors that contribute to the persistence of ineffective technologies such as fetal sex prognostication. For one thing, many sex prognostication methods may be intuitively plausible either due to our evolved psychology (Miton, Claidière, and Mercier 2015) or culturally transmitted background beliefs (Hong, forthcoming). For example, ancient China had elaborate theories regarding the determination of fetal sex based on yin-yang and the Five Phases principles (Zhou 2020), and people who are committed to such theoretical beliefs (including many medical professionals at the time) would naturally find fetal sex prognostication methods derived from these principles attractive.

The perceived authoritative status of certain prognostication methods also plays a role: the popularity of using the Chinese Lunar Calendar to predict fetal sex, for example, can be partly attributed to its perceived authority. This Calendar is said to have been sequestered inside

a royal tomb near Beijing (O'Shea 2003), and the literal meaning of the name of the method "Qing Gong" (Palace of the Qing dynasty) certainly adds to its trustworthiness and prestige in appearance. Different fetal sex prognostication methods may also be evaluated simultaneously, resulting in a "multiple testing" problem (Hong, Slingerland & Henrich, forthcoming): when there are many methods for predicting fetal sex on the market, some methods may appear efficacious by chance. Finally, ineffective technologies may persist when people are not consciously comparing the perceived efficacy with chance efficacy: in the case of fetal sex prognostication, many people, even those with substantial education, think that a diviner with 50% success record on predicting fetal sex (exactly same as chance) is "pretty good" or even "good" and "very good", and believe that a random guesser would achieve substantially less than 50% success rate (Hong, unpublished). Such response patterns suggest that whether individuals think some technology is worth using may depend primarily on the absolute value of perceived efficacy rather than whether or not it outperforms chance.

All the above factors may work in concert with biased reporting in sustaining the persistence of fetal sex prognostication methods that do not outperform chance. Indeed, given the finite nature of human cognitive capacity, it is not surprising that humans occasionally misperceive the efficacy of various culturally transmitted technologies. The overwhelming predictive success of fetal sex prognostication in historical records is both a consequence and a cause of such misperception: the more people believe in the efficacy of the technology, the more likely biased reporting will result, creating a positive feedback cycle (Hong 2021).

To conclude, we have proposed a theoretical framework for understanding the psychological aspects of fetal sex prognostication and provided rich historical evidence showing a probabilistic understanding of its efficacy and a substantial bias in preferentially recording

predictive successes. Through examining the cognitive consequences of such recording, we argue that individuals may get a false impression that various fetal sex prognostication methods being more efficacious than they actually are (i.e., chance), and such mechanism may be quite general in the persistence of divination and magic practices in human societies. We hope that this piece of work will inspire more inter-disciplinary effort in addressing classic anthropological questions from historical, cognitive, and cultural evolutionary perspectives.

Chapter 3. Ghost, Divination, and Magic among the Yi: An Ethnographic Examination from Cognitive and Cultural Evolutionary Perspectives

(Publication: Ghost, Divination, and Magic Among the Yi. Under Review.)

Here, I present a detailed ethnography of magic and divination of the Yi people in southwest China, and offer a cognitive account of the surprising prevalence of these objectively ineffective practices in a society that has ample access to modern technology and mainstream Han culture. I argue that in the belief system of the Yi, ghosts, divination, and magical healing rituals form a closely inter-connected web that gives sense and meaning to otherwise puzzling practices, and such belief system is importantly supported and reinforced by individuals' everyday experiences. Contemporary Yi people overwhelmingly treat these practices as instruments of achieving specific ends and often entertain considerable uncertainty regarding their efficacy, which may be over-estimated for a number of reasons: 1) the intuitive plausibility of divination for ghost identification and exorcist rituals is enhanced by the belief in the existence of ghosts as a result of abductive reasoning, 2) negative instances (divinatory or healing ritual failures) are under-reported, and 3) people's mis-perception of the probability of uncertain events' occurrence often prevents them from realizing that the effectiveness rate of magical/divinatory practices do not outperform chance. I finally offer some suggestive comments on the generality of the psychological and social mechanisms discussed.

1. Introduction

The Yi (彝) is 6th largest ethnic group in the People's Republic of China residing primarily in Sichuan and Yunnan province in the southwest with a population of more than 8 million. It is important to note that the official designation of the 8 million Yi people in the southwest of China does not refer to a single ethnic group with a shared identity based on cultural similarity but all the groups formerly known as *Luoluo* by their Han neighbors[88] (Harrell 1990). As a result, the Yi people today consist of six related but mutually unintelligible Tibeto-Burman dialect groups (Chen 1985). This paper will focus on the Yi in Liangshan autonomous prefecture (Figure 3.1) and hereafter by Yi I exclusively refer to this ethnic group.

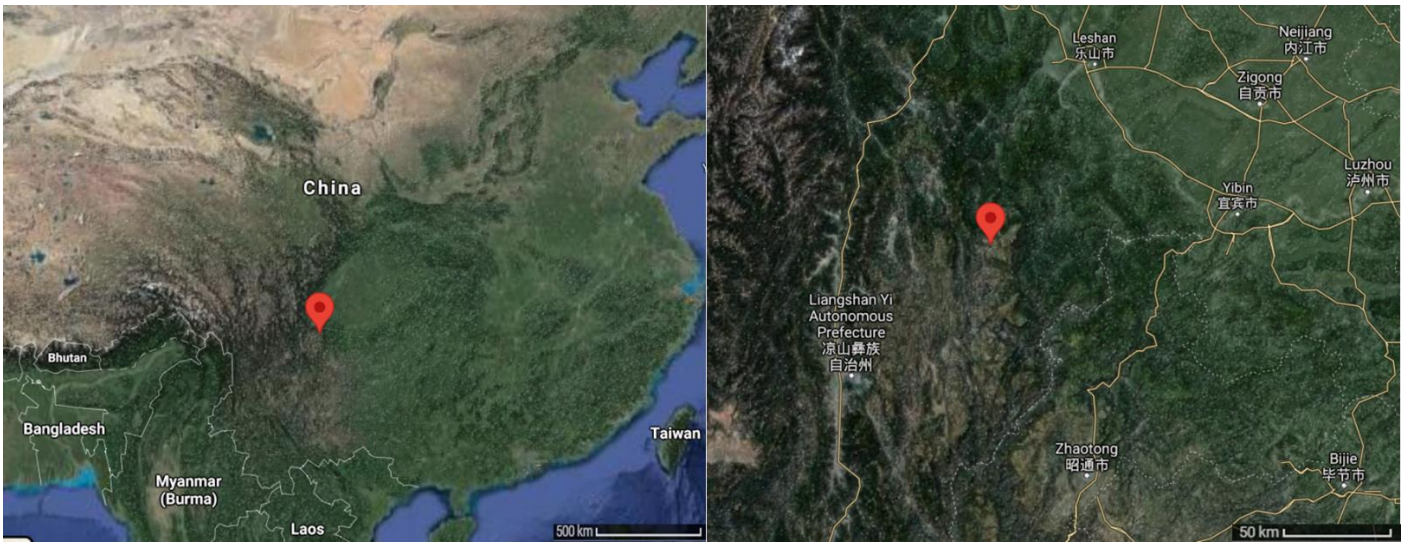

Figure 3.1. The geographical location of the field site. The picture on the right is a zoomed in version of the one on the left.

[88] Although in more recent years such shared identity has been intentionally encouraged and fostered by the government.

The Yi society in Liangshan is highly patriarchal (and hierarchical before 1958), and has a typical clan-based segmentary lineage social system (Lin 1947). Historically the Yi have been small-scale agriculturalists that grew corn, potato, and buckwheat. Nowadays, with the rapid improvement in infrastructure, in particular roads and tunnels, a substantial proportion of young Yi are going to larger cities to seek odd jobs (打工), usually as temporary workers in the electronic manufacturing industry. Yi's everyday life has also been influenced by modern commercialism: not only are many local Yi individuals running groceries stores, restaurants, and auto repair shops, larger, modern-style supermarkets are also being built in towns by outside Han businessmen. Additionally, as part of the campaign of "Targeted Poverty Alleviation" (精准扶贫), many Yi people are moving out of their traditional houses made of wood and mud, and relocating into newly constructed apartment buildings (Figure 3.2).

Figure 3.2. Newly constructed apartment buildings in Hongxi town. Many people from nearby villages have been relocated to here. The characters on the wall say “The Chinese dream is [our] people’s dream, and also every Chinese person’s dream” by current CCP president Xi Jinping.

What is perhaps surprising, then, is that despite all the external influence, the Yi in Liangshan retain a substantial amount of their traditional cultural practices that are seemingly incompatible with modern life. I am, of course, referring to the rich practices of magic and divination. Although superstition beliefs and practices are far from extinct in the modern world, they are usually marginalized by the mainstream culture (Hong and Henrich 2021). Among the

Yi, however, it plays a prominent role in everyday life, especially when it comes to diagnosing and treating illnesses, and to a lesser extent ensuring general good luck and avoiding bad fortune.

There has been a vast amount of literature on magic in Yi populations[89]. In the Yi language, to perform a magic ritual (which typically involves interaction with supernatural[90] entities) is called "*bi*", and the individuals performing these rituals are called *bimo*"[91] ("*mo*" means masters of some craft). In contemporary China, studies of Yi magic are often referred to as "*Bimo* (毕摩) culture studies" due to the official categorization of most Yi magical practices as "ethnic traditions" to be preserved. Indeed, the Meigu county in Liangshan autonomous prefecture (where I conducted my fieldwork) touts itself as "the homeland of Bimo" (毕摩之乡) and attracts both scholarly attention and some tourism. Most of these studies, however, treat Yi magic as a kind of art possessed by a class of elite practitioners, with a heavy focus on its manifested form. As a result, in most published work we often see a detailed description of *how* these rituals are performed but not *why* they are performed. When explanations are offered, they are usually formulated as a casual combination of Malinowskian accounts of magic and Marxist theory of labor and productivity: magic rituals are attributed to a gap between people's subjective desires/abilities and the objective reality, and the reason for such gap is due to a lack in productive forces (See Liao (2010); Zhang (1994); Zhang (2015)) . For example, Zhu (2005) outlines such an explanation in the beginning of his extensive analysis of Yi magic:

> In situations where there is a huge difference between the forces of nature and the productive forces of the society, the Yi enhance their self-confidence through the visible

[89] Most of this literature is in Mandarin Chinese published in China. For a start, see Bamo (1994).
[90] From a western scientific perspective, that is.
[91] Also "Pi-mu" or "Bi muo" in earlier works of Yi magic.

> activities of magic, and believe that they could control nature by means of magic. Such belief in magic and ritual reflects the primitive psyche of the early Yi and their desire to control the objective world.

Admittedly there is truth in this type of explanation, yet it is woefully incomplete and often presented in a way as if no further explanation is necessary. The truth in such an explanation, I suggest, is that a large expected benefit of achieving some ends (e.g. healing illness) will naturally produce an incentive for people to perform some action (e.g. healing ritual). However, for individuals to actually perform this action, this incentive has to be combined with some confidence that the action will likely work (see Hong & Henrich (2021) for a formal analysis of this dynamic). Additionally, it is not a guarantee that an increase in productive forces (or technological capability) will lead to a decrease in magic and ritual practices. In his seminal work *Religion and the Decline of Magic*, Keith Thomas (1971/2003) emphatically points out that the decline of various magical beliefs and practices occurred *before* the technologies at the time were able to solve the practical problem that people faced. Conversely, in certain societies that are by any measure technologically advanced such as Taiwan and Hong Kong, superstitious beliefs such as geomancy (*feng shui*), auspicious date selection and various kinds of deity worships are widely popular (Emmons 1992; R. Y. M. Li et al. 2016; P. R. Katz 2003). A recent, astonishing example is that the Taiwanese government organized a public rainmaking ritual where officials and local people alike prayed to the sea goddess Mazu for rainfall during a severe drought in the spring of 2021 (BBC News, 2021).

In the western literature, there has been relatively little work that specifically examines Yi magic and divination. On the topic of magic in general (divination is usually classified as a subtype of magic), however, there has been plenty of anthropological theorizing since the time of

Tylor (1871) and Frazer (1890). Briefly, early anthropologists tend to treat magic as having the same goal as modern science: to explain and predict worldly events and possibly exert control (Horton 1967). Later scholars tend to focus on the symbolic and conventional aspects of magic (Tedlock 2006; Keita 2007; Tambiah 1990). In a previous article, we have strongly argued for the instrumentality of divination practices drawing from a wide range of ethnographic and historical sources (Hong and Henrich 2021). As will be shown, traditional Yi magic and divination have an unmistakable instrumental component, and people emphatically care about whether or not magic/divination works.

In the rest of the paper, I present a detailed ethnographic account of Yi magic and divination and address the persistence of these practices from cognitive and cultural evolutionary perspectives. To do so, I first explain the Yi concept of the ghost which serves as the theoretical basis for many Yi divinatory and magical rituals, and then analyze and explain why these rituals are seen as effective and are practiced in everyday life. Briefly, I argue that people's belief in ghosts is supported by both intuition and abductive reasoning (interpreting ambiguous events as involving ghosts), and people's confidence in the efficacy of divination and magic is a result of both their theoretical plausibility and under-reporting of failures. Finally, I point out a cognitive bias where individuals misperceive the probability of uncertain events happening by chance. These cognitive and social factors collectively contribute to the persistence of ineffective technologies such as divination and magic.

2. A Cognitive and Cultural Evolutionary Account of Ghost beliefs among the Yi

2.1. Ghost in Yi culture: ever-present ancestral spirits

Like many traditional societies in the world, the Yi have a polytheistic worldview and believe in life after death (Bamo 2003). Specifically, the Yi believe that deceased individuals become ghosts (*nuci*) and may exert very real impacts on the world of the living by causing certain forms of illness or misfortune. Notably, in the Yi belief system *nuci* primarily affect individuals of their own clan; that is to say, *nuci*-related illnesses are most often attributed to dead relatives of the patient. One reason for this may be that in Yi culture, descendants have a strong responsibility to their elderly generations, alive or dead. This responsibility is in an important sense material; for example, during festivals married sons (and to a lesser extent daughters) would visit their parents with a non-trivial amount of gifts. Similarly, after the death of one's elderly relatives, it is the later generations' responsibility to offer sacrifices to make sure that their deceased relatives are happy in the afterworld (See SM video 1 for a funeral march). As a result, the Yi would perform regular safety-keeping rituals called *xiaobu* to satisfy their deceased relatives as well as *ad hoc* exorcist rituals to appease and send away *nuci* that already haunts the patient (L. Zheng 2003).

For the Yi, *nuci* can be either good or bad just like living people. Bad *nuci*, often described as having insatiable appetites, bothers the living and causes illness (Vermander 1999). Good *nuci*, on the other hand, can attach itself to certain individuals and grant them super-human powers. These good *nuci* are called *rasa* and may decide to attach themselves to their living relatives at any moment in life. Such attachment initially causes physical discomfort and/or

illness, and the host of such *rasa* needs to go through a ritual to officially become a *suni*[92], after which not only the illness goes away but the host also obtains extra-ordinary powers (Yueqi, 2021). The *suni* can then communicate with his/her *rasa* for both informational purposes and exorcism, as will be elaborated in later sections.

Those who experienced violent or unexpected deaths are believed to turn to an extremely malicious kind of *nuci* called *ze*. Unlike regular *nuci*, *ze* is described as having a definitive physical form and can directly communicate (e.g. having a conversation) with the living. Occasionally, these *ze* would "visit" living people who may then decide whether to accept it and thus become its "host". If a *ze* is accepted, it will benefit its host primarily in the form of stealing things (usually food) from other households and give it to its host[93]. The host, however, needs to treat *ze* very carefully as it may decide to harm the host if it is not satisfied for whatever reason. Readers familiar with the anthropology of witchcraft may notice that the underlying logic of *ze* is very similar to that of the practice of keeping the ghost/spirit of infants with unexpected death as a tool to ensure wealth and good fortune in Southeast Asia (Watson and Ellen 1993).

In addition to the above types of *nuci*, there are numerous other types of ghosts and spirits of natural objects (mountain spirits, water spirits, etc.) in the Yi belief system, characteristic of a polytheistic worldview (Bamo 2003). The exhaustive elaboration of all supernatural entities of the Yi people is neither possible nor necessary, as this paper primarily concerns with the general psychological and social mechanisms that sustain ghost beliefs, a

[92] In the standard literature on Yi people, *suni* and *bimo* are categorized as two different types of professionals where suni resembles a typical shaman that would enter into an altered state of consciousness, whereas bimo are usually literate and are deemed the possessors of transmitted knowledge. One can "learn" to be a bimo whereas to become a suni divine inspiration is always required.

[93] In a sense, *ze* is a powerful "helper" of the household, in the field I also collected stories of *ze* helping his host family catching fish and finding lost cattle, for example.

subject that has become the focal topic in the cognitive science of religion (Barrett, 2007; Boyer, 2001) yet largely ignored by traditional anthropological studies.

2.2. Ghost beliefs sustained by cultural transmission and abductive reasoning

Why do people believe in the existence of ghosts? One explanation that has been repeatedly invoked by cognitive scientists is that they are intuitively believable. The literature in cognitive science of religion has largely pointed out two key psychological tendencies that contribute to ghost beliefs: first, our mentalizing ability leads us to project human-like mental states to non-human objects (Barrett, 2004; Guthrie, 1995), possibly conferring adaptive advantages (J. M. Bering, McLeod, and Shackelford 2005); second, mind-body dualism, which refers to the intuitions that minds and bodies are separate entities, makes plausible the belief that human soul or soul-like entities may survive death and exert influence on the living (Bloom 2007). The amount of theoretical and empirical research that focuses on innate intuitions is very large and I shall not further belabor this point. What I would like to point out, however, is that cultural transmission often works alongside innate intuitions about ghosts and spirits and reinforces such beliefs, particularly through abductive reasoning (Coltheart, Menzies, and Sutton 2010). In short, innate intuitions about ghosts make people more likely to interpret ambiguous situations as ghost encounters[94] (inference to the best explanation) which may then be transmitted to naïve individuals as factual testimonies. That is, during the transmission process the uncertainty involved in the interpretation of the situation may get lost and the "fill in the blank" memory reconstruction process (Schacter, Guerin, and St. Jacques 2011; Manning and

[94] Of course, there is great individual level variation regarding the propensity to interpret sensory experience as spiritual. See Luhrmann et al. (2021) for a recent large scale study.

Loftus 1996) may cause the "ghostness" of the story to be exaggerated. Below I briefly describe how the cultural transmission process contribute to ghost beliefs among the Yi people.

For the Yi, cultural information contributes to ghost beliefs primarily in two ways. First, many public, social activities either implicitly or explicitly assume or "demonstrate" *nuci*'s existence. In addition to the aforementioned regular "safety-keeping" and *ad hoc* healing rituals, there are ample social gatherings such as funerals and the spectacular *cubi* ceremony[95] which lasts for three days/nights nonstop to appease the dead when entire generations of individuals have passed away. A more dramatic ritual that explicitly portrays the existence of *nuci* is called *nucituo*[96] (literally, to chase *nuci* away). This ritual is performed when the *nuci* involved is deemed especially malicious (such as *ze*) and needs to be chased away in a quite literal manner. It is conducted by the *suni* who would enter a trance-like state and allegedly summons his/her *rasa* in order to see the *nuci*. The *suni* then walks towards the presumed direction of the *nuci* and chases it back to its grave (*chi'he*, where the former body of the *nuci* was burned, see SM Figure 2), followed by a group of local people cursing and spitting in the presumed direction of the *nuci* during the chase. There are variations of this ritual: a simpler version is called *nuciguo* where the *nuci* is only chased out of the house and not all the way back to its grave (see SM video 3). A more spectacular form of this ghost-chasing ritual is called *sijiezi* where the suni picks two (usually young) individuals from the audience to act as a temporary host of her *rasa* to "chase away" the *nuci*. The procedure starts with the to-be-possessed people holding a Y-shaped tree branch with both of their hands. Then, as the *suni* chants, one of the possessed people begins to

[95] For the Yi, to properly send deceased individuals to the afterword (so that they don't bother living individuals in the form of illness anymore). Before *cubi*, dead people wander around in the world of the living as spirits that cause illness and misfortune.

shake his hands (which is said to be caused by the shaking of the tree branch induced by the *rasa*). The *suni* then verbally commands the possessed to chase the *nuci*; if the ritual is successful, the possessed person would jump or run (which is interpreted as "the *rasa* is controlling the person to chase the *nuci*") towards the *nuci*'s grave. When the presumed grave location is reached, the possessed would stick the Y-shaped tree branch into the ground which symbolizes the end of the ritual as the *nuci* is believed to be sent back to its grave. Occasionally, objects deemed unclean such as dead dogs or chickens would be dumped onto the *nuci*'s grave to ensure that it does not come back to the living.

For a naïve person, the most straightforward explanation for the above cultural practices and phenomena is that ghosts indeed exist and that certain individuals in the community possess the ability to interact with them (in practice, almost always sending/chasing them away). In reality, however, these practices and phenomena may be observed for a variety of other (naturalistic) reasons. For example, people may perform healing rituals when standard medical treatment fails due to a simple cost-benefit analysis: the expected benefit of a successful ritual is very large and people are willing to "give it a try" even if they are quite skeptical of the efficacy of these rituals (Hong and Henrich 2021). Social factors such as norm adherence and peer pressure could also lead individuals to perform these exorbitant rituals such as *cubi*. On the practices that allegedly "demonstrates" the existence of ghost and the extraordinary powers of *bimo* and *suni*, a modern reader could easily come up with naturalistic reasons for them: the *suni* that correctly identifies the grave of the presumed *nuci* may have done so due to chance and selective reporting of successful predictions; it is also quite possible that he/she uses social cues during the ghost-hunting march to infer the correct location of the *nuci* grave. One of my informants told me that he has noticed that certain *suni* pay close attention to where the crowd

(largely consists of local people who know the grave location) look, and these *suni* walk towards the direction of the people's gaze. We do not know the extent to which these deceptive tricks happen among the Yi, but from classic ethnography we know deception happens quite a bit and certain people are aware of such possibility (Evans-Pritchard 1937). What about the most spectacular and hard-to-explain phenomenon, *sijiezi*, where a *suni* allegedly uses his/her *rasa* to control other people? Many of my informants have personally experienced the ritual (holding the Y-shaped branch, shaking and jumping/running), and report a not fully conscious mental state (e.g. "I don't quite remember what I was doing"/ "I saw see a dim light in front of me") that resembles symptoms of hypnosis[97] (Kihlstrom 2016). Ethnographically, hypnosis is also observed being used in traditional societies to induce altered state of consciousness either in oneself or others (Lancy 1996; Bullock 1950). Therefore, it is highly likely that the "mind-control" type of magic is in fact a form of hypnotism. This explanation, however, requires an advanced understanding of human psychology which is almost certainly absent for the Yi people. Indeed, a few of my most skeptical informants who generally deny the existence of ghosts and the efficacy of magic rituals admit that *sijiezi* is very hard to explain with naturalistic means. For the Yi who witness it, it must have been an overwhelming experience which they have no explanation other than that of some supernatural power attaching itself to a host human to chase the ghost. Table 3.1 provides a more comprehensive list of the phenomena that purportedly "demonstrate" the extra-ordinary power of the *bimo*/*suni* and the potential scientific explanations.

[97] Mose Cihuo, a pioneering researcher in documenting Yi magic told me another practice that resembles hypnotism even more: the bimo/suni would induce people into a sleep-like state and use extensive verbal suggestion during their sleep; when they wake up, the bimo/suni would ask them to describe where they have been to and what they saw in their dreams. (interview conducted on 07/2021 at Southwest Minzu University)

TABLE 3.1. A LIST OF PHENOMENA THAT PURPORTEDLY DEMONSTRATE THE EXTRA-ORDINARY POWER CONFERRED BY RASA.

Description	*reference*	*Potential scientific explanation*
Bimo/suni correctly identifies the location of nuci's grave	(Bamo 2003)	*Chance/under-reporting of failures, intentional cheating (following the gaze of local people)*
Bimo/suni makes people chase alleged nuci via chanting	*Field observation*	*Chance/under-reporting, hypnotism*
Bimo/suni rubbing their bare feet against/licking hot iron without being burnt	(L. Zheng 2003)	*Training; the physics of thermal conduction and heat transfer (see Coe (1957) and Leikind & McCarthy (1988) for the science of firewalking, and* (Zeuner et al. 2019) *for Leidenfrost effect)*
Bimo/suni biting a rope attached to a goat and swinging it in circles	*Field observation*	*Training*
Bimo/suni correctly reveals information that he/she has	(Zhu 2005)	*Chance/under-reporting of failures*

no direct access to in divination sessions		
Bimo/suni makes boiling water not as hot when whipping the water onto a patient's body in healing rituals using spells	(L. Zheng 2004)	*Placebo effect; the water does not feel very hot anyways after being transferred from the wok onto the body.*
Bimo/suni uses chicken as a diagnostic device that correctly identifies the location of illness of the patient	(Du 2016)	*Chance/under-reporting of failures*

The second way in which cultural information contributes to ghost beliefs is that *nuci* is talked about very often in casual settings. People would share their "ghost stories" with each other either in the form of their own experiences or second or third-hand hearsays. These stories often include vivid details of the occasion in which *nuci* are encountered, what *nuci* looks like, and sometimes what happened after the protagonists had seen *nuci*. Unsurprisingly, *nuci* are almost always seen during night-time. Regarding *nuci*'s appearance, although the exact descriptions from different individuals vary, there are some general features to be noted. First, a *nuci*'s face cannot be seen which is interpreted by the local people as either the *nuci* not showing its face or that all those who have seen *nuci*'s face have died. Second, *nuci*'s figure is often portrayed as vague and blurry. Outcomes of *nuci* encounters, when mentioned, are almost

exclusively unfortunate events happening to the protagonist. In fact, these unfortunate events are sometimes used as *evidence* that the protagonist has indeed seen a *nuci*. For example, a man in Meigu County told the following story when prompted to share his *nuci* experience:

> A long time ago I worked as a schoolteacher in a village. I was sitting outside [of the classroom] eating lunch and saw two people coming towards me. I thought they were neighbors coming to play around; when they came close, however, they gave me a scare and walked away. It did not bother me very much, but later I was told that there was an old woman down the road (that the two people were going towards) who fainted after seeing them, and then I realized that they were *nuci*.

This is a slightly atypical ghost story as the protagonist did see the *nuci* quite clearly. Here, though the person telling the story did not suffer an unfortunate fate himself, another person did (the old woman who fainted) and this was used as evidence that he met *nuci* that day. Here we observe abductive reasoning at play: for the protagonist, among all possible explanations of why the woman fainted, the theory that she met *nuci* is the most likely one (from a Bayesian perspective, this would be a natural outcome if the prior belief of ghosts existing and can cause harm is sufficiently high (Powers, Mathys, and Corlett 2017)), and therefore he reasons that the strangers that he met were *nuci* when in fact they could have been two naughty villagers joking around.

What is perhaps more interesting, however, is when individual level abductive reasoning combines with population-level transmission dynamics. When an explanation is attributed to the story which is then told to another individual, it is quite possible that the listener does not view the transmitted information (e.g., I saw ghosts) as an inference obtained through abduction but as

a factual observation, thus mistakenly increases the receiver's belief that ghosts exist. In other words, a probabilistic assessment of the actual situation in the story teller's mind (I'm 60% percent confident that I saw ghosts) often turns into a factual statement (I saw ghosts) and may be interpreted by the listener as such. Of course, the extent to which such mis-inference exists in actual human populations is an open empirical question, but the many extraordinary ghost stories among the Yi strongly suggest some exaggeration of the original story is happening.

3. Magic and divination in everyday context: an instrumental practice

3.1. General description of Yi magic and divination

With a basic understanding of the Yi concept of ghost, *nuci*, we are now in a good position to understand the form and logic of magic and divination rituals. Before delving into the details, a bit etymology may be helpful. The term that Yi people use to collectively refer to magic, divination, and other superstitious practices is *mixin*. This term originated from the Japanese during the Meiji restoration (Figal 1999) and was borrowed by the Chinese at the turn of the 20th century by reformist scholars such as Liang Qichao (K. Huang and others 2013). Initially, *mixin* was used to describe all kinds of traditional practices that are not scientifically based, which not only included everyday superstitious practices but also organized religion (Shen 2006). In southwest China, which is populated by ethnic minority groups, *mixin* was used extensively to refer to the shamanistic and divinatory practices and had a very strong negative connotation both during the New Culture Movement and the Cultural Revolution (Ha 2009). In late 1980s, however, the government's cultural policies sharply reverted and most of the hitherto prohibited

mixin practices of ethnic minority groups were re-classified as "traditional customs" to be preserved (Lu 2019). The word *mixin*, however, remained a colloquial term among local people and has lost its negativity over time. In contemporary Yi populations, for example, *mixin* is used in a quite casual manner and few people remember its derogatory connotation in the not-so-distant past.

Today, *mixin* is primarily used to refer to traditional healing rituals which for the Yi are usually various forms of exorcism. Numerous ethnographic studies of the Yi have pointed out that the indigenous theory of illness among the Yi is *almost exclusively* ghost/spirit aggression or soul loss[98] (Bamo 2003; Zhu 2005), a phenomenon not uncommon in traditional, small scale societies around the world (Murdock 1980). Although recent scholars have emphasized the importance of herbal medicine in addition to exorcism rituals (Sha 2016; Y. Li et al. 2017), during my own fieldwork among the Yi in Meigu county most of my elderly informants told me that herbal medicine was rarely used and only for minor wounds, including professional Yi scholars at the Bimo Culture Study Center of Meigu County (美姑县毕摩文化研究所). In fact, many of them emphasize that *mixin* was the *only* healing method for any serious illness when hospitals were not accessible. Nowadays, *mixin* in the form of exorcism provided by *bimo* and *suni* coexists with modern medical care provided by doctors in hospitals, and the two ways of treating illness are strictly viewed as alternatives despite having fundamentally different theories of illness and corresponding treatment methods (L. Zheng 2004).

Given the common goal of curing illness yet different theoretical foundations regarding what *causes* illness, one might expect the Yi to conceptually divide illnesses into those to be

[98] Even in soul loss (to which children are particularly vulnerable) some malicious spirit is believed to be responsible for either kidnapping the soul or leading the soul astray.

treated by doctors and those to be treated by *bimo*. In an important sense this is true: local Yi people often stress that the patient needs the right kind of treatment to regain health. If the illness is caused by *nuci* then it is of no use to go to the hospital, and if the illness is not caused by *nuci* then *bimo* cannot do anything about it (Tang 2017). In practice, however, it is not at all clear that the manifested symptoms neatly categorize the underlying illnesses into the two groups, and many individuals will adopt a "try one, if not work, then another" strategy or simply employ both traditional exorcism and modern medicine simultaneously (Zi. Wang 2018). Occasionally, divination methods will be used to decide the nature of the illness and whether the patient should hire a *bimo* or visit a doctor (see SM video 2).

When the patient (or his family members) decides that the illness is caused by *nuci*, there are generally three steps to take. First, the *bimo* or *suni* needs to determine what *nuci* is involved. Bamo (2003) lists more than a dozen methods for doing this including the use of eggs, various chicken body parts, natural signs, and astrological tables[99]. My own fieldwork indicates that the most common method of identifying causative *nuci* is egg divination (*vaqihe*) (Figure 3.3. SM video 9-15). According to Bamo (2003):

> The *bimo* rubs a raw egg over the patient's body, and then pierces a small hole on top of the egg and lets the patient blows his/her breath into the egg from the hole. Then, the *bimo* brushes the egg with water using an Artemisia twig and starts chanting. He then breaks the egg and drops its yolk into a bowl of water and observes the shape, color as well as the distribution of egg bubbles in order to decide the nature and seriousness of the illness as well as the specific *nuci* involved. After such observation, he stirs the egg-water

[99] The Yi astrological tables use a combination of the patient's age and their zodiac signs to deduce the *nuci* involved.

mix and places the broken egg shell onto the swirling water. When the eggshell stops moving, the *bimo* can tell whether the soul of the patient is still with him/her by the orientation of the egg shell. If the soul is lost, then a soul-recall ritual should be performed… (my translation)

Figure 3.3. A *bimo* performing an egg divination ritual (*vaqihe*) for a local woman on the street of Hongxi town.

What Bamo describes here is likely the complete, ideal procedure of egg divination. In practice, the brushing of the egg is often omitted, and the body rubbing using the egg is not done by the *bimo* but by the patient him/herself or a friend/family member. Occasionally, the identification of *nuci* is not sufficient to determine the treatment, as the *nuci* can be potentially satisfied by a number of offerings (i.e. chicken, pig, sheep, goat, cow). Thus a second step is sometimes performed with either sheep shoulder blade bone (*yopiqi*) or artemisia twigs (*saiyomo*) to determine whether sacrificing certain animals would satisfy the *nuci*. In the context of exorcism

rituals, both methods require the *bimo* to ask a question in the form of "will sacrificing X be the right thing to do?" and then to generate signs by burning the bone to produce cracks or cutting marks on the twig with a knife and counting the parity of the number of marks (see supplemental material for a detailed description of the two divining methods). If the sign is favorable, then the domesticate animal of question will be sacrificed. Finally, the sacrificial ritual is held; depending on the type of *nuci* identified the ritual may contain slightly different procedures. Generally, the *bimo* (occasionally *suni*) would make effigies using dry grass, plastic ropes and mud which represents the *nuci* that will be expelled away (Figure 3.4), and then the *bimo/suni* would perform a number of symbolic/sympathetic actions where the *nuci* is offered sacrificial meat, induced out of the patient's body and sent away (full description of the healing ritual is available in the SM. See SM video 6-8 for how it's used). Notably, these ritual procedures make a lot of sense from the locals' perspectives: anyone who spends some non-trivial amount of time with the Yi would get the basic idea of their traditional healing ritual (illness caused by ghosts → identification of causative ghosts →exorcism), and although the audience of the ritual often do not fully understand the meaning of every single action, they nonetheless believe that these actions are instrumental to the eventual success of the ritual. The practitioners of the ritual (i.e., the *bimo* and *suni* themselves), on the other hand, almost always know what they are doing. If we consider the ability to perform an exorcist ritual as a type of specialized knowledge, then the differential understanding of ritual actions may be viewed as a division of cognitive labor that has been discussed extensively in philosophy of science (Kitcher 1990; Weisberg and Muldoon 2009) and cognitive psychology (Kominsky, Zamm, and Keil 2018; Lutz and Keil 2002).

Figure 3.4. Effigies made of grass and mud that represents ghosts (nuci) made by a suni during a exorcist ritual.

On divination, a few more notable types deserve mentioning in addition to the illness-causing ghost identification methods. First, recall that the *suni* is believed to possess superhuman powers conferred by his/her *rasa*. The *suni* can then quite literally perform divination using his/her *rasa*; in a market setting, the suni may be appropriately called a diviner. The fee that they charge their clients vary, and extremely famous *suni* may charge an exorbitant amount of money. Typically, for a 20-30 minute session the client pays 20-150 RMB (3-20 USD) in either cash and/or cigarette/alcohol to inquire about health, career, marriage, or luck in general, though most inquiries are illness related. Although in theory the *suni* can just summons his/her *rasa* for

answers, in practice additional information-generating methods like palm reading or egg divination is often used in combination with invoking *rasa*.

Other informational methods may also fall under the umbrella term divination, broadly defined. The aforementioned Artemisia twig divination (*saiyomo*), for example, may be used as a general epistemic device for individuals who need to make decisions in situations of uncertainty. Its most frequent use is to indicate directions to search for lost items. Similar to sheep shoulder blade divination, one first needs to ask a question in the form of "will X (lost item, e.g., cattle) be found in direction Y (e.g. north, south, west, east)?" If the sign is favorable, then the same question is repeated, and in cases of a second favorable sign, one may be assured of the answer[100].

The Yi also use dreams for informational purposes , a very common phenomenon ethnographically (Lincoln 1935; Grunebaum, Caillois, and others 1966). However, there is no professional diviner who relies on dreams partly because of the idiosyncratic features of dream divination (Hong 2022). At the folk level, though, people often use dream signs to predict the sex of fetus in casual settings. In a highly patriarchal society like the Yi, knowing the sex of the yet-to-be-born is not only a matter of curiosity but also of practical significance. Because the Yi family line is carried by the males and daughters are essentially considered "outsiders" from an inheritance perspective, a Yi couple would not stop reproduction until they have at least one boy. Because of the great interest on this subject, there are many folk methods to predict fetal sex, including 1) shape of the pregnant women's belly, 2) timing of the pregnancy based on some horoscopic calendar, 3) words of young children who just learn to talk, 4) esoteric techniques of

[100] See Hong & Henrich (2021) for a list of divination methods that require auspicious signs to appear multiple times to ensure that the sign is not a result of "noise".

individual diviners, etc. Dreams, however, remain the most talked-about methods for fetal sex prognostication, and will be used as an important case study to illustrate the psychological and social mechanisms that contribute to the persistence of magic and divination in later sections.

3.2. The maintenance of magic and divination from an empirical perspective: under-reporting of failures

A central question around magic and divination rituals is whether they "work". This is a crucial question not only for anthropologists and ethnographers trying to understand their exotic cultural practices but also local people themselves who rely on these technologies for important, sometimes life-and-death situations. In the summer of 2019 a *bimo* performed egg divination for me in the town of Hongxi to see if I have health problems and potential sacrificial rituals to perform (see video 3). He ended up offering rather specific predictions about my health and family events. For instance, he predicted that my father had a sister who died and turned into *nuci*, which is causing me health issues (this is unfortunately wrong; my father does have a sister but she is alive and well). Whenever I told my divining experience to local people, they *always* asked me "so did your father indeed have a sister who died?" Of course, the locals may be particularly interested the accuracy of divination in my case because they want to know whether traditional Yi divining procedures work on outsiders as well. Nonetheless, this anecdote illustrates that people do care about the outcomes of divination, and also provides a plausible mechanism for why certain diviners are able to charge significantly more money than others for their alleged accurate predictions. The same is true for traditional exorcist rituals: *bimo* and *suni* are famous almost always because they have established a good reputation for their healing success, and stories of their miraculous healing achievements circulate widely in the community.

Regarding the efficacy of divination and magic in general, we have previously shown that many Yi individuals are able to give a subjective estimate in the form of percentages (Hong and Henrich 2021). Figure 3.5 shows the combined data collected during five months of fieldwork among the Yi in Meigu county between 2019 and 2021. We can see that most subjects believe that magic and divination rituals are quite efficacious, and the subjectively reported efficacy estimates are not significantly predicted by sex, age, or educational level.

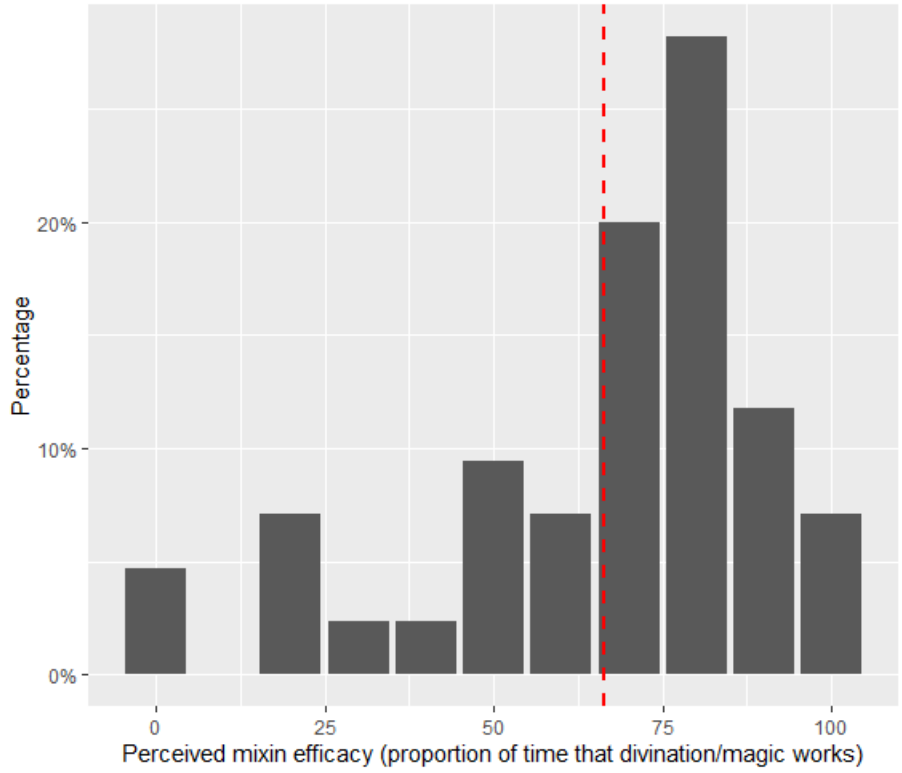

Figure 3.5. Distribution of subjectively perceived mixin efficacy. N=85. Red dashed line (x=66.24) represents the mean of the distribution.

So how do we account for the apparent empirical success of various divination and magic practices[101]? There are two main possibilities. First, certain traditional healers indeed have extra-

[101] One suggestion from some Han people who run business in Yi villages is that most people suffer from malnutrition in the past, and because the meat of the animals sacrificed in exorcist rituals was cooked and shared by

ordinary powers and can cure their patients either by successfully exorcising the ghost that bothers them or by some other means, and diviners have the ability to correctly foretell future events due to their *rasa*. In fact, some anthropologists implicitly hold this view by invoking some mysterious forces that humans do not yet fully understand[102]. Second, there may be some general social and psychological mechanisms that make magic and divination practices appear more effective/accurate than they actually are. Importantly, these two possibilities are not mutually exclusive: magic and divination may be genuinely effective and at the same time their effectiveness can be over-estimated. For psychologists and cognitive scientists, the first possibility is usually not seriously entertained, and I remain agnostic about it in this paper and will not discuss it in any detail. Instead, I will focus on the second possibility and examine the extent to which there exists factors that bias people's assessment of the efficacy of magic and divination.

In the literature, psychological factors such as placebo effect for traditional healing rituals (Humphrey 2018) and regression to the mean (i.e. illness recovers regardless of any treatment applied) (Linden 2013; Morton and Torgerson 2003) have been well-studied and they certainly contributes to the perceived efficacy of *healing* rituals due the mind's suggestive power and the fact that illness frequently recovers on its own without interventions (L. Zheng 2004). However, these factors do not explain the perceived success of divination practices where the generation of accurate information is typically not affected by suggestion or regression to the mean (e.g.

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the ritual participants, the patient would feel better after consuming the much needed calory input. This is unlikely to be the case because in most exorcist rituals the meat is considered to be sacrificed to the ghost, and although it is cooked and shared, the patient suffer from the illness is forbidden from consuming the meat for fear of the ghost attaching itself back to the patient.

[102] This position is especially prevalent among Chinese anthropologists and ethnographers (see Du (2016)). Though not always appear in formal writing, genuine, extraordinary powers of healers and diviners are often invoked and attributed to some mysterious forces that science cannot account for in casual conversations.

whether one will find his lost cattle by going north). Therefore, some more general mechanisms may be needed to account for the high perceived success of these traditional practices.

In Hong and Henrich (2021), we have formally modeled the process of individuals updating their belief regarding the efficacy of some technology and the parameters that could bias individuals' efficacy estimate during the information transmission dynamics at the population level. One key parameter that leads individuals to over-estimate the efficacy of some technology is the extent to which negative instances (ritual failure) is under-reported. In subsequent empirical evaluation of the model, we have identified substantial reporting bias in both traditional rainmaking and dream divination using historical data (Hong 2022, Hong, Slingerland & Henrich, forthcoming), and conclude that under-reporting of negative evidence of some socially-approved technology is likely a common, recurring feature in human societies that contributes to the persistence of magic and divination in general. Among the Yi, I primarily examine such reporting bias in the most prevalent kind of magic practice, traditional exorcist healing rituals (roughly accounts for 80% of *mixin* rituals, see (Mose 1996)) and a particular form of divination (loosely defined), fetal sex prognostication.

Between summer 2019 and summer 2021, we opportunistically interviewed 72 Yi participants and asked the following questions in the form of vignettes:

> Q1: "If a friend of yours feels ill, and after a *mixin* ritual is performed he does not recover and still feels ill, to what extent are you willing to tell this (incident) to others?"
>
> Q2: "If a friend of yours feels ill, and after a *mixin* ritual is performed he recovers and doesn't feel ill anymore, to what extent are you willing to tell this (incident) to others?"

Participants were instructed to answer this question on a 5-point Likert scale (very willing – willing – don't care– unwilling – very unwilling) and to provide verbal justifications for their choice when possible. Figure 6 shows the distribution of participants' answers to the two questions. Note that the only difference between the two questions is the outcome of the illness recovery: the protagonist recovers in Q2 yet does not recover in Q1.

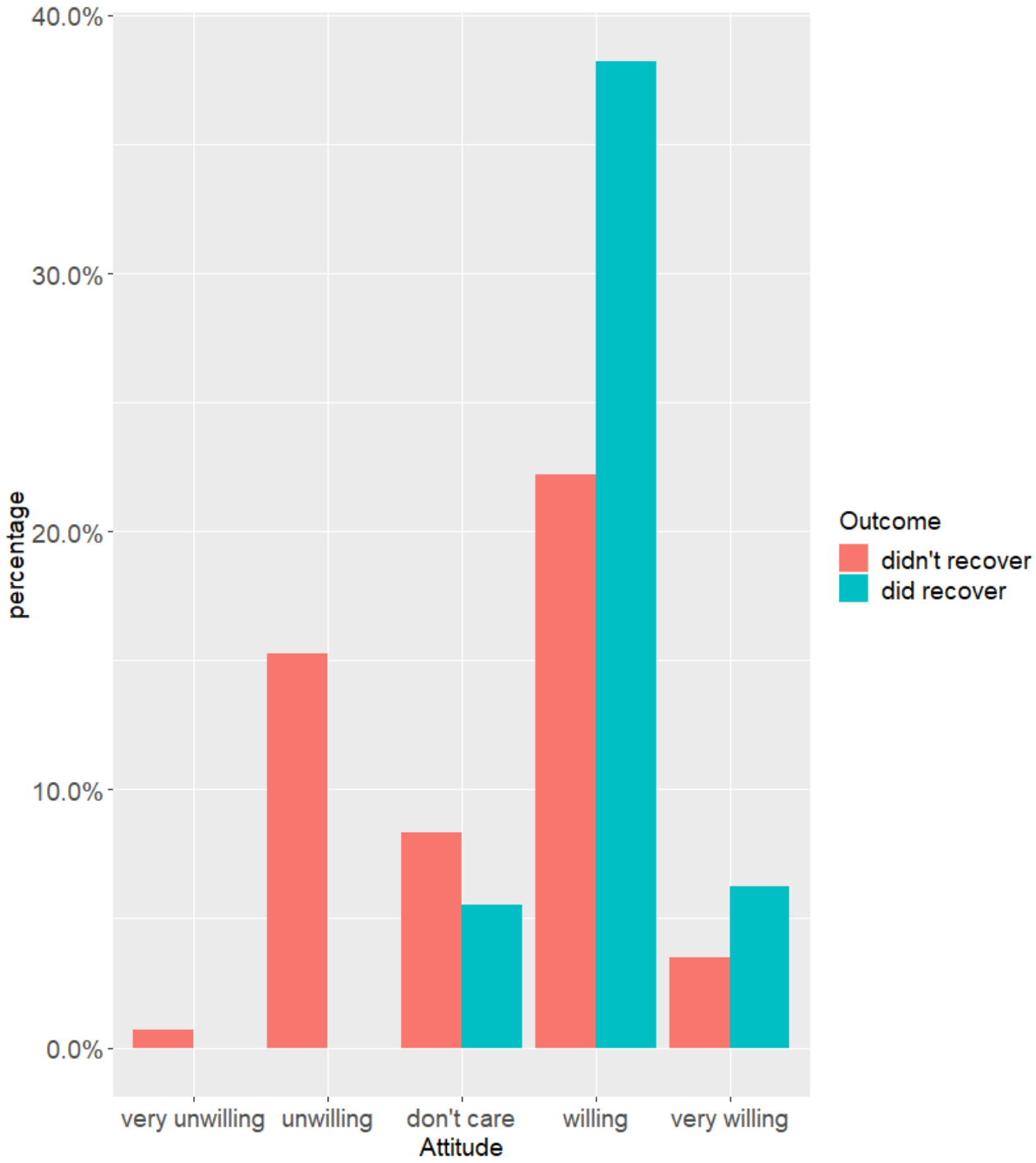

Figure 3.6. The frequency plot of willingness of Yi participants to tell the traditional healing experience to others, broken down by the outcome of the healing ritual. Mean (did recover)=4.01, SD (did recover)=0.49; mean (didn't recover) = 3.25, SD (didn't recover) = 1.02.

From Figure 3.6 we can see that while a substantial proportion of individuals (~15%) are unwilling to share their stories of ritual failures, in the case of ritual success most participants choose to share the story with others. relatedly, the proportion of participants who choose "very willing" and "willing" is significantly higher in the vignette scenario of recovery than in that of non-recovery, meaning that individuals are more likely to share a happy story (illness recovered) than a sad one (illness not recover/death).

There are some general patterns in participants' responses regarding why they are unwilling to reveal a healing failure to others. First, people are quite explicit in making the point that in the case of recovery, of course one is willing to share the good news whereas if the patient doesn't recover, people do not wish to talk about it because of the negative emotions it may incur. Indeed, the underlying psychology of preferentially thinking and talking about positive experience has been extensively studied in social psychology (Gable et al. 2004; Langston 1994). Second, since people know that these rituals are not meant to work 100% of the time, failures can be easily explained away by invoking technical issues of fate (the patient is destined to become ill/die), and as such the *bimo* (occasionally *suni*) who perform the ritual is really not responsible for the ritual failures. In a sense, the *bimo* is helping the host family to negotiate with the *nuci* by offering it meat, etc., and the audience of the ritual can clearly see this[103]. Because the *bimo* are often friends or relatives of the host family who invite them to perform the healing ritual, people are generally concerned that spreading these failures to others may negatively affect their reputation. Even if the incompetence of *bimo* is suspected, there is the more serious worry that since *bimo* are believed to have super-human powers, if they come to know that

[103] The voluntary nature of inviting *bimo* to perform healing ritual is often emphasized, that is, nobody forces the host family to invite any particular *bimo* and there is an implicit agreement that the *bimo*'s effort to trying to cure the illness should be acknowledged and appreciated regardless of the therapeutic outcome.

whoever has said bad things about them (e.g. attributing healing failures to their incompetence), they may curse these people and cause material harm. Therefore, a common response from the participants is that "if a *bimo* fails to cure the illness, just don't ask him to perform the ritual again; no need to tell this to others."

To check the robustness and generality of the under-reporting pattern, we asked the same two questions in an online survey in three nearby colleges. Because subjects in the survey are largely Han individual who may not know about *mixin*, we changed the wording "after a *mixin* ritual is performed" into "after going to a hospital". The same pattern is observed (Figure 3.7): People are more willing to report their experience to others when the outcome is positive, though the reporting bias is not as pronounced as in the *mixin* case among the Yi people.

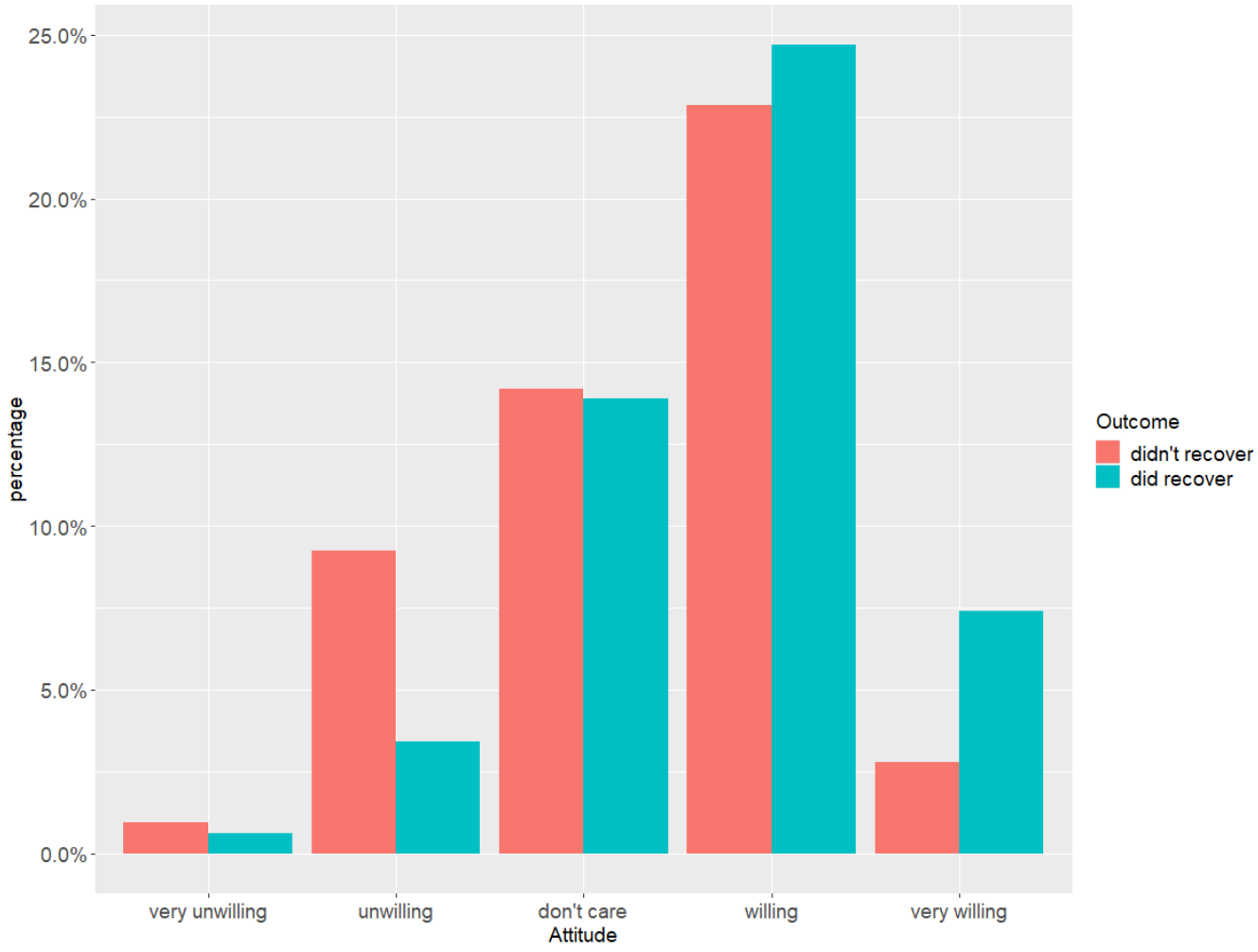

Figure 3.7. The frequency plot of willingness of college subjects to tell the hospital experience to others, broken down by the outcome of hospital treatment. Mean (did recover) = 3.70, SD (did recover) = 0.85; mean (didn't recover) = 3.34, SD (didn't recover) = 0.91.

Now let us turn to the divinatory practice of fetal sex prognostication to better observe the potential reporting bias in action. Because we know that the probability of a pregnant women giving birth to a boy or a girl is roughly the same (50%) (Orzack et al. 2015), the chance efficacy of fetal sex prognostication is 50%; that is, if one only randomly guesses the sex of fetus he/she will achieve a long term success rate of 50%. If we assume that common folk methods for fetal

sex prognostication do not out-perform chance, then any significant deviation from 50% in people's reports of predictive success and failures would be evidence for a reporting bias.

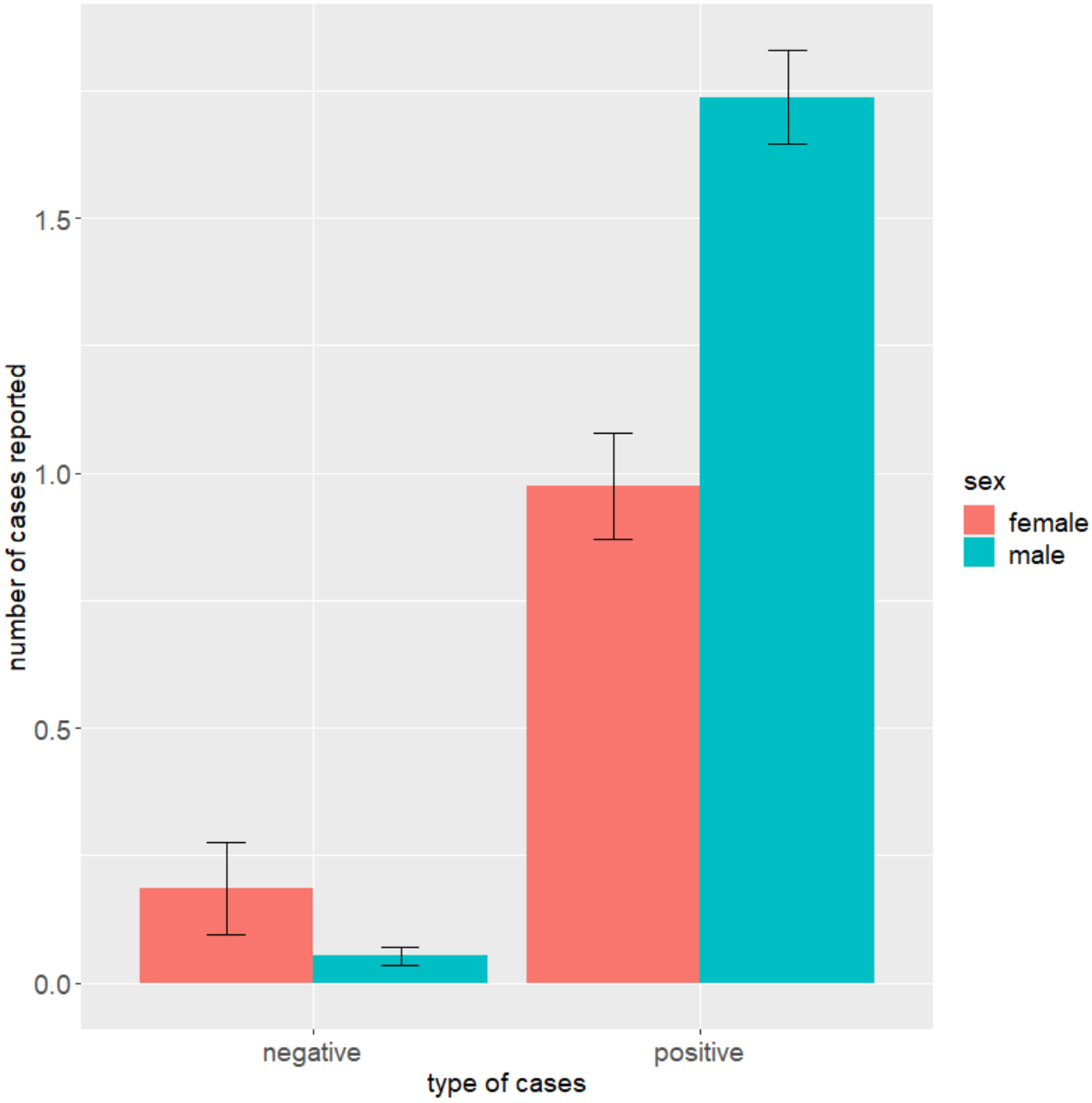

Figure 3.8. The number of predictive success and failures (broken down by sex) from participants' reports (N=39). There was one subject who reported 7 incorrect dream predictions.

We first asked participants if they know of any folk methods of predicting fetal sex, and then specifically inquired whether they have either personally experienced or heard about predictive successes or failures. Importantly, we emphasized predictive failures by repeating the question "have you heard of any predictive failures (inaccurate predictions)?" Figure 8 shows the average number of predictive success and failures by sex for participants who reported at least one incidence of fetal sex prognostication. We immediately observe the overwhelming pattern that reported predictive successes vastly outnumber failures. In fact, out of all 39 subjects only two participant (one has received formal medical training and is very skeptical about folk methods of fetal sex prognostication, the other dreamt of girl related items 7 times yet every time gave birth to a boy; she concluded that her pregnancy dreams were "opposite" to others) reported predictive failures. Of course, we cannot definitively rule out the possibility that some folk methods are indeed effective; for example, telling the sex of fetus by the shape of the pregnant women's belly. In our sample, most individuals reported the use of dreams as a predictive device (if the pregnant woman or her close relatives dream of boy-related items such as gun or knife then she'll give birth to a boy, and girl-related items such as earrings or bracelet then she'll give birth to a girl), and to my knowledge there is no scientific evidence showing that pregnant women's dream content correlates with the sex of their baby. Moreover, if we take participants' subjective report at face value, the "success rate" of fetal sex prognostication is 94%!

The results above thus suggest a very large reporting bias. In fact, it is so large that what we observe in Figure 3.8 is most likely more than just under-reporting of failures; other factor such as retrospective inference (e.g. inferring/misremembering that one must have dreamed of boy-related items after a boy is born, see (Hong 2022). It is possible, however, that individuals are aware of the existence of such bias and take it into consideration when evaluating the

efficacy of fetal sex prognostication. My fieldwork indicate that this is not the case; during focus group discussions many individuals expressed strong confidence in the correlation between dream contents and fetal sex. Indeed, from the perspective of cultural transmission, the learner must find the evidence for various types of fetal sex prognostication overwhelming. Additional psychological mechanisms such as confirmation bias and norm adherence[104] that give rise to under-reporting have been suggested (Hong and Henrich 2021), and it is beyond the scope of this paper to go into the details. The bottom line is that such under-reporting of negative instance will recursively maintain individuals' confidence in fetal sex prognostication over generations at the population level.

3.3. misperception of chance in evaluating the efficacy of magic and divination: evidence from fetal sex prognostication

For a modern reader, the *empirical* reason that we deem some technology with uncertain outcomes as ineffective is almost always that it does not out-perform chance. However, as Hacking (2006) points out, the modern understanding of probability did not emerge until rather recently in human history, and we do not have a very good understanding of whether and how ancient people without formal statistical training compare the efficacy of some technology with chance. Here, we use fetal sex prognostication as a case example to examine this important question in the field. Crucially, we want to explore the extent to which Yi individuals realize that the empirical requirement for some technology to be effective is that it needs to out-perform chance. Fetal sex prognostication again is an ideal case here because we know that its "chance

[104] See (L. Zheng 2003) for a description of the normative pressure on performing *xiaobu* ritual in rural communities.

efficacy" is roughly 50%, and with this knowledge we can examine individuals' understanding of technological efficacy and chance in a straightforward setup.

In particular, we have asked the two following questions:

Q1) If a diviner correctly predicts the fetal sex 50 out of 100 pregnant women, what do you think of his/her divining ability? (5-point Likert scale from very low to very high)

Q2) If someone without any divining ability only randomly guess fetal sex, how many out of 100 do you think he'll guess correctly?

On the surface, the answers to these questions should be very obvious to anyone with basis knowledge of statistics and probability. However, these are far from trivial questions for Yi participants. Firth & Cole (1975) have long pointed out that individuals in illiterate, traditional societies often have trouble answering questions that involve hypothetical scenarios. For the above questions, the Yi often find 2) particularly difficult. A quite amusing response that we encounter in the field is "I don't know, as there is not that many pregnant women in the village."

In total, we collected 159 responses for Q1) and 114 response for Q2), and Figure 3.9 visualizes the distribution of individual responses. There are a couple notable patterns. First, the majority of participants think that a diviner that performs exactly at chance level has some divining ability after all. While over half of the participants think diviner with 50% success record is merely "mediocre" (note that even "mediocre" here is a somewhat positive evaluation and can also be translated in English as "fair"), a substantial amount (over a quarter) of the participants rate the diviner's ability as either "high" or "very high". Correspondingly, few participants (less than 15%) think that a random guesser would achieve a 50% success rate

(which from a statistical perspective is the most likely outcome), and the majority think that he/she would have a success rate much smaller than 50%.

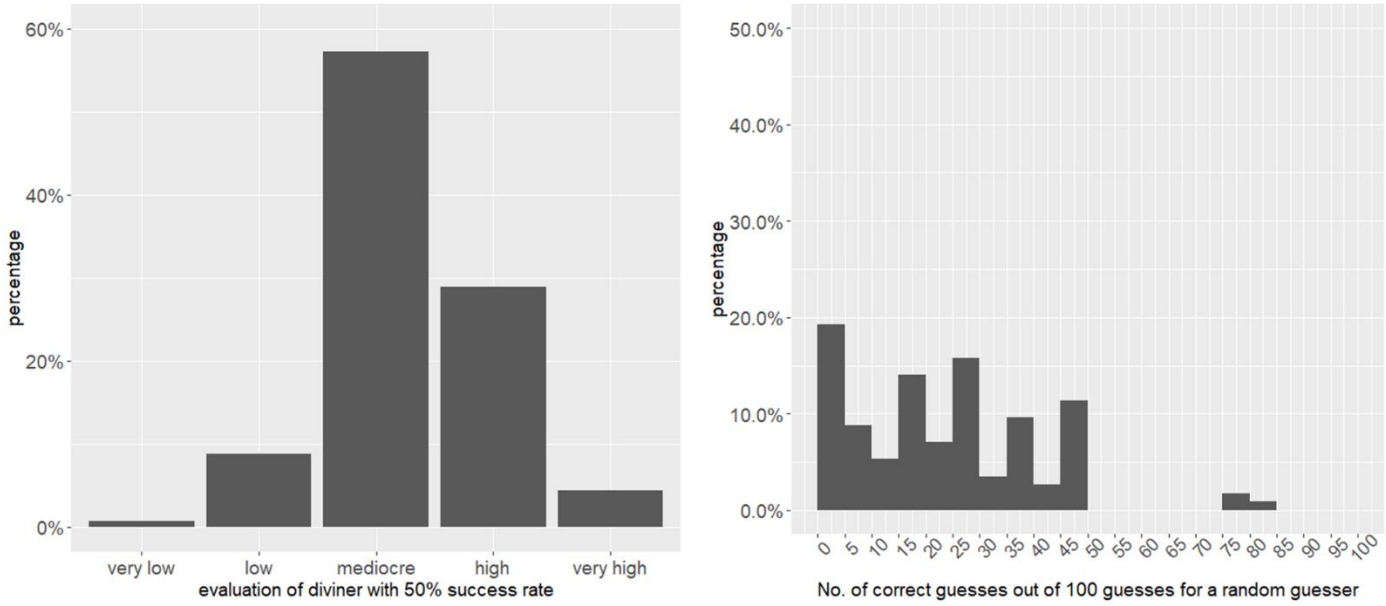

Figure 3.9. The distribution of participants' response to questions on chance and uncertainty of fetal sex prognostication.

These results may appear shocking, and one may worry that participants in the field simply lack the numeracy required to understand the questions correctly. While this is certainly a possibility, there are reasons to think that the above patterns meaningfully represent how individuals reason and think about these scenarios. First, lack of numeracy alone does not explain the obvious skew in distribution of people's estimation of a random guesser's number of correct guesses, where individuals systematically report numbers smaller than 50. Second, as mentioned earlier in the paper, many individuals in this population have a rudimentary understanding of percentages and would spontaneously re-phrase the questions as "so his success rate is 50%..." and certainly know that a good diviner should have a high success rate. Additionally, I have collected survey and interview data showing that even college educated

individuals respond to these questions in the same pattern (Hong, unpublished), suggesting a potentially very robust psychological bias when people think about chance and uncertainty.

During interviews and focus group discussions, participants often express that the 50% feels like a substantial percentage and that someone who achieves that success rate is, although not "very good", certainly possesses some mediocre predictive ability. Moreover, the idea of "randomly guessing" is a very unfamiliar one, and in the field we often needed to "act out" someone who mindlessly points finger at imaginary pregnant women with his eyes closed, murmuring "boy, girl, boy, boy, girl…" for the participants to get a basic understanding of "random guessing". Indeed, who would do such a thing except for professional statisticians! For the Yi, it is quite sensible that someone tries to perform fetal sex prognostication, but such prognostication must be based on some technique or knowledge, be it the belly shape checking, dream interpreting, palm reading, or something else. In reality, because one is trying to offer accurate predictions, presumably based on all available information, "random guessing" is something that makes very little sense.

Yet this creates a problem: although individuals can easily tell a good diviner from a bad one based on their empirical success record, it is rather difficult to realize that a diviner's fetal sex prognostication is no better than a coin flip, and as such various types of fetal sex prognostication may never be definitively rejected. In a different paper, we have analyzed fetal sex prognostication in China using extensive historical record and show that it very much persisted till the late Qing dynasty (1644-1912 CE) and to some extent the present day (Hong, unpublished).

Like under-reporting of negative evidence, such bias in thinking about chance and uncertainty may contribute to the recurrence and persistence of ineffective technologies quite generally. As long as the promised result can appear by chance, people may fail to recognize that technologies do not perform any better than "doing nothing". The key here is that people are not consciously comparing the efficacy of some technology with the natural frequency of positive outcomes, which, when sufficiently large, may create the illusion that technologies aiming at producing these outcomes have a fairly high success rate and are thus worth using. Note that this phenomenon occurs even when individuals have full access to the empirical data needed for such comparison such as fetal sex prognostication. In everyday life, such information is often not readily available in most other domains, creating an additional layer of difficulty for definitively rejecting certain technologies as ineffective.

4. Discussion

In this paper, I have presented detailed ethnographic descriptions of Yi divination and magic and provided cognitive and cultural evolutionary explanations for the persistence of these cultural practices. For a cultural category as rich and complex as divination/magic, a full understanding of it necessarily requires multifaceted explanations. I agree with cognitive and psychological researchers that people's intuitive theories about the world plays a large role in maintaining various kinds of supernatural beliefs, but would like to emphasize the synergistic interaction between intuition and the unique information transmission dynamics in human societies. From a developmental perspective, although children may be said to be "predisposed" to believe in ghosts and spirits as a result of dualism and agency detection (Bloom 2007), cultural inputs are nonetheless indispensable for the eventual formation of theistic beliefs (Harris 2012). In fact, I

argue that in times of significant social change vis-à-vis people's supernatural beliefs (e.g., the booming research on religious beliefs as a natural, cognitive phenomenon (J. L. Barrett 2007) and the prominent rise of New Atheism (Schröder 2017; Schulzke 2013) in the West), it is more pressing than ever to understand the sociological and cultural dynamics for belief formation, both on the existence of spiritual entities and the effectiveness of cultural practices (e.g. magic and divination rituals) that aim to achieve specific ends via interaction with these spiritual entities.

The Yi in southwest China thus provides an ideal opportunity for a detailed case study. Arguably one the most superstitious ethnic groups in contemporary China, the Yi have ample access to mainstream cultural information and technology, yet they have managed to maintain much of their traditional beliefs in ghosts, magic, and divination. In this paper, building on existing research in cognitive science and cultural evolution, I have provided empirical evidence for the psychological biases that powerfully reinforce the existing beliefs in ghosts/spirits and the efficacy of technologies based on such beliefs. Below, I offer some additional comments on these biases in the Yi context, as well as the possibility of having a general, unified theory of divination and magic.

4.1. On ghost beliefs and abductive reasoning

I am not the first to point out the relationship between abductive reasoning and supernatural beliefs (Boyer 1994; Coltheart, Menzies, and Sutton 2010), I have, however, broadened the ways in which abductive reasoning contribute to these beliefs and emphasized its importance in the process of cultural transmission. Specifically, abductive reasoning not only plays a role in situations where individuals misinterpret sensory data but also in situations where one attributes beliefs to other individuals in order to make sense of their behavior. For example, from the

observed action “X performs a healing ritual” to the inference “X believes in the efficacy of the healing ritual” and further to the inference “the healing ritual is effective” is very much abduction at work. Regarding cultural transmission, as long as the uncertainty involved in abductive reasoning gets somewhat lost via transmission channels such as testimony, the naïve listener may mis-process the data and end up over-estimating the probability that ghosts exist or the efficacy of some technology (Hong and Henrich 2021), and these ghost beliefs in turn serve as the theoretical basis for traditional healing and divination.

4.2. The cultural consequences of under-reporting of negative evidence

As mentioned, under-reporting of negative evidence is likely to be a very common bias in human societies when people evaluate the efficacy and report success/failures of some technology. Note that in addition to the obvious effect of up-biasing people’s estimate of technological efficacy, under-reporting of failures has some interesting, indirect consequences. The vast majority of my participants, for example, believe that *bimo*/*suni* in the past were more powerful than those now, and some even go as extreme as “all practicing *bimo* and *suni* today are charlatans.” This is a natural consequence of under-reporting of failures: because although failures are generally under-reported, most individuals can still personally experience failures to some extent which will no doubt affect their evaluations of the specific *mixin* practitioners and perhaps the efficacy of *mixin* in general. However, people cannot directly experience the *mixin* rituals of past *bimo*/*suni* and thus all their information regarding these past *bimo*/*suni* is obtained through testimony which is subject to biased reporting.

It is possible that the psychological tendency to under-report failures also contributes to the common cultural myth that technologies (many of which would be considered magic and

divination by a modern reader) and practitioners of these technologies were very powerful in ancient times, and gradually became worse and worse over time (which stands in sharp contrast to modern science which is getting increasingly powerful) (Eliade, 1963; Malinowski, 1926/2014). In fact, some of my informants would explicitly mention this and provide reasons for such presumed power/ability decline, such as cumulative ability deterioration (a student cannot be as good as his master, and his student is even worse) and recent human interference with the environment that disrupted the man-nature relationship[105] (e.g., use of explosives to build roads and railways in the mountain). Of course, these are likely post-hoc rationalizations to justify the impression that *bimo*/*suni* today were less powerful than those in the past.

4.3. The non-trivial mathematics behind computing "chance efficacy"

In many evolutionary accounts of magic and divination, the key puzzle is posed as "why would people perform these objectively ineffective yet often costly rituals?" (Rossano 2015; Ruffle and Sosis 2007; Soler 2012). This puzzle can be rephrased without loss of much information as "why would people not *not* perform these rituals?", i.e., not do anything when normally some ritual is expected. Here, the implicit assumption is that in so far as individuals treat these ritual practices as instruments for achieving specific ends, they should compare the efficacy of these rituals with chance. I have shown, based on data on fetal sex prognostication in the field, that individuals may not possess the statistical capability to compute chance efficacy, and therefore fail to recognize that these prognostication methods do not outperform chance. From a strict probability perspective, the number of correct fetal sex predictions follows a binomial distribution with parameter n and p, where n denotes the number of independent

[105] Very similar to the Han idea of *fengshi* being disrupted by the construction of railroad in the early modern period (Brown 2017)

"trials" and *p* denotes the probability of success for each "trial". Mathematically, the probability of obtaining k out of n successes is given by:

$$Pr(X = k) = \binom{n}{k} \cdot p^k \cdot (1-p)^{(n-k)}$$

The inferential problem, then, is to determine the most likely number of successes (chance) given certain *n* and *p*. The brute-force way to do this would be to compute the probability of occurrence for each number of success (i.e. from $X = 1$ to $X = n$), compare them, and pick the one with the largest value. Needless to say, this is a very computationally intensive process. The smart way would be to realize that the shape of the distribution is unimodal and to obtain the most likely number of success one can simply compute the mean or mode of this distribution[106], which is *np*. It is unlikely that the Yi people in the field know either mathematical fact. In fact, many of the participants who answered correctly (a random guesser would guess 50/100 correct) did so probably due to the well-known "equiprobability bias", a tendency to believe that any process that involve some randomness would result in a fair distribution where all possible outcomes have equal probability (Morsanyi et al. 2009; Gauvrit and Morsanyi 2014).

4.4. On the persistence of magic and divination: general psychological and cognitive factors

So far, I have explained how beliefs about ghosts/spirits may be sustained by abductive reasoning, the psychological factors that makes magic and divination appear more efficacious than chance and the difficulty of computing "chance" in the first place. Although I primarily used the Yi as an illustrative example, such psychological and social factors may be quite general

[106] When *np* is an integer, the mean median and mode are the same and equal *np*.

in sustaining ghost beliefs and ineffective technologies in traditional human societies. This is because the psychological biases do not depend on the specificities of the society's belief systems, and the information transmission dynamics is largely similar in small scale, traditional societies. In fact, even in contemporary, modern societies reporting bias has been shown to inflate people's assessment of efficacy of medical products (de Barra 2017; De Barra, Eriksson, and Strimling 2014). In traditional societies where there is no epistemic authority to regulate the production of knowledge, individuals' beliefs are subject to many kinds of biases and inferential mistakes (Hong and Henrich 2021).

The fact that many problems frequently solve themselves and many technologies achieve their desired ends probabilistically means that we often need to decide whether some technology performs better than chance, and the difficulty in computing "chance efficacy" may thus present a large barrier for the rejection of some technology in societies where statistical knowledge is lacking, especially when it is the only method for dealing with some practical problem. Significance testing, randomized controlled trials and other advanced statistical methods for determining whether something is due to chance is a very recent cultural achievement in human history, and there are good reasons to suspect that before the advent of these tools identifying technologies as having no better than chance performance was genuinely hard.

It is my hope that this work could inspire more efforts to explore general psychological and social factors that affect our understanding of technologies which we rely upon on a daily basis. Although a complete theory of magic may not be possible (Hong 2022), our understanding of technological practices, ineffective and effective, past and present, could still be greatly enhanced by focusing on both individual psychology and the social contexts in which it is embedded.

Conclusion

In conclusion, my dissertation addresses the prevalence and persistence of ineffective technologies such and divination and magic from cognitive and cultural evolutionary perspectives, and combines theoretical modeling, historical case studies, and fieldwork to make the following points:

1) Divination and magic practices are goal-directed activities, and people care much about whether these activities achieve desirable outcomes.

2) The efficacy of these practices is often over-estimated due to various biasing factors in cultural transmission, in particular under-reporting of predictive failures. The extent of such under-reporting may be substantial and may work in conjunction with other mechanisms to recursively inflate individuals' efficacy estimate.

3) Chance efficacy may be mis-perceived. This factor is best illustrated in fetal sex prognostication where the chance efficacy is consistently estimated to be lower than 50%. As such, a diviner or some divination technique with 50% success record may be perceived as "quite good".

This dissertation also has broader implications for the advancement of human knowledge and the unprecedent power of modern science. Although adaptive, cumulative cultural evolution can certainly happen in traditional societies (Joseph Henrich 2016), regarding the veracity of beliefs we argue that contemporary modern societies differ in two crucial ways that explain why people in modern societies are able to obtain more accurate beliefs about worldly events. 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 from 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 connection. Second, modern societies have a larger division of labor in knowledge 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 under-reporting of negative evidence and other biases. With statistical training, scientists are keenly aware of the need to use chance as the baseline for efficacy evaluation of technologies, thus are able to reject ineffective ones (those that do not outperform chance) and retain effective ones. Lay people on the other hand, by de-valuing 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.

Supplementary Materials

Supplementary materials are available at the following links.

Chapter 1

https://github.com/kevintoy/diviniation_as_technology

Chapter 2.1

https://github.com/kevintoy/rainmaking

Chapter 2.2

https://github.com/kevintoy/dream_divination

Chapter 3

https://github.com/kevintoy/Yi_ethnography

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