

Barcelona 2020–2021

Suhayl

International Journal
for the History of the Exact
and Natural Sciences
in Islamic Civilisation



Volume **I8**



UNIVERSITAT DE
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Edicions



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International Journal for the History of the Exact
and Natural Sciences in Islamic Civilisation

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The earliest Arabic magic squares

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ABSTRACT: My aim here is to shed light on the origins of magic squares in the Islamic world. This question has often been tentatively addressed, but previous studies considered only part of the evidence. The earliest Arabic texts discussing squares (al-Ṭabarī, Jābir ibn Ḥayyān, *Ghāyat al-Ḥakīm*, Brethren of Purity) are examined here together for the first time, as well as the Indian medical sources.

KEYWORDS: Magic squares, transmission, Indian medicine, al-Ṭabarī, Jābir ibn Ḥayyān, *Ghāyat al-Ḥakīm*, Brethren of Purity, *Cyranides*

STATE OF THE ART

It is well known that magic squares enjoyed considerable success in the Islamic world as a mathematical subgenre of arithmetic, although they do not seem to have been part of the standard Arabic mathematical synthesis.¹ Insights into where mathematicians placed squares theory can be gained from inspecting the context of their first surviving testimony in Arabic mathematical texts, namely the *Commentary to Nicomachus' Arithmetic* by *al-Anṭākī*, recently edited and translated by J. Sesiano.² The surviving text consists of a third book written as a sort of appendix to the two (non-extant) previous books which probably formed the com-

1. J. HØYRUP, *In Measure, Number, and Weight. Studies in Mathematics and Culture*, New York 1994, at 119.

2. J. SESIANO, *Magic Squares in the Tenth Century. Two Arabic Treatises by Anṭākī and Bāzjānī*, New York 2017. Sesiano rightly argues that the inclusion of magic squares in this commentary does not imply any awareness on the part of Islamic authors that Greek mathematicians had knowledge of them, and I remain unconvinced by Vinel's arguments. Cf. Sesiano, *Magic Squares* 16; N. Vinel,

mentary on the two books of Nicomachus. This third book contains three chapters, on Euclidean definitions on number theory, magic squares, and hidden numbers. The last topic was a kind of challenge that was played out in pairs; one person thinks of a number on which he is required to perform some intricate operations, and then reveals the result to the other person, who has to guess the number as quickly as possible. The concomitance with the chapter on magic squares might then suggest that the latter were conceptualized as a similar optional complement to arithmetic — perhaps, too, for recreation, which is their main use today in the West. In India, however, there is a medical tradition of magic squares, deriving from old practices contemporary with the earliest uses of squares in the Islamic world. The magic square of three in the medical encyclopedia of al-Ṭabarī (*Firdaws al-Ḥikma*) predates the earliest known mathematical texts on squares (al-Anṭākī, al-Būzjānī, end of 10th c.) by a century and a half; although the latter obviously presuppose a considerable previous acquaintance with squares, the fact that the text of al-Ṭabarī is so close in time, place, and content to Indian texts using squares is practically conclusive proof that it is the origin of magic squares in the Islamic world. A. Roşu already pointed out this coincidence between the Indian testimonies and al-Ṭabarī, but he was undecided as to the direction of the transmission, and did not look at al-Ṭabarī's text.³

The context of the earliest Arabic magic squares has been interpreted in different ways, but previous studies have considered only part of the evidence. Sesiano, for example, maintains that magic squares arrived from India in the 7th c. along with chess, arguing that the first mathematical treatises on squares use chess vocabulary to describe the displacements of the numbers on the grid; he rules out an early magical use.⁴ However, it is entirely conceivable that mathematicians, equipped with chess vocabulary, would have described methods of constructing this new artifact using these terms if they were found to be useful. Sesiano does not seem to consider earlier medical use; perhaps misled by the tradition of the mathematical genre (operative since Greek Antiquity) of suppressing any extra-mathematical comments, he may have deduced from the mathematicians' silence that they were ignorant of medico-magical use. But he may also have confused

«Un carré magique pythagoricien? Jamblique précurseur des témoins arabo-byzantins», *Arch. Hist. Exact. Sci.* 59 (2005), 545-562.

3. A. Roşu, «Études āyurvédiques III. Les carrés magiques dans la médecine indienne», in G. J. Meulenbeld and D. Wujastyk (eds.), *Studies on Indian Medical History*, Groningen 1987, 103-112.

4. SESIANO, *Magic Squares* 6.

magic with astrology. As we will see, astrology did not enter the squares tradition until later, but magical medicine was present from the very first moment. For his part, probably unaware of the Indian evidence, J. Needham proposed a direct transmission from China.⁵ The Indian evidence emerged only a few years later, when Indologists Roşu and T. Hayashi brought to light the earliest known Indian squares.⁶

Hayashi described the use of a modified magic square of four in a treatise by Varāhamihira (6th c.), for the determination of the quantities of the sixteen ingredients of a perfume. Two series of numbers 1 to 8 were used, instead of the sixteen first numbers, probably so that the differences between the quantities of the ingredients would not be exaggerated. Varāhamihira seems to assume that his readership is familiar with these squares, since he does not present the square formally, just naming it *kacchapuṭa*. This term, originally denoting «carapace of a turtle», reveals a clear Chinese origin, since Chinese sources traditionally traced the magic square of three back to a first such square inscribed on the carapace of a turtle.⁷ It is striking that Varāhamihira, along with the medical authors who used the square from the 10th c. onwards, only used modified magic squares adapted to their cultural needs, and to perform functions similar to native artifacts such as *yantras* and *mandalas*. Indeed, the first attested medical magic square displays the even numbers 2 to 18, rather than the natural 1 to 9. There is a reason for this: namely, in this configuration they could use the number 16. 16 appears in the first position in the Indian sense of the script, and is referred to by a marked term;⁸ in view of the prestige of this number in Hindu numerological culture, this cannot be a coincidence.⁹ We know that other diagrams had been used for the same function in earlier medical literature,¹⁰ and that in the same treatise Varāhamihira prescribes traditional *yantras* (meditation images) to define proportions for the construction of temples, implying that, by the time of the earliest known Indian attestations, magic squares seem to have been fully adapted to Indian culture. It is therefore

5. J. NEEDHAM, *Theoretical Influences of China in Arabic Alchemy*, Coimbra 1980.

6. ROŞU, «Études āyurvédiques»; T. Hayashi, «Varāhamihira's pandiagonal square of the order four», *Historia Mathematica* 14 (1987), 159-166.

7. HAYASHI, «Varāhamihira's pandiagonal square» 161.

8. ROŞU, «Études āyurvédiques» 97.

9. D. G. WHITE, *The Alchemical Body. Siddha Traditions in Medieval India*, Chicago/London 1996, 36-44.

10. A. ROŞU, «Mantra and yantra in Indian medicine and alchemy», *Ancient Science of Life* 8.1 (1988), 20-24.

likely that magic squares had been known for a very long time, even if they had not been widely used. They probably reached India together with other Taoist imports between the fourth and the sixth centuries C.E., a period of massive cultural exchange with China.¹¹

It would be wrong not to mention S. Cammann, who, long before the evidence from the earliest Indian attestations was found, had already proposed that India was an intermediary for the transmission of the squares from China to the Islamic world.¹² Interestingly, he supported his claim by arguing that the square of three in the epistle on geometry of the Brethren of Purity derived from applying a well-known Chinese construction method to a natural square filled with numbers 1 to 9 in the natural order and in the Indian sense of the script. In fact, even if we just look at the squares that appear in all principal manuscripts (of order 3, 4 and 5),¹³ they do not seem to be taken from a mathematical treatise. Close inspection of those of order 4 and 5 reveals that they are both obtained from the respective natural squares through displacements (the most primitive method), but that the original natural squares were filled beginning from different angles. It seems, then, that the Brethren had basic knowledge of how to construct squares, and that they wrote their examples *ad-hoc* and did not copy them from a systematic work.¹⁴ In fact, some of the larger squares are built using try-and-failure¹⁵ rather than with the general methods developed in the mathematical treatises.¹⁶ In

11. WHITE, *The Alchemical body* 62.

12. S. CAMMANN, «Islamic and Indian magic squares. Part I», *History of Religions* 8.3 (1969), 181-209, at 190-191.

13. See the new edition by N. EL-BIZRI, *Epistles of the Brethren of Purity. On Arithmetic and Geometry. An Arabic Critical Edition and English Translation of Epistles 1 & 2*, Oxford 2012, ١٤٠-١٤٢ / 156-158.

14. HAYASHI, «Varāhamihira's pandiagonal square» 164 posited a transmission link between the square in Varāhamihira and Islamic magic squares, because the original magic square from which Varāhamihira's was modified was probably the same as the most pervasive Arabic magic square of four, which is the one that appears in the Brethren. However, they were more probably independent developments, since the method is primitive and natural (see, e.g., the explanation of the method in al-Būzjānī).

15. CAMMANN, «Islamic» 191-194.

16. There is a second square of three in the epistle of the Brethren, written in *abjad* numerals and displaying a different position. However, since it is not referred to in the text (unlike the other squares) and because it would merely repeat the square already pictured, I take it to be a later addition illustrating the text. Cf. EL-BIZRI, *On Arithmetic and Geometry* ١٤٣ / 159. CAMMANN, «Islamic

any case, the appearance of the square of three in the Brethren's epistle cannot be taken as evidence of its origins, because they probably did not copy it from any text. Instead, we should look at the square of this order in Jābir ibn Ḥayyān and al-Ṭabarī, which both display the same disposition of numbers.¹⁷ Coincidentally, it turns out that it can be obtained in the way suggested by Cammann:

$$\begin{array}{ccccccc}
& & & & & \Downarrow & \\
& & & & & \mathbf{9} & \\
& & \curvearrowright & & \mathbf{1} & & \\
1 & 2 & 3 & & 4 & 2 & \\
4 & 5 & 6 & & \underline{7} & 5 & \underline{3} \\
7 & 8 & 9 & & 8 & 6 & \\
& & & & \mathbf{9} & & \\
& & & & & \mathbf{1} & \\
& & & & & \Uparrow &
\end{array}
\quad
\begin{array}{ccccccc}
& & & & & \Downarrow & \\
& & & & & \mathbf{9} & \\
& & \curvearrowright & & \mathbf{1} & & \\
1 & 2 & 3 & & 4 & 2 & \\
4 & 5 & 6 & & \underline{7} & 5 & \underline{3} \\
7 & 8 & 9 & & 8 & 6 & \\
& & & & \mathbf{9} & & \\
& & & & & \mathbf{1} & \\
& & & & & \Uparrow &
\end{array}$$

THE ADAPTATION OF INDIAN MEDICAL SQUARES IN AL-TABARĪ

Thanks to the work of Roṣu we know that magic squares were prescribed for easing labor by a series of medical authors from ca. 900 C.E. onwards.¹⁸ The first of these physicians, Vṛnda, describes a ritual including the contemplation of the doubled square of three (with the number 16 in the first cell) among other treatments for easing delivery, such as drinking herbal preparations or the application of herbal pastes or roots to different parts of the body including the vagina. In particular, according to him the woman must look at the square while she drinks water previously incantated by the recitation of a mantra from the classical physician Sūśruta. Later authors quoted this treatment with slight variations, such as Cakrapāṇi in the mid-11th c. C.E., who added the standard magic square of three (without doubling). Cakrapāṇi's 15th c. commentator Śivadāśasena states that after Vṛnda they all prescribed this ritual, in which the magic squares were drafted on a consecrated vase.¹⁹

and Indian magic squares» 190 indicates that the square in Jābir was written in abjad numerals, but this is obviously a mistake; he was probably thinking of the abjad square in the Brethren.

17. There is only one possible configuration of the square of three but, counting rotations and symmetries, it can offer eight different appearances.

18. ROȘU, «Études āyurvédiques» 96.

19. ROȘU, «Études āyurvédiques» 98.

The points of contact with al-Ṭabarī are numerous and strikingly accurate. First of all, it must be borne in mind that this Persian physician undertook a synthesis of Syriac, Greek, Persian and Indian materials in his *Firdaws al-Ḥikma*, quoting from the classical Ayurvedic physicians as well as from unidentified Indian authors. Arabic translations of Indian medical texts were readily available in his time, mainly coming from Gundishapur in southern Persia, an important medical hub for both Christian Nestorian and Indian physicians.²⁰ In his chapter on easing labor, al-Ṭabarī introduces the square ritual as something magical (*šay'un 'ajībun*) ascribing the prescription to his father Sahl Rabbān.²¹

تأخذ خزفتين من كوز او جرة جديدة لم يصبها الماء وتصور عليها شكلاً مثل هذا وتكتب فيها حساباً
كيف ما حسبت طولاً وعرضاً او من زاوية الى زاوية كان خمسة عشر وتكتب حولها آيتين من الزبور
وتؤتي بهما المرأة حتى تنظر الى ما فيهما من الكتابة نعماً ثم تضعهما تحت قدميها

You take two pieces of ceramics, from a new jug or jar in which no water has been poured, and draw upon them a figure like this, using numbers so that they add up to fifteen horizontally or vertically or from corner to corner. Write two lines [of the psalms] of David surrounding the figure, and bring them to the woman, so that she can see the writing on them well. Then place them under her feet.

Together with this, al-Ṭabarī proposes making a paste from the mud from a nest of swallows (*min 'uši al-khaṭāṭifi*) and rubbing with it the pubic hair and the waist, as well as placing a coriander root in the vagina. He then proceeds to give the numbers for the square and the Arabic translation of the verses of the Psalms, which are written in Syriac around the figure in the manuscripts:

هو بالسريانية وتفسيرها اخرج نفسي من المحبس لأشكر اسمك وليؤملني ايرادك اذا انت كافي

20. See e.g. *Encyclopaedia Iranica* IV,3, s.v. *Boḡtišū* (L. Richter-Bernburg); H. D. ISAACS, «Arabic medical literature», in M. J. L. YOUNG, J. D. LATHAM, and R. G. SERJEANT, *Religion, Learning and Science in the 'Abbasid Period*, Cambridge 1990, 342-363, at 343-345.

21. Text in M. Z. SIDDIQI, *Firdausu'l Hikmat or Paradise of Wisdom*, Berlin 1928, p. 280. The whole chapter is translated into German in A. SIGGEL, «Gynäkologie, Embryologie und Frauenhygiene aus dem "Paradies der Weisheit über die Medizin"», *Quellen und Studien zur Geschichte der Naturwissenschaften und der Medizin* 8 (1941/42), 216-272.

They are in Syriac and their meaning is this: «Let my soul go out of the prison, so I can thank your name. May your will give me hope, as you have rewarded me».²²

Elements that are also found in the Indian ritual are the ceramic support of the square (here apparently two *ostraka*) and the need to look at it, the making of a paste to be rubbed on the pubic region, and the placing of a root of a plant in the vagina,²³ all of which appear close to one another in the Indian texts. Crucially, al-Ṭabarī also prescribes drinking incantated water in the same chapter:

تأخذ حاشية ثوبٍ جديدٍ فتكتب عليها انفتح باب السماء فخرج منه سبعة من الملائكة بأيديهم
قضبان من نار بالله لا ذهبتم الى فلانة بيت فلانة حتى تخرجوا ما في بطنها حياً كان او ميتاً [...] ثم
تأخذ ماءً عذباً وتجعله في جام وتغمس الخرقه فيه وتعصره وتسقيه تلك المرأة

You take the rim of a new dress and write upon it: «The door of heaven was opened. Therefrom came seven angels holding torches. By the Lord, you have not yet visited so-and-so in the house of so-and-so, in order that she gives birth to what she has in her belly, be it alive or dead [...]». Then you take fresh water, pour it in a cup and plunge the shred in there; wring it out and have the woman drink it.

Both this passage and the verses written around the magic square are remarkably similar to the mantra from Suśruta from the Indian ritual, where it is likewise prayed that divine entities should visit the house of the woman, and where the child is explicitly portrayed as imprisoned in the womb.²⁴ In my opinion, this is sufficient proof that both prescriptions in al-Ṭabarī — that of the square with paste and root, and the water-drinking ritual — were imported and adapted from contemporary Indian medical practice, probably from a written source. The Biblical verses might suggest that the adaptor was a Christian Nestorian author, perhaps al-Ṭabarī's father himself.

22. Corresponding to *Psalms* 142 line 8. Cf. SIGGEL «Gynäkologie» 254 n. 3.

23. The plant in Cakrapāṇi is pāthā. The plants do not coincide, but this seems natural as most of them are endemic to the Indian subcontinent in Ayurvedic texts.

24. The *mantra* is transcribed in P. V. SHARMA, *Chakradatta. Text with English Translation*, Delhi 1994. Cf. translation and comments of J. FILLIOZAT, *Études de démonologie indienne*, Paris 1937, at 31-34.

But let us now examine the differences. In the rituals in al-Ṭabarī, words do not act at a distance as they do in the Indian ritual, but by direct contact with the Biblical text, either together with the square and passed through the feet, or dissolved in water wrung from a cloth and directly entering the body through drinking.

Secondly, al-Ṭabarī prescribes that the pieces of ceramic be placed under the feet. The condition that they come from a new vase — in which no water has been poured²⁵ — can perhaps be considered as equivalent to the Indian consecration ritual which, according to the commentator Śivadāsaśena, needs to be performed on the drinking vase. The dress from which the rim is taken should also be new. The reason why the contact should be made under the feet is more difficult to fathom. Pastes are only rarely applied to the feet in Indian texts, and never specifically on the soles. One possibility would be that al-Ṭabarī was alluding to the *ḥadīth* about a would-be-warrior asking for advice to the Prophet, who responds that he should stay with his mother, «for paradise is beneath her feet» (*al-janna taḥta riḥlayhā*).²⁶ Since this piece of oral tradition was already recorded by al-Nasāʾī in the 9th c. C.E., this does not seem a far-fetched hypothesis, considering that al-Ṭabarī completed his work around 850 C.E. and that he used not only Biblical texts in his remedies, but also lines from the Qurʾān.²⁷ However, as far as I know, elements from the Bible and the Qurʾān in other magical remedies prescribed in the *Firdaws* are incorporated directly in the prescriptions as some form of written text, and so this would be the only case of its kind.

We will see below that the other attestations of the square of three show a great affinity with the so-called *Cyranides*, an originally Greek medico-magical manual. As it turns out, the *Cyranides* recommends the laboring woman to hold a feather of a swallow and a root of basil for an easy delivery (I 24), quite similar to al-Ṭabarī's paste (from the same bird!) and root. Elsewhere in the text, it is said that an eagle's feather must be placed under the feet of a woman suffering from a difficult labor in order to achieve a quick delivery.²⁸ Familiarity with this text is

25. Siddiqi's edition does not contain this phrase, which appears at least in MS BL Arundel Or 41 f. 135r, and which I have printed in the text above. He may have considered it to be a gloss.

26. NASĀʾĪ, *Jihad* 6.

27. Surah 18, line 25 is to be written on a piece of paper by a woman who feels that she is about to have a miscarriage. Cf. SIGGEL, «Gynäkologie» 258 n. 1.

28. *Cyranides* 3.1: ἀετοῦ δὲ πτερόν ἑάν τις ὑπὸ τοὺς πόδας θήσῃ δυστοκούσῃ γυναικί, πάραυτα τέξεται.

much more probably the reason why al-Ṭabarī places the two *ostraka* under the woman's feet.

I will now devote a few lines to what we know about Sahl Rabbān al-Ṭabarī, the father of the author of the *Firdaws* and prescriber of the square-ritual. In his biographical encyclopedia Al-Qifṭī describes him as a Jew, which has been interpreted as a misunderstanding of his name Rabbān, which in fact means «senior teacher and leader», as recounted by his son in the medical encyclopedia.²⁹ Interestingly for our purposes, al-Qifṭī also says that Rabbān was an astronomer or astrologer (the same word in Arabic, *munajjim*), a physician experienced in geometry and all branches of mathematics (*ṭabībān ʿālimān bi l-handasati waʿanwāʾi al-riyāḍati*), and a translator of scientific texts (*ḥalla kutubān ḥikmiyyatan min lughatin ʿilā lughatin*). It is doubtful, however, that his mathematical interests led him to develop methods for constructing magic squares of higher order, given the late date of the first known mathematical treatises (end of 10th c. C.E.).

Sahl Rabbān is sometimes cited as being the first translator of Ptolemy's *Almagest*,³⁰ though this attribution relies on al-Qifṭī's account, which is also probably mistaken here. Al-Qifṭī³¹ explains that the astrologer Abū Maʿšar could only find «the place where the rays are cast» (*maṭrāḥu al-šwʿāʾi*) in al-Ṭabarī's translation of Ptolemy's *Almagest*. However, no casting of rays is discussed in the *Almagest*. This is a standard astrological theory, according to which planets cast rays influencing certain parts of the zodiac through aspect or vicinity. Ptolemy briefly discusses ray-casting in the *Tetrabiblos* (I 24), but does not specify the arcs around the planets (the orbs) affected by rays, what Abū Maʿšar was looking for. The translator al-Ṭabarī could have provided the customary orbs himself as a gloss. If this is the work Abū Maʿšar was referring to, then al-Ṭabarī should instead be counted among the first translators of the *Tetrabiblos*; this in fact makes more sense considering the difficulties entailed in the translation of the *Almagest* and Rabbān's early date. Actually, al-Qifṭī describes the versions that did not contain that doctrine as «old» (*qadīma*), seemingly implying that there were many previous translations.

29. S. K. HAMARNEH, *Health Sciences in Early Islam II*, Texas 1983, 353-358.

30. O. PEDERSEN, *A Survey of the Almagest*, New York 2010, 16; H. Suter, *Die Mathematiker und Astronomen der Araber*, Leipzig 1900, 14.

31. Text in J. LIPPERT, *Ibn al-Qifṭī's Ta'rīḥ al-ḥukamā'*, Leipzig 1903, 187.