The Psychology and Social Dynamics of Fetal Sex Prognostication in China: Evidence from Historical Data

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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 paper, 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 over-estimation 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 detailed a historical analysis showing that individuals often entertain considerable uncertainty regarding the accuracy of sex prognostication, and quantitative data demonstrating a significant bias towards 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.

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。

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 1983). 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[1] 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[2]. 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, 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[3] 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[4] (Dawson 1929); 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[5] (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 a baby (Popov 1946; Naik 1956).

Though fetal sex prognostication likely occurs due to social demand, that 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 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 think that it has no chance of correctly predicting the sex of the fetus. This leads to an obvious question: are pre-modern 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 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; Zare and Sekhavat 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[6]. However, the effect sizes of these studies are extremely small: 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% 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); 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[7] 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 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 (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 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, and Henrich, forthcoming; Hong 2022). 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 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 it to "work" 100% of the time, and 2) people would under-report[8] predictive failures and/or fabricate success stories., In this paper, 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 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 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 methods in China. As such, Chinese historical records serve as 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 evidence 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 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.

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, and in a famous case 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, which 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 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[9] (轉女為男) or in the extreme case, abortion).

Among there many methods of fetal sex prognostication there 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 cravings [10], swelling of the *husband*'s breast (either left or right) *husband* (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 pre-modern readers (Hong and Henrich 2021). The seemingly implausible method of telling the sex of fetus by the condition of the husband's breasts, for example, has been repeatedly recorded in later medical texts[11] 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 (清宮圖), 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 Trend) 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* (風水) 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[12] 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; Katz and Wylie 2009).

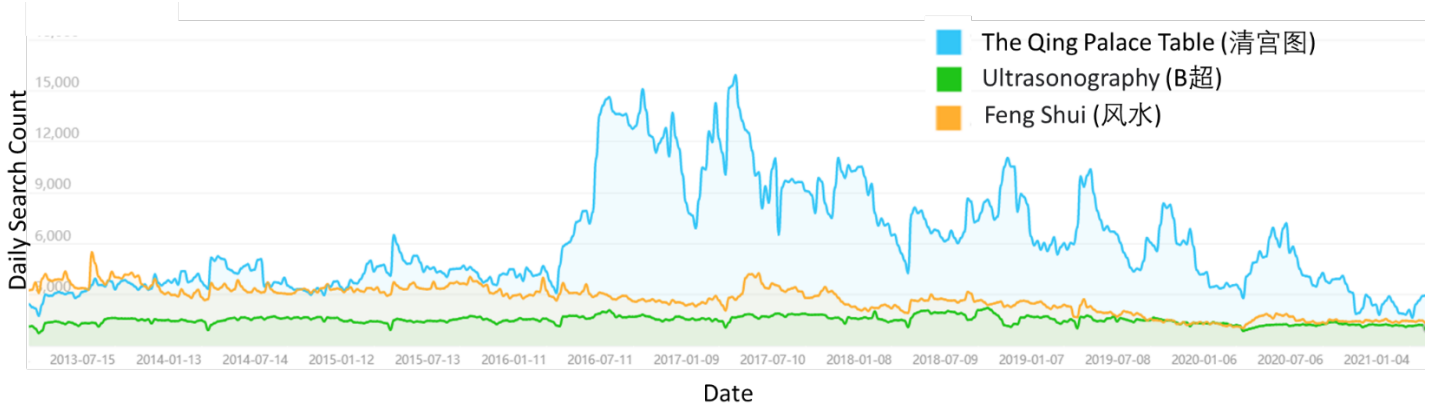

Figure 1. The daily count of internet search queries for "The Qing Palace Table", "Ultrasonography", and "Feng Shui" from 2013 to 2021.

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 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 prediction of 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.[13]

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 BCE)[14]. 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 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 Xianning county (Qianlong Period)[15]

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 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…[16]

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); 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 (最為應驗) when you write the characters mindlessly (i.e. not consciously thinking/worrying about the parity of numbers). [17]

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, 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 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 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 & 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 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 the 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. Note that the intended audience of these documents always has been the elite educated class members; 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 paper.

The quantitative data on the reported fetal sex prognostication instances were obtained by retrieving information in the above-mentioned 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 include 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[18]) 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 rhetoric 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[19]. 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 which 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 in the way as in the other genres, and as such need not privilege boys over girls as the predicted sex.

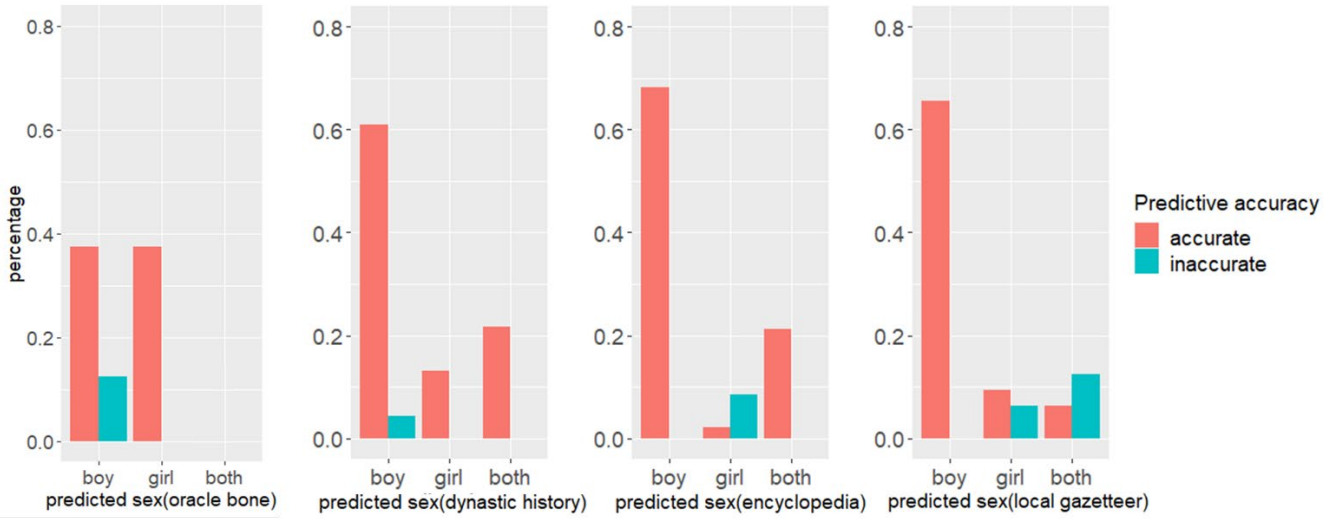

Figure 2. Percentage of predicted sex broken down by accuracy and genre. N=16, 23, 47, and 32 for oracle bone inscriptions, dynastic history, encyclopedia and local gazetteers respectively. The x-axis denotes the predicted gender. "Both" means that

there were multiple births and the prognosticator predicted both sexes; if one prediction fails, the entire episode is classified as "inaccurate".

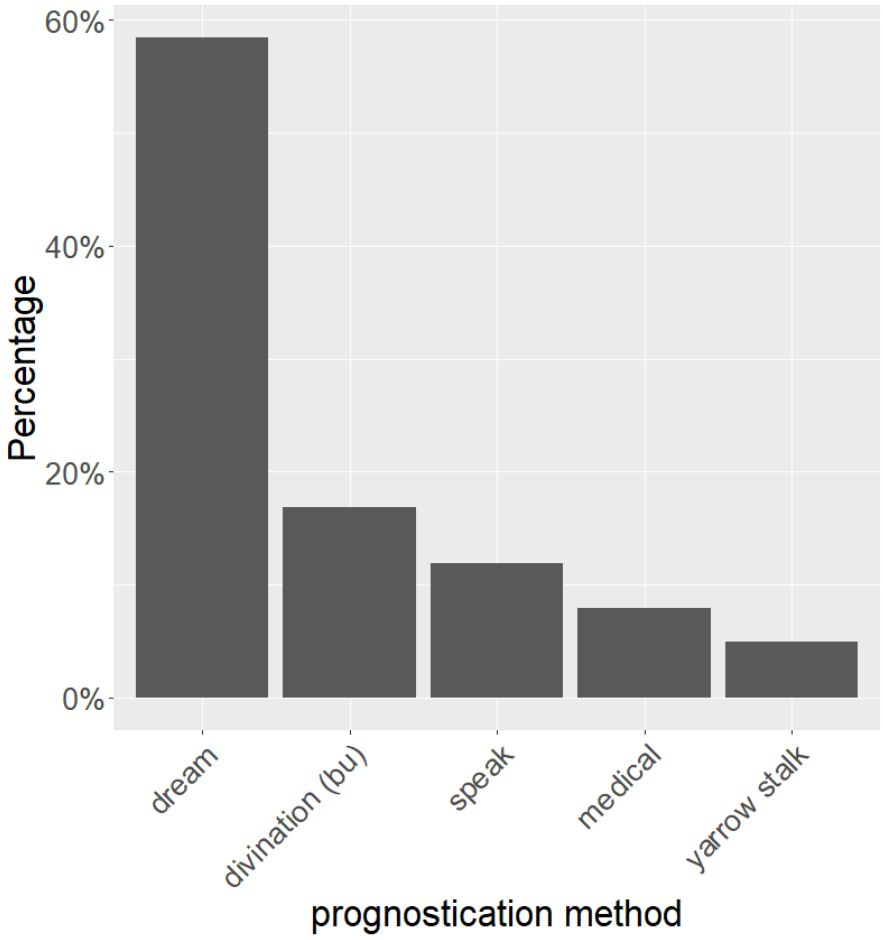

Figure 3. Percentage of methods used for fetal sex prognostication discovered with the help of keyword dataset in all sources combined (excluding oracle bone inscriptions). Over 50% of the recorded fetal sex prediction instances involve the use of dreams, followed by general divination (bu) 蔔 where the 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% of the total cases.

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[20]. As mentioned, this may be attributed to under-reporting 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% predictive accuracy as appears in transmitted texts means about 90% of the predictive failures are either not recorded or fabricated as successes.

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.

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% of the time), and people must have been aware of the possibility of lucky guesses[21]. 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, *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[22] 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.[23]

Here, the diviner not only correctly predicts that a boy will be born but also his life trajectory, and in particular, how he dies, highlighting the diviner's extra-ordinary 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 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 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.[24]

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 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.[25]

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 the skeptics almost always questions 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 under-reporting 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: 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[26], however, to think that people at that time generally believed the contents of these texts to be true.

First, due to the lack of a 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[27] (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 the 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.[28] 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, 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.

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 has an unmistakably instrumental component. In this paper, we have offered a thorough examination of the fetal sex prognostication practices described in a large number of historical documents of pre-modern 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 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 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 pre-existing beliefs (Nickerson 1998; Johnson 2017). Therefore, for people who already believe in the plausibility of fetal sex prognostication, it is very natural to record predictive successes rather than failures. Second, there is evidence that such reporting biases exist in societies without writing. During our fieldwork the Nuosu people[29] (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%, with dreams being the most frequent 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 paper

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, Eriksson, and Strimling 2014; de Barra 2017).

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; Hong 2022a) 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 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. 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% 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.

Data Availability

All data associated with the study can be found at
https://github.com/kevintoy/fetal_sex_prediction

Notes

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[1] Throughout this paper "gender" and "sex" will be used interchangeably, where the term "gender" is used in more traditional context of "born sex".

[2] 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 be 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.

[3] 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).

[4] Note that this method is mentioned in the traditional medical context.

[5] 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.

[6] 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.

[7] 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).

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

[9] 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.

[10] See (Xue Guyu, 2004, p. 73)

[11] See (Wang Huazhen, 1982) (Zhang Yaosun, 1990), (Lu Yitian, 1990). 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 (Wang Huazhen, 1982).

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

[13] Xiong Bolong, 1979, quot. By Liu Wenyin, Cao Tianyu, 2003, p.333.
[14] 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, 1960) P.303.

[15] See (Han, 1759, ch. 28. p.13)

[16] See (Shen, Yan, 1988, p.40)
[17] See (Zh ā ng Zhènyún, 1990, p.56)

[18] 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.
[19] 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).
[20] 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.
[21] In traditional Chinese, this type of "success by chance" is referred to as ouhe 偶合(coincidence).
[22] An item representing the official status in Chinese bureaucracy.
[23] See (Hou Han shu, 1965, vol. 8, ch. 65, 皇甫張段列傳 (Huángf ǔ zh ā ng duàn lièzhuàn), p.2144).
[24] (Liu, Cao, ibid)
[25] See (L ǚ Z ǔ qi ā n, 東萊左氏博議 (Donglai zuoshi boyi), ch.8, p.181)
[26] 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 & Henrich (2021).
[27] Interestingly, the lack of distinction between fiction and history has also been suggested for western literature (Mortensen and Agapitos 2012; Ashe 2015). Interested readers may also check Veyne (1988) for a similar discussion on ancient Greek myths.
[28] See *(Jiong Yuan; Yi Yuan , 1937).*
[29] 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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Figure Captions

*Figure **Error! Main Document Only.**. 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.*

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".

Figure 3. Percentage of methods used for fetal sex prognostication discovered with the help of keyword dataset in all sources combined. Over 50% 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% of the total cases.