

# The psychology and social dynamics of fetal sex prognostication in China: Evidence from historical data

Ze Hong<sup>1,2</sup>  | Sergey Zinin<sup>3</sup>

<sup>1</sup>Department of Sociology, Zhejiang University, Hangzhou, Zhejiang Province, P. R. China

<sup>2</sup>Department of Human Evolutionary Biology, Harvard University, Cambridge, MA, United States

<sup>3</sup>Warring States Workshop, University of Massachusetts Amherst, Amherst, MA, United States

## Correspondence

Ze Hong, Department of Sociology, Zhejiang University, 866 Yuhangtang Road, 310058, Hangzhou, Zhejiang Province, P. R. China.  
Email: [ze\\_hong@g.harvard.edu](mailto:ze_hong@g.harvard.edu)

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## Abstract

Fetal sex prognostication has been a common practice in many human societies, yet most of the prognosticative methods do not perform better than chance. Why do these ineffective prognostication practices recur across societies and persist for long periods of time? In this article, we use historical texts of four different genres in traditional China (oracle bone inscriptions, dynastic history, encyclopedia, and local gazetteers) to examine the social and cognitive factors that lead to the overestimation of the predictive accuracy of sex prognostication and place fetal sex prognostication into a more general framework to understand the persistence of ineffective cultural practices. In particular, we present a detailed historical analysis showing that individuals often entertain considerable uncertainty regarding the accuracy of sex prognostication and quantitative data demonstrating a significant bias toward selectively reporting successes in (fictionalized) historical texts. We conclude by discussing how such reporting bias combined with humans' imperfect information processing may help explain the persistence of ineffective technologies, such as divination, and magic in general.

## KEYWORDS

China, cultural evolution, cognition, divination, fetal sex

## Resumen

El pronóstico del sexo del feto ha sido una práctica común en muchas sociedades humanas, sin embargo, la mayoría de los métodos de pronóstico no son mejores que el azar. ¿Por qué estas prácticas ineficaces de pronóstico son recurrentes a través de las sociedades y persisten por largos períodos de tiempo? En este artículo, usamos textos históricos de cuatro diferentes géneros en la China tradicional (inscripciones en huesos de oráculos, historias de dinastías, enciclopedias y gaceteros locales) para examinar los factores sociales y cognitivos que llevan a la sobreestimación de la exactitud predictiva del pronóstico del sexo y situar el pronóstico del sexo del feto en un marco más general para entender la persistencia de prácticas culturales ineficientes. En particular, presentamos un análisis histórico detallado mostrando que los individuos a menudo tienen un nivel de incertidumbre considerable en relación con la exactitud del pronóstico del sexo, y datos cuantitativos demostrando un sesgo significativo reportando selectivamente éxitos en textos históricos (vuelto ficción). Concluimos discutiendo cómo este reporte de sesgo combinado con el procesamiento de información imperfecta de los

seres humanos puede ayudar a explicar la persistencia de tecnologías ineficaces, tales como la adivinación y la magia en general. [evolución cultural, cognición, adivinación, sexo fetal, China]

### Abstract in Chinese

辨胎行為在人類社會中屢見不鮮，但絕大多數辨胎方法的成功率並不比隨機預測高。這些無效的辨胎行為為何在人類社會的歷史上反復出現並長久延續？在本文中，我們使用了中國古代四種不同類型的歷史文本（甲骨文、正史、類書和地方誌），來考察導致高估辨胎準確性被高估的社會性和認知性因素，並將辨胎行為納入一個更普遍的框架之中，以解釋無效文化習俗的延續。具體來說，我們通過對歷史材料的詳細分析來說明，人類個體通常能夠意識到辨胎方法具有相當大的不確定性；而定量資料表明，在（虛構的）歷史文本中存在選擇性報告成功預測的顯著偏見。最後，我們得出結論，這種報告偏見與人類不完善的資訊處理方式使占卜和巫術等無效技術得以持續存在。

## INTRODUCTION

Throughout history and across societies, humans have been fascinated by the possibility of knowing the future, out of both curiosity (Fatma, Rosa, and Zurmailis, 2020; Kahlos, 2018) and practical needs (Bennett, 1983; Hong and Henrich, 2021). 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 has always existed. Contemporary Westerners may purchase baby gender<sup>1</sup> prediction kits purely for curiosity's sake, 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.<sup>2</sup> On the extreme end, knowledge of fetal sex allows for sex-selective abortion or infanticide when there is a strong cultural preference for a given sex (though the preference cross-culturally is almost always boys) (Goodkind, 2015; Lamichhane et al., 2011). In China and India, 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<sup>3</sup> is found in many historic cultures and 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 (Dawson, 1929);<sup>4</sup> the ancient 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* suggests many methods for predicting the sex of the fetus, including examining which foot the pregnant woman uses to take a first step (Garay and Jeay, 2007).<sup>5</sup> Written records of fetal sex prognostication remain scant in small-scale societies, yet ethnographers have documented plenty of folk methods for predicting the sex of a baby (Naik, 1956; Popov, 1946).

Though fetal sex prognostication likely occurs due to social demand, that is only part of the story. To fully explain the recurrence and persistence of sex prognostication, we also need to consider the cognitive aspect: Why do 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 thought that it had no chance of correctly predicting the sex of the fetus. This leads to an obvious question: Are premodern fetal sex prognostication methods effective?

Unlike many divinatory/magical activities that explicitly invoke supernatural entities, certain fetal prognostication methods are biologically plausible and may indeed be effective (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 trying to evaluate the efficacy of folk fetal sex prognostication methods (Ghalioungui, Khalil, and Ammar, 1963; McKenna et al., 2005; O'Shea, 2003; Ostler and Sun, 1999; Perry, DiPietro, and Costigan, 1999; Rosengarten and Bebbington, 1995; Zare and Sekhvat, 2013). However, so far 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 noted that there are some studies showing that certain physiological traits, such as morning sickness (Rashid et al., 2012) and hypertension (Liu et al., 2019), are statistically associated with fetal sex.<sup>6</sup> However, the effect sizes of these studies are

extremely small; for example, Liu et al.'s (2019) large cohort study ( $N = 205,605$ ) that presumably shows an association between gestational hypertension and fetal sex reports male delivery rates of 51.1 percent and 52.0 percent 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 that is often associated with genetic fitness (Durham, 1991); 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 and Henrich, 2021): our evolved capacity for obtaining information from conspecifics generally facilitates the spread of adaptive culture (Boyd and Richerson, 1985; Henrich, 2016), yet at the same time such cultural capacity enables the spread of nonadaptive, or even maladaptive, cultural practices (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 they update their beliefs about its efficacy<sup>7</sup> based on various types of information sources, with testimony from others being a crucial input. In plain language, one does not expect a technology to "work" every single time, and positive reports from other people increase 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 confirmatory testimonies (i.e., instances of technological actions with outcomes specified), the higher individuals will subjectively perceive the (probabilistic) efficacy to be. In Hong and Henrich (2021), we suggest that such psychological bias and information-transmission dynamics may be a general feature of human societies that helps explain the persistence of ineffective technologies. Note that the overrepresentation of confirmatory stories may be due to a number of social and psychological reasons, such as selective reporting (reporting successes more than failures), deliberate fabrication (making up successful stories), and retrospective inference (falsely inferring the existence of sign based on an outcome) (Hong, 2022b).

In two previous studies, we analyzed rainmaking and oneiromancy in traditional China and showed that transmitted historical records were likely to have been significantly influenced by underreporting of failures and deliberate fabrication (Hong, 2022b; Hong, Slingerland, and Henrich, forthcoming). In this article, 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.

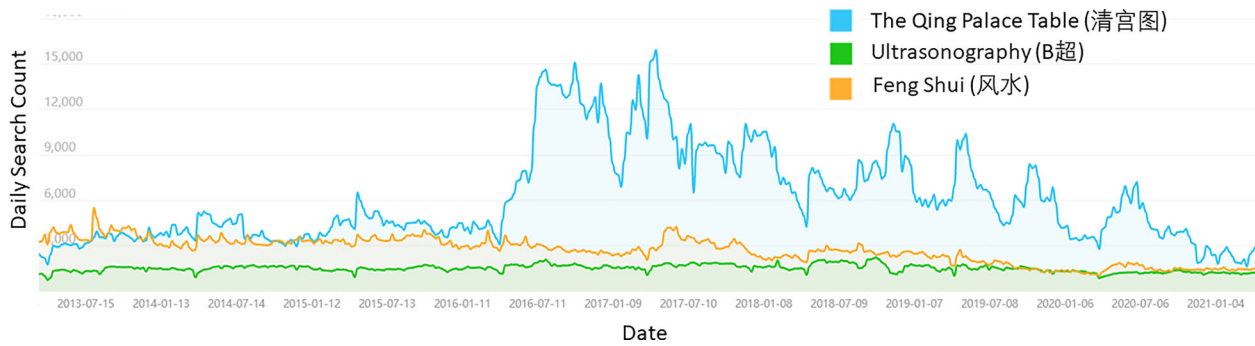
Unlike oneiromancy and rainmaking, however, we know the "chance efficacy" of fetal sex prognostication is roughly 50 percent, given that human sex ratio at birth does not deviate much from 1:1 (Jacobsen, Møller, and Mouritsen, 1999; Orzack et al., 2015). Therefore, if the success record of objectively ineffective sex prognostication methods is substantially higher than 50 percent, 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 and empirical evidence, 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 them to "work" 100 percent of the time—and (2) people would underreport<sup>8</sup> predictive failures and/or fabricate success stories. In this article, we take advantage of the extensive historical record and offer a detailed examination of fetal sex prognostication in traditional China to see if it provides further support for our previous findings. The analysis of historical records also allows us to understand how the folk methods of prognostication functioned in a traditional society that was not yet affected by the modern medical perspective. As we will show, even the arrival of modern prognostication methods has not completely eliminated these methods in China. Therefore, Chinese historical records serve as an invaluable source of knowledge about the functioning of these methods in the past.

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

## A BRIEF OVERVIEW OF FETAL SEX PROGNOSTICATION IN CHINA

The full history of sex prognostication is necessarily beyond the scope of this article; 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, and in a famous case the unborn was predicted to be a girl and therefore "inauspicious" (De Bary, Chan and Watson, 1960). There have been many predictive methods documented in transmitted texts, which were not confined to literature on divination: even in texts devoted to mathematics, we see such methods recorded.



**FIGURE 1** The daily count of internet search queries for “The Qing Palace Table,” “Ultrasonography,” and “Feng Shui” from 2013 to 2021. Data were obtained from Baidu Index. [This figure appears in color in the online issue]

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 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 lay people and the elite literati class. In a society that is highly patriarchal like traditional China, the sex of a 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<sup>9</sup> [轉女為男], or in the extreme case, abortion).

Among the many methods of fetal sex prognostication are birth timing during the day (Cook and Luo, 2017), the Zhouyi trigrams (Cook and Lu, 2017), numerology (Zhou, 2020), physiognomy (Wang, 2013), dreams (Hong, 2022b), the food cravings of the pregnant woman,<sup>10</sup> swelling of the husband’s breast (either left or right) (Cao, 2000), and pulse diagnosis (Zhou, 2020). For a modern reader, the mechanistic worldview makes some of these methods appear more plausible than others, but we need to keep in mind that all of these methods had some degree of plausibility for premodern readers (Hong and Henrich, 2021). The seemingly implausible method of telling the sex of the fetus by the condition of the husband’s breasts, for example, has been repeatedly recorded in later medical texts<sup>11</sup> since it was first proposed in the *Pulse Classic* by Wang Shuhe in the third 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 in the predictive accuracy of the Qing Palace Table, even though they may not necessarily believe in it. To quantitatively evaluate the popularity of this method, we used Baidu Index (the Chinese equivalent of Google Trends) to examine the daily count of internet search queries for “Qing Palace Table” in mainland China, with the modern medical equivalent, ultrasonography (B超) and the general term for geomancy *feng shui* (风水) also shown for comparison purposes. From Figure 1, we can see that the folk method Qing Palace Table has consistently been a more popular search query than ultrasonography<sup>12</sup> 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 that found that it is no better than a random coin-flip (Katz and Wylie, 2009; O’Shea, 2003; Ostler and Sun, 1999).

## ANALYSIS OF FETAL SEX PROGNOSTICATION FROM CHINESE HISTORICAL RECORDS

### 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 and 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 predicting the gender of the fetus, using dream signs from a classic poem from the *Shijing*:

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[s] of certain signs she must give birth to a son or a daughter. There are also instances where one dreams of a bear yet gives birth to a daughter, and instances where one dreams of a snake and gives birth to a son.<sup>13</sup>

Here, on the issue of the efficacy of dream divination, Xiong addresses the well-known belief that dreaming of a bear would lead to the birth of a girl, and a snake the birth of a boy, which originally came from the poem “Sigan” in the Confucian classic the *Classic of Poetry* (11th–7th century BCE).<sup>14</sup> Note that here, although Xiong endorses the association between one’s dreams and fetal sex (later in the text, he justifies it with the *yin-yang* theory), he does not think that using dreams to predict fetal gender works every single time.

It is interesting that this classic interpretation, even endorsed by the authority of the *Classic of Poetry*, was not completely accepted in the Chinese tradition. On the very same topic of pregnancy dreams and the sex of the fetus, we find interesting discussions of it in local gazetteers, also alluding to the *Classic of Poetry*:

the poem says that bears signify males and snakes signify females, and the explanation was that snakes 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 Jianning county, Qianlong period)<sup>15</sup>

In evaluating the accuracy of a 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 observe acknowledged uncertainty in the discussion of transmitted prognostication methods. In *Shenshi Nyke 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 checking 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 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.<sup>16</sup>

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” [馬]; keep 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 [最為應驗] when you write the characters mindlessly [i.e., not consciously thinking/worrying about the parity of numbers].<sup>17</sup>

In this text, by specifying the conditions under which the method is “most accurate,” the author is implicitly acknowledging the possibility of failed predictions. Therefore, individual cases of failed predictions rarely definitively invalidate a particular prognostication method. They do, 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, and Henrich, [forthcoming](#)).

Therefore, although people do not necessarily reason in a perfect Bayesian fashion, historical evidence suggests that individuals in the past nonetheless acknowledged the uncertainty in 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 for interpreting failures as successes.

## Reporting bias in fetal sex prognostication from historical records

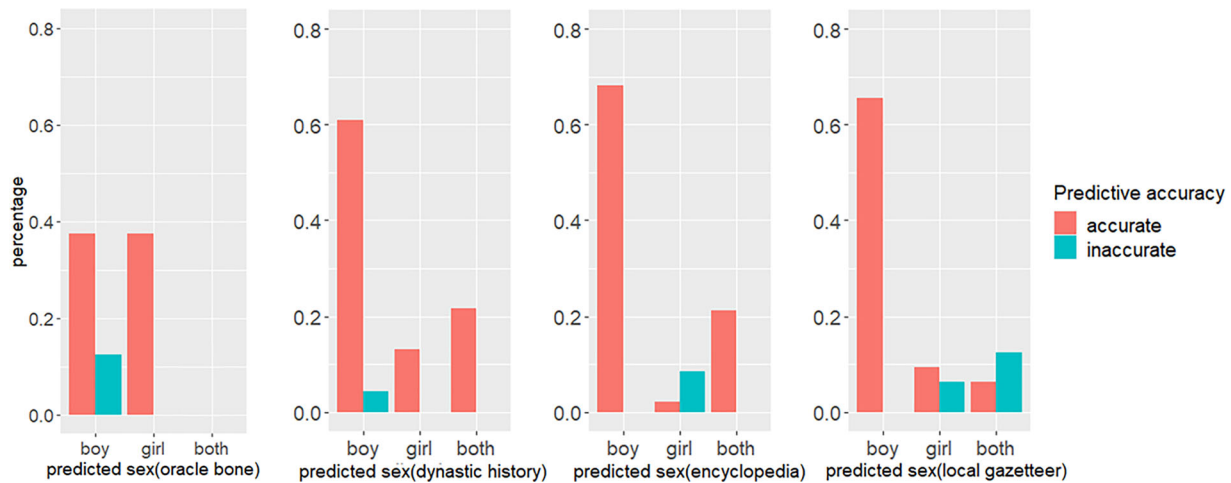
To examine the extent to which predictive successes appear more often than chance in the historical records, we used texts of four different genres: oracle bone inscriptions, which are divination records on ox scapula and turtle plastron during the late Shang dynasty (Keightley, 1985); official dynastic histories, which are written by professional historians of subsequent dynasties and include descriptions of events, dynastic customs and institutions, and biographies of prominent personalities (Wilkinson, 2012); officially compiled encyclopedia (leishu 類書), which include quotations, citations, and excerpts of earlier textual sources categorized in an encyclopedia manner (Zurndorfer, 2013); and gazetteers (difangzhi 地方誌), which are official records of history, economy, geography, and cultural traditions of specific localities. For oracle bone inscriptions, we used the published records of oracle bone collection *Jiaguwen Heji* (甲骨文合集), which contains over 40,000 oracle bone pieces. For official dynastic histories, we used the fully digitized *Twenty-Four Histories* (二十四史) plus *Zuo Zhuan* (左傳), compiled as an open-source resource for the project of provided by Zinin and Xu (2020). For encyclopedia, we used *Taiping Guangji* (太平廣記) and *Taiping Yulan* (太平御覽) 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 mainly concern 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 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 article: as long as they were perceived (by the literate public) as reports of real events, people's evaluation of the efficacy of various fetal sex prognostication methods would have been affected. As we argue later in the article, these reports played an instrumental role in corroborating and propagating ineffective practices to the extent that it influenced the readers' confidence in the efficacy of fetal sex prognostication. Note that the intended audience of these documents always has been members of the elite educated class; however, analyzing the methods of prognostications as well as their context does allow us to identify patterns and regularities, some of which may more generally apply to the wider population, as will be discussed later in the article.

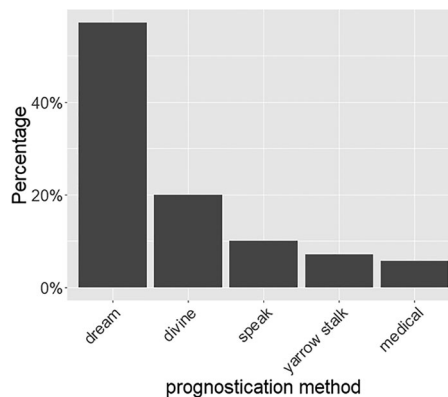
The quantitative data on the reported fetal sex prognostication instances were obtained by retrieving information in the abovementioned four types of texts through keyword searches. The historical description of such cases could be stylistically and semantically vague, and this required the creation of a dedicated semantic keyword dataset. In this article, the dataset includes the following keyword combinations to ensure maximum coverage in dynastic history, encyclopedia, and gazetteers: *nv* 女 (female) or *nan* 男 (male) and *yun* 孕 (pregnant); *nv* or *nan* and *bu* 蔔 (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). For oracle bone inscriptions, we used the keyword 女力 (give birth to a boy)<sup>18</sup> and looked for cases with explicit verification statements. Application of this keyword dataset allowed extraction of a total of 114 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 shows the relative percentage of predicted sex cases, broken down by accuracy and genre. Two patterns become immediately noticeable: first, with the exception of oracle bone inscriptions, boys are predicted more often than girls in the three other 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 the birth of a boy is often used as a rhetorical method for introducing another male actor, where the successful prediction of his being born male is to stress the predestination for his manly activities and/or demonstration of luck of his family.<sup>19</sup> The concept of predestination is supported by the fact that the most commonly used prognostication method is dream divination (excluding oracle bones; see Figure 3 for a full breakdown of prognostication methods), which could be considered, in the framework of Chinese culture of portents, as a legitimizing portent that conveys the will of Heaven (e.g., a concubine who dreamed of the Sun and later gave birth to an emperor; see Hong, 2022b). The fact that oracle bone inscriptions do not show such a pattern may be due to fact that these ancient fetal sex prognostication records are typically rather brief and are not narrative stories, as in the other genres, and as such need not privilege boys over girls as the predicted sex.

Second, we observe the overwhelming pattern that the vast majority of fetal sex prognostication cases, discovered by the application of the keyword dataset, were recorded as accurate.<sup>20</sup> As mentioned, this may be attributed to underreporting of predictive failures, as in the case of rainmaking (Hong, Slingerland, and Henrich, forthcoming), and/or fabrication of success stories, as in the case of dream divination (Hong, 2022b). 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 percent predictive accuracy as appears in transmitted texts means about 90 percent of the predictive failures are either not recorded or fabricated as successes.



**FIGURE 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 the prognosticator predicted both sexes; if one prediction fails, the entire episode is classified as “inaccurate.” [This figure appears in color in the online issue]



**FIGURE 3** Percentage of methods used for fetal sex prognostication discovered with the help of keyword dataset in all sources combined. Over 50 percent of the recorded fetal sex prediction instances involve the use of dreams, followed by general divination (bu 蔔 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 cosmological theory are used; finally, “yarrow stalk” refers to a very specific divination method (shi 筮) and accounts for less than 5 percent of the total cases.

Of course, oracle bone inscriptions, official dynastic histories, and encyclopedias (and to a lesser extent local gazetteers) all serve political purposes; historians in the past did not write or compile them in order for 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, and (2) fetal sex *can be* accurately predicted by the right people, with the right method, for the right individuals. 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 percent of the time), and people must have been aware of the possibility of lucky guesses.<sup>21</sup> A careful examination of these prognostication methods reveals that the prognosticator is sometimes portrayed as possessing extraordinary abilities, and the fact that they correctly foretell 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, *Book of the Later Han* records the following story:

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<sup>22</sup> 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.<sup>23</sup>

Here, the diviner correctly predicts not only that a boy will be born but also his life trajectory, and in particular, how he dies, highlighting the diviner's extraordinary predictive ability and 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" (無不如占), "no failed predictions using yarrow stalks" (筮無不中), and "all as he [the diviner] predicted" (皆如所言). 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 would seriously entertain the possibility of accurate fetal sex prognostication.

Although we cannot be fully certain about the veracity of recorded historical events, it is highly likely that such miraculous stories were made up to emphasize the idea of predestination, karma, the will of Heaven, or possibly to serve some other social, cultural, and political purposes. Correctly predicting the sex of a fetus and their 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 makes this comment immediately after pointing out the uncertainty involved in fetal sex prognostication using dreams:

The poets [diviners] tell the cases where their predictions are fulfilled and do not talk about the cases where their predictions failed.<sup>24</sup>

Similarly, the Song scholar Lü Zuqian (1137–1181 CE) makes a more general comment on the underreporting 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 rare. If divination cases were of deceptive nature or had failed predictions, they would not have been 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."<sup>25</sup>

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, then, is the extent to which people realize that failures are underreported 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, the validity of various divination and magic practices was generally unchallenged in traditional China, and the skeptics almost always question their theoretical plausibility rather than empirical inadequacies (Hong, Slingerland, and Henrich, *forthcoming*). There were indeed scholars who would point out the underreporting of failures, 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. Additionally, if people take underreporting into consideration and perform the necessary calculations when they update their belief, then stories of diviners who have correctly 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—and in particular, whether they treated them as factual cases or made-up stories. This issue is especially concerning for an encyclopedia like *Taiping Guangji*, as many of its stories are supernatural in nature by modern standards. There are good reasons,<sup>26</sup> however, to think that people at that time generally believed the contents of these texts to be true.

First, due to the lack of central, organized religious institutions, 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 some level of theoretical plausibility.

Second, the distinction between fiction and history came rather late in Chinese history<sup>27</sup> (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 suggested that fiction (xiaoshuo 小說) 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 authors who tried to convince their readers of the veracity of stories that involve ghosts and spirits (Wu, 2019).

Most of the editors of encyclopedia compilations, such as *Taiping Guangji* (originally published in 978 CE), served as historians and participated in the compilation 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.<sup>28</sup> Because its original intended audience was the emperor Taizong, books like *Taiping Guangji* were compiled with the intention of categorizing knowledge rather than making up stories (Yuan, 2020). Therefore, the vast majority of the stories recorded in *Taiping Guangji* have their original sources clearly indicated.

Therefore, given that people in traditional China read these stories and likely believed them to be true, these stories would 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.

## 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 (Burkert, 1985; Flad, 2008; Struck, 2016), fetal sex prognostication has an unmistakably instrumental component. In this article, we have offered a thorough examination of the fetal sex prognostication practices described in a large number of historical documents of premodern China and show that (1) people clearly understood that methods for predicting fetal sex do not work every single time, and (2) there are many more predictive successes recorded in transmitted texts that contribute to the overestimation 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 is that regardless of the exact causes of such biased reporting, a reader of these historical records would very likely 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).

As indicated already, the historical texts in our study only have been available to a segment of the educated Chinese elite. It is true that transmitted texts are different from other types of transmission (e.g., oral transmission), and textual records are largely absent in illiterate, small-scale societies, but there are reasons to suspect that the patterns identified may be more generally applicable. First, the reporting bias likely has some firm psychological basis. A considerable body of psychological studies shows that people have a tendency to search, recall, and interpret evidence that fits their preexisting beliefs (Johnson, 2018; Nickerson, 1998). Therefore, for people who already believe in the plausibility of fetal sex prognostication, it is natural to record predictive successes rather than failures. Second, there is evidence that such reporting biases exist in societies without writing. During our fieldwork with the Nuosu people<sup>29</sup> (small-scale agriculturalists in southwest China), it was discovered that local individuals are also much more likely to report predictive successes when asked to recall instances of fetal sex prognostication. The overall reported success rate is also roughly 90 percent, with dreams being the most frequently used method (Hong, forthcoming). 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 article to be valuable for both anthropologists who are interested in folk culture and historians whose research focuses more on the literati class. In fact, such reporting bias has been shown to exist even in contemporary societies: online reviews of medical products have fewer negative outcomes than we would expect based on data from the clinical trials of the same products, and such underreporting is sufficient to bias peoples’ decision-making (De Barra, 2017; De Barra, Eriksson, and Strimling, 2014).

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 contributes 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 (Hong, 2022a; Miton, Claidière, and Mercier, 2015) or culturally transmitted background beliefs (Hong, 2022b). For example, in ancient China, the yin-yang and the Five Phases principles were deeply ingrained into its culture (Zhou, 2020), so theories about fetal sex prognostication grounded in these established belief systems would appear more plausible.

The perceived authoritative status of certain prognostication methods also plays a role: the popularity of using the Chinese 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. Different fetal sex prognostication methods may also be evaluated simultaneously, resulting in a “multiple testing” problem (Hong, Slingerland, and 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 percent success record on predicting fetal sex (exactly same as chance) is “pretty good” or even “good” and “very good,” and they believe that a random guesser would achieve substantially less than 50 percent 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 it outperforms chance.

All of the above-mentioned 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 that 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 are 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 work will inspire more interdisciplinary effort in addressing classic anthropological questions from historical, cognitive, and cultural evolutionary perspectives.

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## DATA AVAILABILITY STATEMENT

All data associated with the study can be found at [https://github.com/kevintoy/fetal\\_sex\\_prediction](https://github.com/kevintoy/fetal_sex_prediction)

## ORCID

Ze Hong  <https://orcid.org/0000-0002-5343-3008>

## ENDNOTES

- <sup>1</sup> Throughout this article, “gender” and “sex” will be used interchangeably, where the term “gender” is used in more traditional contexts of “born sex.”
- <sup>2</sup> Of course, there are rare instances where the sex of the newborn cannot be immediately determined, and there is substantial cultural variation regarding how these individuals are treated. Ancient Greeks, for example, perceived the hermaphrodite as “the perfect balance between male and female” (DeVun, 2018), but these individuals may also be viewed as abnormal and thus persecuted (Foucault, 2003). Sometimes the sexually ambiguous individuals were assigned a gender at birth due to pragmatic concerns (e.g., inheritance) (Gesink, 2018). In the case of traditional China, more emphasis has been placed on the transformation of sex (i.e., turning from male to female or vice versa) at some point of an individual’s life course. Such transformation stories were largely treated as curious or strange incidents, but sometimes also as omens of dynastic change (Milburn, 2014). To our knowledge, there was no definitive category for intersex individuals in Chinese culture.
- <sup>3</sup> 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 or 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).
- <sup>4</sup> Note that this method is mentioned in the traditional medical context.
- <sup>5</sup> 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.
- <sup>6</sup> Some of the positive finding yield contradictory results; for example, Zare and 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.
- <sup>7</sup> Here “efficacy” refers to the probability that a technological action being followed by the putative outcome. Throughout this article, “efficacy” takes this specific definition and is therefore a real number between 0 and 1 (inclusive).
- <sup>8</sup> Here, we take “report” to mean the general process where individuals reveal information in some medium that is taken up by other individuals.
- <sup>9</sup> In traditional China, a great deal of effort was devoted to manipulating the sex of the baby (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.
- <sup>10</sup> See Xue Guyu (2004, 73)
- <sup>11</sup> See Wang Huazhen (1982), Zhang Yaosun (1990), and Lu Yitian (1990). Interestingly, in some of the texts the original method of checking the husband’s breast was mistransmitted as checking the pregnant woman’s breast (Wang Huazhen, 1982).
- <sup>12</sup> In mainland China, it is currently illegal to use ultrasonography to identify fetal sex due to selective abortion of girls.
- <sup>13</sup> Xiong Bolong (1979, quoted by Liu Wenying, Cao Tianyu, 2003, 333).
- <sup>14</sup> The *Shijing*, section *Xiaoya*, *ode Si Gan* (189)  
... 夫人占之。  
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, [1871] 1960, 303).

<sup>15</sup> See Han and Zhu (1759).

<sup>16</sup> See Shen and Yan (1988, 40).

<sup>17</sup> See Zhāng Zhènyún (1990, 56).

<sup>18</sup> There is no equivalent character for “to give birth to a girl” in the oracle bones. To indicate the birth of a girl, a simple negation (“not to give birth to a boy” 不女力) is typically used.

<sup>19</sup> 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).

<sup>20</sup> Readers may notice that there appears to be some inaccurate predictions when the predicted sex is female, especially in the encyclopedia. This is due to the particular way that we coded the text regarding the use of dreams as omens for fetal sex: in encyclopedia there were two instances where the royal mother dreamed of moons and gave birth to sons (who later became emperors), and we coded these as “inaccurate” because moons are generally associated with the birth of royal females. However, the original authors of the two stories apparently treated such dream omens as predictively significant despite the mis-association.

<sup>21</sup> In traditional Chinese, this type of “success by chance” is referred to as ouhe 偶合 (coincidence).

<sup>22</sup> An item representing the official status in Chinese bureaucracy.

<sup>23</sup> See Hou Han shu, 1965, vol. 8, ch. 65, 皇甫張段列傳 (Huángfū zhāng duàn lièzhuàn), 2144).

<sup>24</sup> See Liu et al. (2019) and Cao (2000).

<sup>25</sup> See (Lǚ Zúqiān, 東萊左氏博議 (Donglai zuoshi boyi), ch.8, 181).

<sup>26</sup> A full exposition of the psychological, social, and cultural factors for people’s credulity is beyond the scope of the present paper. Interested readers may find additional references in Hong (2022) and Hong and Henrich (2021).

<sup>27</sup> Interestingly, the lack of distinction between fiction and history has also been suggested for Western literature (Ashe, 2015; Mortensen and Agapitos, 2012). Interested readers may also check Veyne (1988) for a similar discussion on ancient Greek myths.

<sup>28</sup> See Yuan and Yuan (1937).

<sup>29</sup> 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.

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