Square Kufic Tessellations

تبليطات الكوفي التربيعي المتطابقة

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ملخص

تتناول هذه المقالة التبليطات التي تتم كتابة الكلمات فيها بالخط الكوفي التربيعي بطريقة تجعل المساحة أو الخلفية بين الحروف تُقرأ أيضًا ككلمات نص. أحد الأمثلة الأكثر شيوعًا لهذا النوع من التصميم هو نموذج 'محمد/ علي' المربع؛ حيث تتم كتابة الاسم 'علي' في الفراغ بين حروف الاسم 'محمد'، ويتشابك الاسمان لتشكيل تصميم واحد متماسك بتكرارهما أربع مرات دورانيًا. في تصميم الـ 'ستة عليات' يتم استخدام كلمة 'علي' نفسها للنص وخلفيته بشكل متطابق، ومن هنا استخدمتُ اسم التبليطات المتطابقة لهذا النوع من التصميم.

لقد اقتُرح في أحد الأبحاث المنشورة أن كلمة 'علي' في تصميم الـ 'ستة عليات' الموجود على واجهة مبنى إسلامي من أوائل القرن الثالث عشر في الهند هي الكلمة الوحيدة التي يمكن تبليطها أو تكرارها بشكل مسدس؛ بحيث يكون النص وخلفيته متماثلين ومتطابقين. أناقش هذا الافتراض في مقالي هذا وأبين أن تبليطة 'علي' المتطابقة يمكن أن تتم في أشكال هندسية متعددة، وكذلك يمكن عمل مثل هذه التصميمات بكلمات أخرى مثل 'محمد'، و'الله'، وكذلك باستخدام جملة مثل 'لا إله إلا الله' و 'ولا غالب إلا الله'.

يظهر لنا من خلال توثيق تطور هذا النوع من التصميمات أن الخط الكوفي التربيعي تمتع بشعبية قوية بين القرنين الثالث عشر والخامس عشر، ثم تضاءل استخدامه في القرون التالية. تعد التبليطات المتطابقة من أصعب أنواع تصميمات الكوفي التربيعي وأكثرها جمالاً وإثارة للاهتمام.

Introduction

Tessellated designs constitute an intriguing type of Square Kufic calligraphy motifs used in architecture and other Islamic artifacts. A tessellated design is a tiling where one or more geometric shapes fit together to cover a surface without any gaps or overlaps. Most tessellations incorporate polygons of various types, such as the first three panels in M.C. Escher's work 'Six Symmetry Motifs' a woodcut from 1957[1] (Fig. 1a). Such simple polygons can become the basis for more organic and elaborate designs as in the other three panels in Escher's work, one of which is based on panel A and shown in (Fig. 1b). The 'Figure-ground reversal' in such works adds delight and charm to works of art produced in many cultures.

It is also possible to create such tessellations from text written in Square Kufic calligraphy.[2] This article[3] will focus on tessellations where words are written in Square Kufic and their shape manipulated in such a way to allow the space or background area between the letters to also read as text. A Square Kufic tessellation in this article refers to a tiling where the constituent tiles read as text and connect to each other on all their sides. This means that Fig. 1c[4] is a Square Kufic tessellation because the grey/blue words reach the black words on all sides, while Figs. 1d and 1e are not strictly Square Kufic tessellations. In Fig. 1d,[5] each copy of the word Ali includes a letter *Ayn*, and the two interior sides of the letter *abut* one another rather than an adjacent repetition of the word. The same occurs between the letters *Ayn* and *Lam* that *abut* each other instead of including a part of another word between them. In Fig. 1e,[6] the black words are readable, but the white designs are not. This definition excludes a large number of patterns that incorporate text in Square Kufic calligraphy written inside various

geometric shapes where only parts of the text touch adjacent shapes. These may be described as in-tile Square Kufic and require study as well.[7]

Square Kufic works particularly well in tessellated designs due to the style's geometric qualities, extremely simple shapes, and the ability to bend and turn the letters and words within the

(Fig. 1) Tessellations in Art and Square Kufic Calligraphy
1a. Panels 'A–C' of 'Six Symmetry Motifs,' by M.C. Escher (woodcut, image size 7.3''× 9.6'', 1957) (M. Sakkal collection);
1b. Panel '1' of 'Six Symmetry Motifs' by M.C. Escher;
1c. Proper Square Kufic tessellation of four Ali's;
1d. Square Kufic tiling of Four Ali's;
1e. Square Kufic tiling of four Ali's;
1f. Ali in Square Kufic style;
1g. Ali in monumental Kufic style;
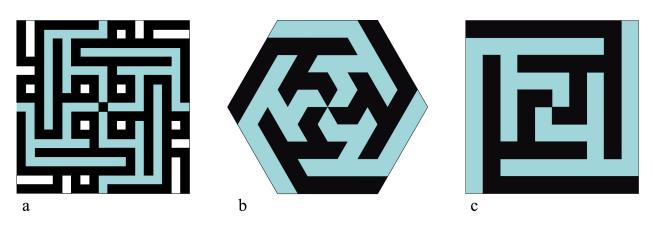1h. Ali in Naskh style; and
1i. Ali in Nastaliq style, white lines are added to separate the three letters that make up the word Ali (*Ayn*, *Lam*, and *Yeh*) and make it easier to distinguish the boundaries of each letter. Figures 1c–1i (© Mamoun Sakkal, 2018).

design grid. For example, the name 'Ali' can be written in different styles of Arabic calligraphy where the basic structure of the letters remains similar (Figs. 1f–1i), however the shapes and proportions of the black letters and the white spaces between them are more similar to each other in Square Kufic (Fig. 1f) than in the other styles (Figs. 1g–1i).

One of the most common examples of a tessellated design is the 'Four Muhammad/Ali' motif where the name Ali is spelled out in the space between the letters of the name Muhammad, and the two names are interlocked to form one cohesive design (Fig. 2a). There is an even more complex type of design where the black and white not only read as text, but actually read as the *same* text, as in the traditional 'Six Ali' motif to be discussed in detail in this article. This type of design is more challenging because of the strict limitations imposed on the designer. The word, or words, have to fit with each other perfectly but still be readable without unusual or extreme modifications that may obscure legibility or cause misreading. These designs where Figures of identical shape, but of two different colors disposed so as to cover a surface

exactly, without any interstices, as do the squares on a chessboard, are said to counterchange.[8]

This type of Square Kufic design is not dealt with frequently in the literature. Articles by Emil Makovicky, Erzsébet Rózsa, Michael Field, István Hargittai and Magdolna Hargittai, Slavik Vlado Jablan, Hacali Necefoglu, and Reza Sarhangi, all contain a brief mention of Square Kufic designs.[9] Hudu Memmedov *et al*., on the other hand, include more detailed information about the geometry of regular Square Kufic design in general, and about some of the Square Kufic tessellations presented in this article including 'Four Allah' in Bardaa, 'Six Ali' designs in Baku and Aksaray, and 'Four Ali' tessellation. In addition to these historical examples, the article presented nine original contemporary Square Kufic designs including a tessellation of the name Nasimi by H. S. Memmedov, a tessellation of the name Allah by I. R. Emiraslanov, and repeat patterns of other names by H. Necefoglu.[10]

Mangho Ahuja and A.L. Loeb discussed the 'Six Ali' design in their article 'Tessellations in Islamic Calligraphy'[11] and concluded that it is only possible to obtain a proper tessellated Arabic text

a   b   c

(Fig. 2) Square Kufic tessellations. Here and in the following illustrations, the foreground text is in black, the background text is in grey-blue, and white indicates extraneous elements that are not part of any words (© Mamoun Sakkal, 2018).
2a. 'Four Muhammad/Ali' tessellation;
2b. 'Six Ali' tessellation;
2c. 'Four Ali' tessellation.

design where the text and the background are the same using the name Ali, and only in one variant as found on the façade of a building in India. In the present article, I question this conclusion and endeavor to find out if other forms of this design are possible with the name Ali, or with any other words such as Muhammad.

Brian Wichmann and John Rigby[12] presented the results of enumerating all possible tessellations for designs comprised of four rotated copies of a single design, such as the ones in the 'Four Ali' tessellation (Fig. 2c). Each copy consists of one continuous string of squares connected to each other edge-to-edge, with certain restrictions, usually known as a polyomino in mathematics. Using a computer program, they found that the 'Four Ali' tessellation is one of 1040 possible polyominos to satisfy the perfect tessellation condition in a square made up of 100 small squares as in the 'Four Ali' design.[13] The auther examined these examples and found that 25 can be read as Square Kufic words,[14] and 25 can also be read as words but have one or two extraneous squares as is sometimes found in less regular Square Kufic calligraphy. All these are of course without dots since the polyomino's requirement is to have a continuous string, but none of these words is as significant as the word Ali. This is further evidence that Ahuja and Loeb's assertion that only the word Ali can be tessellated in this manner cannot be true.

The earliest extant example of a 'Four Muhammad/Ali' tessellation is in the Madrasa al-Rukniyya, built 1224–27, in Damascus (Fig. 2a). The 'Six Ali' motif appears as early as 1229 in the Sultan Han portal on the road between Aksaray and Konya (Fig. 2b), while the 'Four Ali' design appears quite later painted on the blind niche below the ceiling of the Amiriya Madrasa in Rada, in

Yemen, in 1504 (Fig. 2c). These motifs and their many variations that developed over the centuries are presented in detail below.
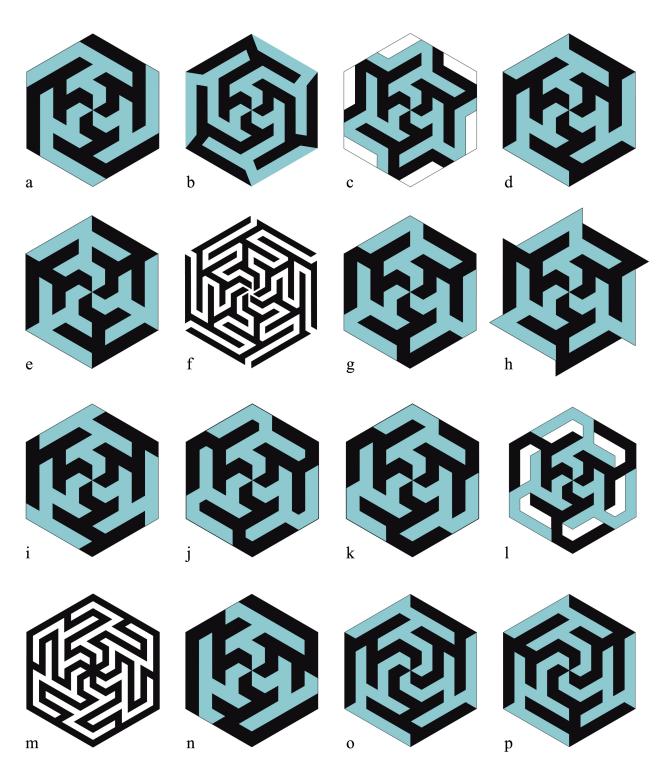
The 'Six Ali' hexagon motif

The precise origin of this design is unknown. One of the earliest examples is from the Great Mosque of Aksehir near Konya (Fig. 3a). The 'Six Ali' (*Shish Ali* in Persian, a phrase also sometimes used in Arabic and Turkish) motif is executed in fine mosaic tile on the elevation of the *mihrab* and repeated to make a surface pattern (Figs. 8a and 9). The Mosque has no foundation inscription; however, an inscription on the base of the minaret indicates that it was built by Abu Said Ibrahim in 610/1213. Bakirer believes that the tiled *mihrab* with the 'Six Ali' motif was built between 1219 and 1236 among the renovation work ordered by the Seljuk Sultan Alaeddin Keykubad and recorded in the Mosque records.[15] Another early example is the Sultan Han in Aksaray nearby (Fig. 3a), commissioned in 1229, also by Alaeddin Keykubad. The 'Six Ali' hexagon design is repeated twice in a symmetrical way over the impressive stone portal of the caravanserai, the largest in Turkey, where it is carved in relief on the two sides of the arch that surrounds the intricate *muqarnas* hood over the door[16] (Fig. 4). Sultan Alaeddin Keykubad also ordered the building of the second largest caravanserai in Turkey, outside Kayseri, in 1232, likewise known as Sultan Han (Fig. 3b). The 'Six Ali' design is carved in masonry above the main door and executed in reverse orientation making it somewhat difficult to read backwards[17] (Fig. 5). This variation of the 'Six Ali' motif is rather unusual because of an additional corner bend inserted between the letters *Ayn* and *Lam* that never occurs in any of the other fifteen variations identified in this article. Obviously,

Keykubad and his builders were determined in promoting the use of the 'Six Ali' motif in Anatolia since the three earliest extant examples were all his commissions. It would be quite informative to understand whether the Sultan himself was instrumental in the dissemination of this motif, or this was due to his team of artisans, this information is not available currently.

In the second half of the thirteenth century, we find two examples in Egypt[18] (Fig. 3c) and Turkey[19] (Fig. 3d). The 'Six Ali' motif was most popular during the fourteenth century where it exists in the Mamluk cities of Tripoli (Figs. 3c and 3f), Aleppo (Figs. 3h and 3i), and Cairo[20] (Fig. 3e); in Ottoman Bursa[21] (Fig. 3g); and in Iran in Abarquh[22] (Fig. 3a), Kirman[23] (Fig. 3j), Yazd[24] (Fig. 3g), and Qumm[25] (Fig. 3a combined with 3d). The Bimaristan Arghun (Hospital) built in 1354 in Aleppo (Fig. 6b) is notable as the only example where the Six Ali hexagon is part of a larger, all-over pattern (Fig. 6a) that leads the corners of the letter *Yeh* to protrude outside the outer hexagon boundaries as shown in Fig. 3h.[26]

The surviving examples from the fifteenth century are less frequent, and the 'Six Ali' motif's popularity continued to decline over the sixteenth and seventeenth centuries. During the fifteenth century, the 'Six Ali' motif continued to be used in Iran[27] (Figs. 3k and 3l) and Turkey[28] (Fig. 3g), as well as appearing in new regions such as in Baku, Azerbaijan[29] (Fig. 3g); and in India where the interior painting of the dome over the Mausoleum of Ahmad Shah Bahmani in Ashtoor near Bidar contains eight repeats of the 'Six Ali' motif in addition to the names of the twelve Shi'a Imams in Thuluth calligraphy[30] (Fig. 3j); in another example from India from the sixteenth century the motif is repeated twice on the main elevation of Atgah Khan

Tomb mausoleum as in the Sultan Han caravanserai[31] (Fig. 3g). Two different variations from the early sixteenth century are in the Topkapı Scroll[32] (Figs. 3m and 3n). An example from *Sahn* Abbasi (*Iwan* Abbasi) in Imam Reza Shrine Complex, Mashhad, from the end of the sixteenth century or beginning of the seventeenth is particularly interesting because the motif appears in a pair where one is colored in reverse as if to draw attention to the fact that both text and background contain the word Ali (Fig. 3a).[33] Two more variations of the motif are in a seventeenth century Ottoman residence in Aleppo where the 'Six Ali' design is repeated eight times among the decorations of a painted ceiling[34] (Figs. 3o and 3p). What is unique about these two variants is the additional turn provided in the center to extend the initial letter *Ayn* of the word Ali, thus increasing the number of lines that fill the hexagon from 10 to 12 as in the variations shown in Figs. 3b, 3c, and 3l as well. Although it is quite likely that the 'Six Ali' motif was used occasionally during the eighteenth, nineteenth, and twentieth centuries, I know of no examples from this period until its resurgence in new cover designs of the early twenty-first century and on a 1979 coin minted in Iran until 2007.[35] The design of the 'Six Ali' on this coin is not as competent as the older designs due to three flaws. First, the end of the *Yeh* tail is inconsistent between the black (raised) and white (depressed) repeats of the motif causing types 'a' and 'd' to combine in alternating fashion. Second, the letter *Ayn* in the depressed repeats has thinner lines. Third, the depressed background of the design is larger than the motif itself, and the depressed *Yeh* tails blend with this background making them thicker than the raised tails. Overall, the design lacks regularity, an essential quality in this symmetric pattern.

(Fig. 3) 'Six Ali' (*Shish* Ali) design variations. (Orientation of illustrations above may not correspond to that in actual specimen) (© Mamoun Sakkal, 2018)

3a. Great Mosque, Aksehir, 1213. Mosaic-tiled mihrab elevation.
    Great Mosque, Malatya, 1224. Mosaic tile of vault above interior sanctuary portal.
    Sultan Han portal, Aksaray-Konya, 1229. Carved masonry exterior portal elevation.
    Tomb of al-Hasan ibn Kay Khusraw, Abarquh, *ca.* 1320.

Tomb tower of Imad al-Din, Qum, 1390. Carved and painted stucco, interior wall.

Sahn Abbasi, also known as Iwan Abbasi (Abbasid Court), Imam Reza Shrine Complex, Mashhad, *ca*. 1600. Inset colored glazed tile, interior wall.

Modern coin, Iran, 1358 SH/1979 CE. This coin combines type "a" and "c" in alternating fashion, so it does not have complete symmetry.

3b. Sultan Han portal, Kayseri, 1232. Carved masonry above door of exterior portal elevation, executed in retrograde or reflected fashion.

3c. Sultan al-Zahir Baybars Madrasa, Cairo, 1262/63. Carved masonry exterior door lintel (the design is repeated as shown in Fig. 8b).

Khan al-Manzil, Tripoli, Lebanon, 1309. Carved masonry slab.

3d. Baba Tekkesi, Tokat Sumbul, Turkey, 1291. Carved masonry exterior portal elevation.

3e. Ahmad Bey Kohya Mosque, Cairo, 1310. Paint interior.

3f. Madrasah-Mosque of al Burtasi, Tripoli, Lebanon, 1310–24. Carved masonry exterior door lintel.

Madrasah-Mosque of al Burtasi, Tripoli, Lebanon, 1310–24 (as in Figure "3f" but the black and white are reversed).

3g. Friday Mosque, Yazd, 1375/76. Inset colored glazed tile, interior of dome.

Yildirim Bayezid I Mosque (Külliyesi), Bursa, 1391–95. Carved masonry of exterior window frame.

Palace of Shirvanshahs, Baku, 1435/36. Carved stucco, exterior elevation above door.

Long Bridge (Ergene Bridge) in the province of Edirne, district of Uzunkopru, 1443. Carved masonry now disappeared.

Atgah Khan Tomb in Khwaja Nizamuddin Chisti's Dargah, north of Delhi, 1566/67. Inset marble, exterior portal elevation.

3h. Arghun Bimaristan, Aleppo, 1354. Carved masonry exterior elevation above window (repeated twice within a geometric pattern panel).

3i. Taghriberdi Mosque, Aleppo, 1397. Carved wood panel (repeated on two sides).

3j. Gök Medrese, Tokat, *ca*. 1270. Inset colored glazed tile, two sides of exterior portal elevation.

Ahmad Shah Bahmani Mausoleum, Bidar, 1436. Painted interior ceiling of dome.

Friday Mosque, Kirman, *ca*. 1349 (the Ali letters in this design are outlined in dark blue and filled with light blue and white; some are reversed).

3k. Friday Mosque, Varzana, 1443. Inset colored glazed tile, sidewall of interior minbar.

3l. Friday Mosque, Varzana, 1443. Inset colored glazed tile, raised panel on soffit of the arch leading to the dome chamber.

3m. Illustration in the Topkapi Scroll, cat. no. 91, Central Asia, *ca*. 1500. Ink on paper.

3n. Illustration in the Topkapi Scroll, cat. no. 71, Central Asia, *ca*. 1500 (this design is not completely symmetrical because the black and white are not similar; the tail of the black Ali is longer than the white).

3o. Residence, Aleppo, 1623. Painted interior wood ceiling (repeated four times).

3p. Residence, Aleppo, 1623. Painted interior wood ceiling (repeated four times). Alternating repeats with variation 'o' so it does not have complete symmetry.

(Fig. 4) Sultan Han portal, Aksaray-Konya. Two 'Six Ali' designs carved on sides of decorative arch; see Fig. 3a (© 123rt.com).

(Fig. 5) Sultan Han portal, Kayseri. 'Six Ali' design is carved between muqarnas and decorative band over door arch lintel; see Fig. 3b (© Hakan Hisarlıgil).

(Fig. 6) Arghun Bimaristan, Aleppo; see Fig. 3h.
a. Front elevation pattern detail.
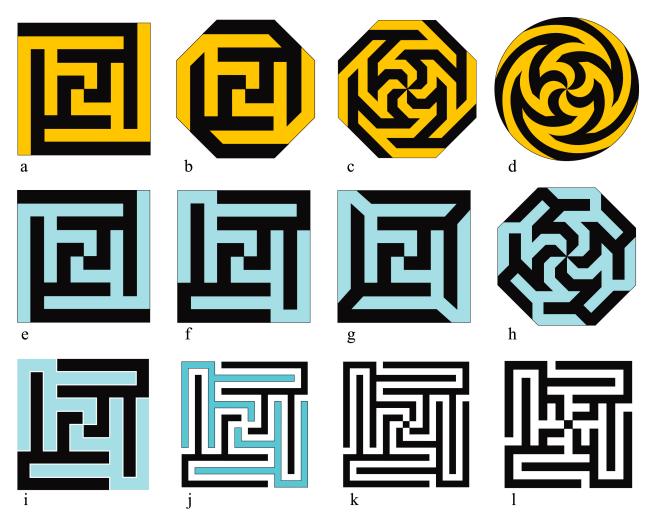b. Front elevation general view.

The requirement to have the black and white spaces identical, yet readable and uniform, suggests that the structure of the 'Six Ali' design must be tightly integrated, thus limiting the number of designs that would meet these strict requirements. Ahuja and Loeb wondered 'Is there perhaps a mathematical relation that only Ali and only the hexagon satisfy?'[36] Using mathematical proofs, they excluded the possibility of creating similar satisfactory designs using other regular shapes such as an octagon or a circle,[37] concluding that 'the 'Six Ali' design stands out as a rare and precious gem of art,'[38] and that perhaps the design used in Atgah Khan Tomb and Palace of the Shirvanshahs (Fig. 3g) is the only possible design to create a balanced calligraphic tessellation where the black and white will read equally as text. The author has already shown 16 different variations that satisfy the symmetry and readability requirements from

historical examples,[39] and was also able to create similar designs in a square, an octagon, and a circle using the word Ali (Figs. 7a-7d). I was also able to find historical examples of 'Ali' tessellations inscribed in square and octagon outlines. Historical examples of Ali tessellations where both black and white read as text are also found in a square design in the Amiriya Madrasa at Rada, Yemen, built in 1504 (Fig. 7e);[40] the sixteenth century

Tomb of Mullah Hasan at Sultaniyah (Fig. 7f);[41] the Nimavard Madrasa at Isfahan built *ca*. 1705/6 (Fig. 7g);[42] and an 'Eight Ali' tessellation in square in the Shrine of Imam Ali at Najaf, rebuilt by the Safavid Shah Ismail I shortly after 1500.[43] Wijdan Ali shows a design with a tessellation of the word Ali where both black and white read as text that is rotated four times to make up a square shape,[44] but no information about the source is provided.

(Fig. 7) Tessellations of the name 'Ali' in square, octagon, and circle (© Mamoun Sakkal, 2018).
7a–7d. by Mamoun Sakkal (1997).
7e. 'Four Ali' tessellation, Amiriya Madrasa at Rada, Yemen, 1504.
7f. 'Four Ali' tessellation, tomb of Mullah Hasan, Sultaniyah, 16th century.
7g. 'Four Ali' tessellation, Nimavard Madrasa, Isfahan, 1705/6. After Mahir al-Naqsh (1991) 259.
7h. 'Eight Ali' tessellation, Kaseh-Garan Madrasa, Isfahan, 1690.
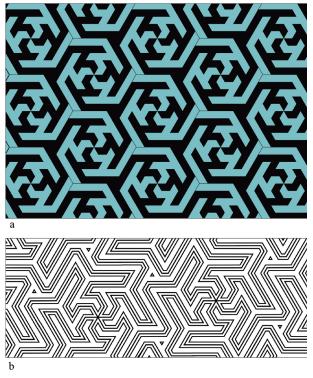7i–7l. Transition between 'Four Ali' tessellation and 'Four Ali' without tessellation.

Humbert shows a design of the word Ali in a pentagon shape, but only the black reads as Ali, so it is not considered part of this group of tessellated designs;[45] however, the design he shows in Fig. 35 is a tessellated Allah where both black and white read alike. No sources are provided to either of these two designs. A proper tessellation of the word Ali in black and white in a regular octagon is shown on a flickr.com page.[46] This is a close up of a tile that also includes the words *Muhammad* and *Allah akbar* in a sophisticated Square Kufic design that appears to be a tile purchased from Afghanistan and attributed to the nineteenth century. The same tile design is inset into a brick wall of Kaseh-Garan Madrasa in Isfahan built in 1690 (Fig. 7h).[47] It is possible to transform the 'Four Ali' tessellation to the 'Four Ali' without tessellation, where black and white do not read the same, by adding a separation space between the text and its background and making a small revision to the first letter *Ayn* (Figs. 7i-7l). This last version has been one of the most commonly used rotating Ali designs in Iran over the centuries.

The morphology of the 'Six Ali' motif seems to follow a general pattern of evolution over time, where the shape of the connection between the letters *Lam* and *Yeh* change gradually from a vertical one in the early thirteenth century (Fig. 3a), to a horizontal one in the early sixteenth century (Figs. 3m and 3n) through transitional stages in 1324 (Fig. 3g) and 1436 (Fig. 3j). Minor variations on these four types shown in Fig. 3 may have been deliberately introduced, but it is also likely that some were the result of the difficulty in documenting an existing design in order to transfer and use it somewhere else. The Topkapi Scroll examples show a case where the design motif was recorded in the architect's pattern book, but such a

readily available source of design was certainly not available to all.

Since the 'Six Ali' motif is composed inside of a regular hexagon, it is sometimes used to produce a complete tiling of the two-dimensional plane, and we have examples from the thirteenth century of patterns created from repetitions of the motif. One is the Ulu Mosque in Aksehir (Fig. 8a) where the area immediately above the *mihrab muqarnas* hood is filled with a repeat pattern of 'Six Ali' motif based on the unit shown in Fig. 3a. The pattern is executed in the proper orientation on the left side, but reflected on the right side to achieve complete symmetry (Fig. 9). The same design was also used in Ulu Mosque in Malatya on the mosaic tile of vault above the interior sanctuary portal where it appears reversed both on the left and right sides (Fig. 10). Another repeat pattern is a carved masonry lintel of Sultan al-Zahir Baybars Madrasa remains in Cairo (Fig. 8b).[48]

The 'Four Muhammad/Ali' motif

We have seen that the 'Six Ali' actually has many different variations to its design and still maintains proper geometry as a fully tessellated Square Kufic motif; let us consider the possibility of having other words, such as the name Muhammad, also tessellated in a similar fashion. The remarkable qualities of the 'Six Ali' designs are due in part to the forms resulting from rotational symmetry. This symmetry produces harmony and balance out of the varied letter forms and adds potent visual attributes to the semantic content of the text. The same symmetry used in the 'Six Ali' designs also provides similar qualities to another popular Square Kufic motif where text is used to make up the composition of the 'Four Muhammad/Ali' (*Char Muhammad* in Persian) design (Fig. 11a).
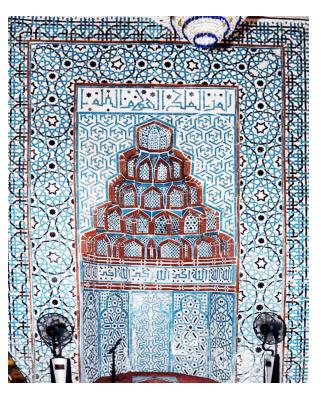
(Fig. 8) 'Six Ali' regular repeat patterns (© Mamoun Sakkal, 2018).

8a. Great Mosque (Ulu Mosque), Aksehir. White and blue mosaic-tiled mihrab elevation. Repeat pattern based on Fig. 2a. Illustration rotated 30 degrees.

Great Mosque (Ulu Mosque), Malatya. Repeat pattern black and blue mosaic tile, vault above interior sanctuary portal.

8b. Sultan al-Zahir Baybars Madrasa, Cairo. Carved masonry exterior door lintel. Repeat pattern based on Fig. 2c.

(Fig. 9) Great Mosque, Aksehir. Mosaic-tiled mihrab elevation. 'Six Ali' used as repeat pattern immediately over mihrab muqarnas hood; see Fig. 8a (© Hakan Hisarlıgil, 2018).
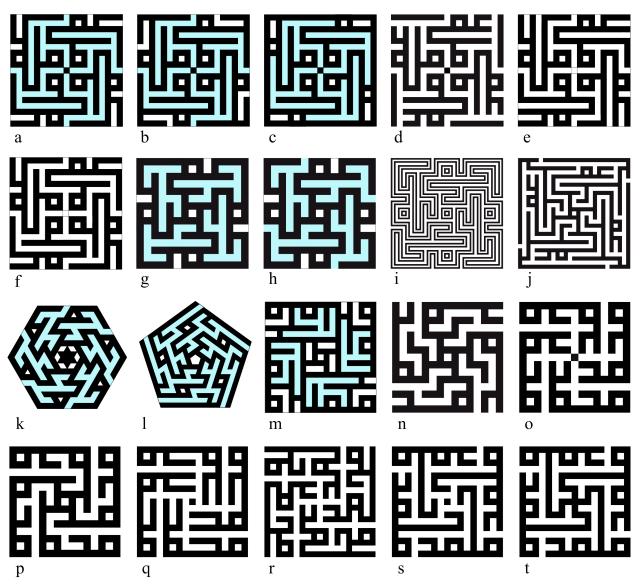

(Fig. 10) Great Mosque, Malatya. 'Six Ali' in repeat pattern mosaic tile, vault above interior sanctuary portal. Note that pattern is executed in reverse; see Fig. 8a (© Hakan Hisarlıgil, 2018).

The 'Four Muhammad/Ali' design is appreciated because it introduces a type of visual manipulation based solely on the calligraphy itself. In this design, the letterforms of one word are tweaked so that the white space between these letters will read as another word, so the text in the foreground and its background become equally readable; this is indicated in the author's illustrations by coloring the text in black and coloring the background text in grey-blue. There is usually no color in the actual specimens. In this design there is no blank space and an essential quality of calligraphy, where symbols or lines that represent certain sounds of the language on a substrate or a background, are transformed into graphic figures that are reversible adding a new dimension of plasticity that is not a typical quality of calligraphy. In a sense, this is one of the earliest uses of calligraphy as illustration or painting where all areas of a design are treated

as visual entities of equal value, and script is transformed from text to form.[49] Much of the work of contemporary artists using Square Kufic builds and expands on this concept of aesthetics, although they rarely create compositions where both text and background are readable.

The exact origin of this motif is not yet known. Although the earliest extant example of a 'Four Muhammad/Ali' design is in the Madrasa al-Rukniyya, built by the Ayyubid Governor of Damascus, Amir Rukn al-Din Mankurs al-Falaki, in 1224–27,[50] the majority of the cited examples here are in Mamluk buildings, dated between 1285 and 1365, and coinciding with the rule of the Qalawunid Dynasty during the Bahri Mamluk period.[51] The 'Four Muhammad/Ali' design was used often in buildings of the thirteenth and fourteenth centuries but gradually went out of fashion afterwards, and this can be demonstrated by listing those extant examples. Despite the large number of lost Mamluk buildings,[52] we still have multiple specimens of the 'Four Muhammad/Ali' motif in three buildings from the thirteenth century[53] and five buildings from the first half of the fourteenth century.[54] Later in the fourteenth century, five buildings from Ottoman Turkey included this design,[55] and four are from the fifteenth century that include two in Mamluk Cairo.[56] From the early sixteenth century, there is one example from Khvaf, Iran[57] (Fig. 11d), one from Cairo[58] (Fig. 11f), and two from Turkey[59] as listed in Figs. 11a and 11d. The last example from this period is in the Safavid Shah Mosque built in Isfahan during 1611–38; however, an undated residential building in al-Mugharbelin neighborhood in Cairo may date to the seventeenth century as well[60] (Fig. 11f). The two examples from the nineteenth century are not on buildings but are from movable artifacts: a linen kerchief[61] and a table.[62] Both are

Ottoman, one from Turkey and the other most likely from Egypt. Despite the existence of a few rare examples in Iran, the 'Four Muhammad/Ali' application is concentrated in Mamluk buildings in Egypt and Syria in the thirteenth and first half of the fourteenth century, then becomes popular in Ottoman Turkey in the late fourteenth century, and continues in use to the sixteenth century on buildings, and up to the nineteenth century on other artifacts. Mamluk buildings often included 'Four Muhammad/Ali' tessellations in groups consisting of two or three copies of the square pattern as in Sultan Qalawun complex (two and three vertical panels, Figs. 11a and 11b); Qubbat Bibars al-Jashangir (two horizontal panels); al-Maridani Mosque (two vertical panels, Fig. 12c); Qubbat Shaikh Zayn al-Din Yusuf (two vertical panels on each side of *mihrab*); Aqsunqur Mosque (two vertical panels with part of top panel missing); Muhammad al-Saghir Mosque (two vertical panels on each side of entrance; the panels are worn out and hardly visible, the ones on the right side may have completely disappeared, Fig. 12d); Saad al-Din bin Ghurab Madrasa and Khanqah (two vertical panels on each side of *mihrab*, Fig. 13); and Khanqah of Sultan al-Ghouri (two horizontal panels separated by borderline frames and blank space). This last example is unique among Square Kufic compositions in architectural applications because the two panels conform to the curved interior of the *mihrab* niche of the great *iwan*. This is achieved by dividing each square panel into five vertical sections, each of which is flat but smoothly connected to adjacent sections to give the impression of a curve.[63]

Fazaili divides Square Kufic designs into three types: simple, intermediate, and complex, and cites this 'Four Muhammad/Ali' as a complex example.[64] It is indeed remarkable to find such a refined

(Fig. 11) 'Four Muhammad/Ali' tessellation variations (© Mamoun Sakkal, 2018).

11a. Madrasa al-Rukniyya, Damascus, 1224–27.

Sultan Qalawun Complex, Cairo, 1284/85 (see Figs. 12a and 12b).

Qubbat Shaikh Zayn al-Din Yusuf, Cairo, 1298.

Qubbat Baybars al-Jashangir, Cairo, 1307–10.

Al-Maridani Mosque, Cairo, 1337–40 (see Fig. 12c).

Aqsunqur Mosque, Cairo, 1347.

Al-Rumi (Menkali Bugha) Mosque, Aleppo, 1365.

Khatuniye Madrasa, Karaman, 1382.

Sultan Kasem Madrasa, Mardin, 1385.

Yildirim Bayazid I Mosque (Külliyesi), Bursa, 1391–95.

Saad al-Din bin Ghurab Madrasa and Khanqah, Cairo, 1406 (see Fig. 13).

El-Rizk (Al-Rizk) Mosque, Hasankeyf (Hisn Kayfa), 1409.

Muhammad al-Saghir Mosque, Cairo, 1426/27 (see Fig.12d).

Haseki Hürrem Sultan Mosque, Istanbul, 1538/39.

Shah Mosque, Isfahan, 1611–38.

Al-Burdayni Mosque, Cairo, 1616–1629.

Linen kerchief, Ottoman, 19th century.

Linen kerchief, Ottoman, 19th century.

Inlaid wood table, Ottoman, 19th century.

Mohammad Ali Tewfik Palace, el-Manial, Cairo, first quarter of the twentieth century. *Mashrabiya* screen of a kiosk main window in front elevation of Residential Palace.

The Holy Shrine of Imam Ali, Najaf, Iraq, twentieth century.

11b. al-Burtasi Madrasa Tripoli, Lebanon, 1310–24.

11c. Firuz Bey Mosque, Milas, Turkey, 1394.

11d. Hadji Beyler Mosque, Karaman, 1358. Carved in masonry over main door.

Suleimaniye Mosque, Alanya, *ca*. 1550. Window shutters, carved and painted wood.

11e. Mosque of Khvaf, Khorasan, Iran, 1502/3.

11f. Yesil Mosque, Bursa, 1419. Painted on corridor ceiling.

Khanqah of Sultan al-Ghouri, Cairo, 1503. Two panels inside the curved surface of mihrab.

House in al-Mugharbelin neighborhood in Cairo, *ca*. 17th–18th century. Used on outside elevation twice carved in masonry, and inside twice on ceiling in carved and painted wood (actual specimen reversed both outside and inside the building, see Fig. 14).

11g. Tomb of Ahmad Shah Bahmani, Ashtoor near Bidar, 1436. Painted twice on each wall for a total of eight.
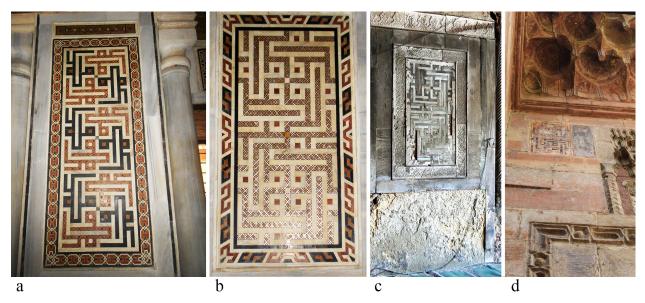
11h. Illustration in Khamsa of Nizami, Herat, 1446/47, Topkapi Saray Library, Ms.H.786, fol. 239b.

Firuz Aga Mosque, Istanbul, 1491. Repeated twice over main entrance door (see Figs. 15a and 15b).

Bitlis Great Mosque, Eastern Turkey, original building from 1150. Commissioned by Ebü'l-Muzaffer Muhammed, the portal including the Square Kufic panel seems like a later reconstruction due to the lighter color of the masonry. Carved in masonry twice over main entrance door.

11i. Masjid al-Rifa'i, Cairo, 1869–80. Used at top and bottom on each of two window shutters, carved wood and inlaid ivory (see Fig 16).

11j. 'Four Muhammad/Ali' new design by Yusuf Ahmad early twentieth century. Palace of Muhammad Ali Tewfik, el-Manial, Cairo.

11k. Muhammad/Ali in hexagon design, Mazar Shah Ala al-Din Husain, Shiraz (after Fazaili, 1971, 171).

11l. Muhammad/Ali in pentagon design, after Hasan Qasim Habash, 1974. Slightly revised, Habash (1990), 57.

11m. Four Muhammad/Ali in square design, Persian standard, 16th century. (Topkapi Museum, Istanbul, see Figure 15c).

11n. Four Muhammad design. Taghriberdi Mosque, Aleppo, 1397. Carved wood panel.

11o–11t. Four Muhammad designs in Square Kufic without the word Ali, various locations.

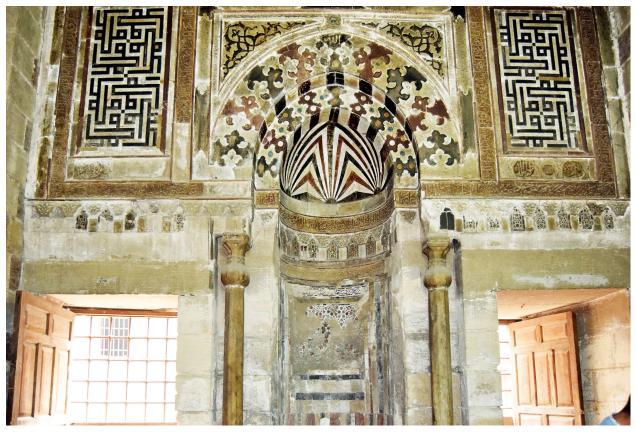a   b   c   d

(Fig. 12) 'Four Muhammad/Ali' tessellation multiple compositions examples from Cairo.

12a. Sultan Qalawun Complex, Cairo, one of four panels with three pattern repeats each (© Mahmud Gafar, 2014).

12b. Sultan Qalawun Complex, Cairo, one of four panels with two pattern repeats each (© Mahmud Gafar, 2014).

12c. Al-Maridani Mosque, Cairo (© Tarek Elsherif 2018).

12d. Muhammad al-Saghir Mosque, Cairo (© Tarek Elsherif, 2018).

(Fig. 13) Saad al-Din bin Ghurab Madrasa and Khanqah, Cairo. (© Tarek Elsherif, 2018).

design early in the thirteenth century, and to have the identical design in use until the present time.[65] Unlike other Square Kufic motifs that evolved over time and had several variants in text and structure, the 'Four Muhammad/Ali' originated complete and remained constant throughout the centuries except for a few known variations. The first is from the al-Burtasi Madrasa in Tripoli, Lebanon, built between 1310 and 1324, where the final *Dal* of the word Muhammad is reversed in direction (Fig. 11b). The second is from Firuz Bey Mosque in Milas, Turkey, built in 1394, where the exterior line is extended all around in continuous border (Fig. 11*c*). The other three variations are from the Haji Beyler Mosque in Karaman (1358) where the letter *Dal* is interrupted causing the formation of an extraneous line facing the

ends of *Dal* (Fig. 11d); the Friday Mosque of Khvaf, in the Khorasan region of Iran built 1502/1503 where the letter *Hah* of the word Muhammad is extended to meet the boundary (Fig. 11e); and Khanqah of al-Ghouri in Cairo (1503), also used in a seventeenth or eighteenth century house in al-Mugharbelin neighborhood in Cairo, where the first letter *Meem* of the word Muhammad has its connecting neck on the left rather than on the right (Fig. 11f). The modifications made to the design in these last three variations removed or added parts to the word 'Ali'. This rendered the name unreadable, which is why the grey-blue color is not used in their diagrams to indicate the name Ali.[66] The 'Four Muhammad/Ali' design in the Cairo house was used on the outside elevation twice carved in masonry (Figs. 14a and 14b), and inside the building

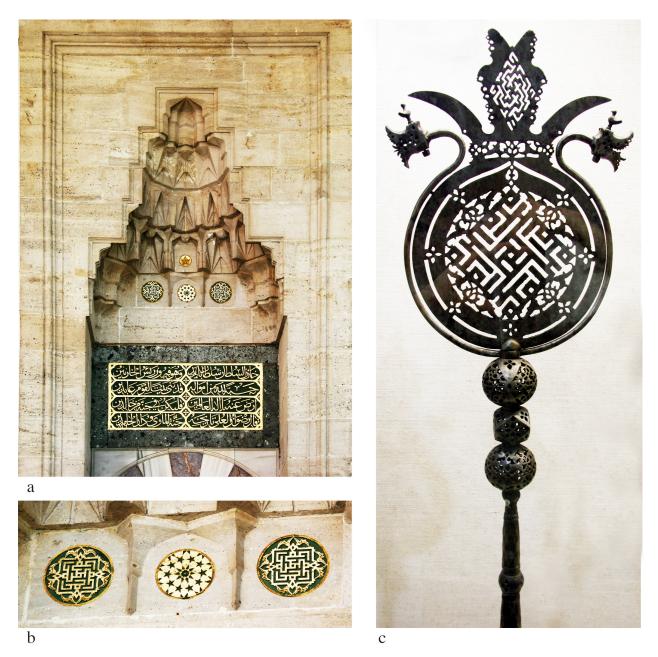a   b   c

(Fig. 14) House in al-Mugharbelin neighborhood in Cairo. (© Tarek Elsherif, 2018).
14a. Exterior elevation;
14b. Detail showing 'Four Muhammad/Ali' panel;
14c. Interior ceiling.

twice on the ceiling in carved and painted wood (Fig. 14c). The actual specimen is reversed, both outside and inside.

Another variation from the fifteenth century represents a more radical modification to the original design (Fig. 11g). This design appears in the Mausoleum of Ahmad Shah Bahmani in Ashtoor near Bidar, India (1436); and in an illustration from a *Khamsa* of Nizami dated 1446/1447 painted in Herat by artist Sultan Ali al Bavardi[67] (Fig. 11h). Since such illustrations depict features that have been already used in existing buildings, the use of the 'Four Muhammad/Ali' design in this region must have been an established practice in the late fourteenth or early fifteenth century. The calligrapher of this design combined the first *Meem-s* of the four Muhammad names into one square in the center of the design, thus reducing the number of cells making up each side of the square from 10 to 8, and creating a more compact composition. However, this did not improve the motif's legibility since combining the *Meem-s* makes reading naturally more difficult, as does the addition of an extraneous line to the final *Dal* in order to define the last part of the name Ali. Soon after, this design appears on the portal of Firuz Aga Mosque in Istanbul (Figs. 15a and 15b) built in 1491 by the Chief Treasurer to the Ottoman Sultan Bayazid II.[68]

An execution of this design in a window wood-shutter of al-Rifa'i Mosque (*ca*. 1912) in Cairo produces a maze-like appearance unique among the specimens discussed here (Fig. 11i). The words were boldly outlined, rather than rendered as solid lines, resulting in a more abstract pattern, but the main calligraphy in slender inlaid white ivory still maintains the proper tessellation geometry of the original design (Fig. 16).

a

b

c

(Fig. 15) Variations on 'Four Muhammad/Ali' design (© Mamoun Sakkal, 2007)
15a. Main entrance portal, Firuz Aga Mosque, Istanbul.
15b. Detail of 15a.
15c. Persian standard, 16th century, Topkapi Museum, Istanbul. Displayed showing the verso.

Yusuf Ahmad (1869–1942) is regarded by many Arab writers as responsible for reviving the traditions of Kufic calligraphy in modern times.[69] In his 1933 booklet, in which he dedicated much space to autobiographical information, he indicates that one of the first major works of Kufic calligraphy that his father asked him to draw was the 'Four Muhammad/Ali' design which he also included in his presentation (similar to Fig. 11a, but without the central square). He also indicated that neither he nor his father knew anything more about this type of calligraphy besides this name design.[70]

In addition to the work he did for historical restoration of Cairo Islamic monuments, Ahmad also designed numerous original Kufic works and was inspired by the *Khamsa* design to produce a Muhammad/Ali monogram where he adjusted the letter proportions to improve the shape of the name Muhammad, but complicated the shape of the name Ali for no apparent reason. He also introduced space between the words so the design no longer is a tessellation where the space between the words spells other words[71] (Fig. 11j). Muhammad and Ali, in this design, do not refer to Prophet Muhammad and his son-in-law Ali, as in the traditional designs but rather to Prince Muhammad Ali Tewfik (1875–1954) who was a collector and connoisseur of fine art and calligraphy, who built a lavish complex of palaces between 1899 and 1930 and commissioned Yusuf Ahmad to design this monogram. The monogram design was used in the Palace complex at least twice, once in inlaid black and white marble on a balustrade wall at the main entrance to the complex, and another time on a *mashrabiya* (turned wood) screen in the Two Mirrors Hall (Poetry and Literature Hall). On the north façade of the Residential Palace, the standard 'Four Muhammad/Ali' tessellation design was used in a central position of another *mashrabiya* screen of the main window in a kiosk projecting off the building elevation. Ahmad's monogram was also appropriately used in recent years as a logo for the Friends of Manial Palace Museum.[72]

The 'Four Muhammad/Ali' design and its variation from the *Khamsa* of Nizami inspired additional variations based on hexagonal[73] and pentagonal[74] grids rather than the original square grid (Figs. 11k and 11l).

(Fig. 16) Masjid al-Rifa'i, Cairo. Window shutters, carved wood and inlaid ivory. (© Hakim Misr, 2018).

In a sixteenth century Persian standard now in the Topkapi Museum, a 'Four Muhammad/Ali' motif was produced based on a completely different design concept (Fig. 11m). Instead of starting the four Muhammad names in the center of the design and moving outward, this design starts at the outside corners of the square and moves inwards towards the center.[75] The name Ali is well balanced in this design, but the name Muhammad includes an awkward *Dal* shape and includes the addition of several extraneous lines. These additional lines could have been designed to produce a better looking Muhammad, but because this was a standard produced by metal casting, it required more supports to keep all the elements connected to each other than would be the case otherwise (Fig. 15c).
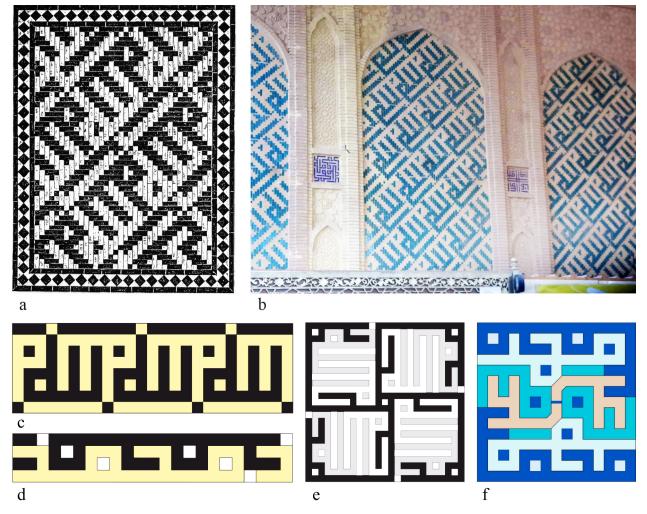
Tehnyat Majeed made a thorough analysis of the 'Four Muhammad/Ali' tessellation design and its use in the architecture of the Mamluks in Egypt in her dissertation and concluded that a strong relationship exists between the shape of the square plans of Bahri Mamluk domes and the 'Four Muhammad/Ali' motifs used inside them.[76] She also asserts the 'expressive intent' of this motif as a formalized and highly stylized version of the tradition of honoring Prophet Muhammad and asserting the Muslim identity of the community by 'aligning and affirming loyalty and paying homage to its chief messenger and spiritual leader'.[77] Although she acknowledges in passing the existence of the word Ali in the negative space of this design,[78] she considers this 'perhaps not even intentional'[79] and does not deal with the challenging question of why a design with a decidedly Shi'ite content would be so popular in the Sunni realms of the Ayyubids, their Mamluk successors, and the Ottomans who

followed. In my view, the design of this motif is deliberate because the modifications to the word Muhammad are not typical and the letterforms are not the outcome of the most natural way to write the word in Square Kufic. Unusual modifications include the reflected *Dal* and its bent extension, the connection of the first *Meem* of Muhammad from the right side as if it is a *Qaf* rather than from the left as is typical for the *Meem* as written in Square Kufic (Fig. 11f), and the extension of the letter *Hah* over the middle *Meem* and final *Dal*. The letter shapes are modified undoubtedly in this manner in order to create a readable word in the negative space. This suggests that the 'Four Muhammad/Ali' motif may have originated in a Shi'ite area before its popular use in Egypt, Syria, and Turkey. It also suggests that perhaps some of the Sunni dynasties where it was used did not completely understand the meaning of the design and overlooked the Shi'ite connotations it embodied. Otherwise, they would have used one of many similar designs that incorporate the name of Muhammad without that of Ali (Figs. 11n–11t). However, it is more likely that the use of this design in Sunni areas reflects a veneration of the Prophet's family without associating it exclusively with Shi'ite connotations.[80] Naji Zain al-Din Masraf indicates that builders (*banna'een*) call this design *Aliyyat* (plural of Ali) and not *Muhammadiyyat* (plural of Muhammad). Although he may reflect the knowledge and understanding of the builders in Iraq, he is nonetheless well traveled and quite aware of calligraphic traditions in other countries, and certainly confirms that the name Ali is an essential component of this design. This is of course contemporary knowledge, but it must reflect traditional experience passed on through the generations.[81]

Phrase tessellations

Although the name Ali lends itself more readily to tessellation design, other words including the names of Allah and Muhammad in various combinations can be tessellated as well. A tessellation of the word Allah in the *mihrab* of al-Ayni Madrasa was illustrated by J. Bourgoin and published in 1892 (Fig. 17a). This illustration was reproduced by Christie, Fazaili, and Masraf, among others.[82] The illustration in Fig. 17c is a slightly revised version based on a sketch by C. Humbert. A variation of Allah tessellation without complete symmetry is in M.M.A. Musa, *Al-kanz al-mawsuf*.[83]

Ibrahim and O'Kane convincingly speculated that al-Ayni *mihrab*'s decoration most likely dates to 1428 when al-Ayni, who founded the Madrasa 1411/1412, redecorated it in the exotic style of Anatolian tiled *mihrabs* such as that of the Great Mosque of Aksehir built 200 years earlier (Fig. 9).[84] As this decoration was applied to the interior cylindrical surface of the *mihrab*, small tiles were

(Fig. 17) Square Kufic tessellations of various words.

17a. Allah/Allah tessellation. Al-Ainy Mosque *mihrab* niche interior, Cairo (after Bourgoin, 1892).

17b. Al-Rawda al-Haydariyya, Najaf, Iraq. Exterior wall (© Ali al-Kindy, 2018).

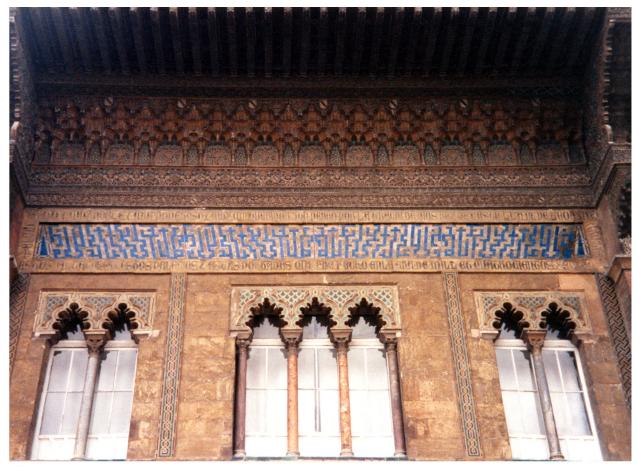17c. Allah/Allah tessellation band (after Humbert, 1980).

17d. Muhammad/Muhammad tessellation band. Mamoun Sakkal, 1996.

17e. Allah/Allah/Muhammad tessellation square, repeated four times by rotation. Shah Mosque, Isfahan (after Fazaili, 1971).

17f. Muhammad, Muhammad, Allah, Ali, repeated twice by rotation. Hakim Masjid, Isfahan (after Fazaili, 1971).

used to build it up in the *hazarbaf* style in order to follow the curved surface. Part of the ceiling fell on the *mihrab* and destroyed its decorative tiling in 1980, and the subsequent rebuilding did not maintain the original design. The only other example of Square Kufic inside a cylindrical *mihrab* I know of

is that of the *Khanqah* of Sultan al-Ghouri in Cairo mentioned earlier in this paper, where the interior surface was divided into twelve flat sections, and each of the two Muhammad/Ali panels was divided into five sections that were seamlessly connected to each other.[85] The Allah/Allah tessellation of

a

b

(Fig. 18) Square Kufic tessellations of phrases: Alcazar, Seville (© Mamoun Sakkal, 1992 and 2018)
18a, 18b. *Wa-la ghaliba illa Allah* (There is no victor but God) tessellation. Square Kufic band above entrance door, Alcazar, Seville, 1364.
  Diagram 18b shows only two repeats of four in building, other two repeats are mirror reflection.
  Diagram slightly revised to maintain symmetry as indicated with circle.

al-Ayni Madrasa has been included, in recent years, to cover the exterior walls of the Holy Shrine of Imam Ali in Najaf, Iraq, known as *al-Rawda al-Haydariyya*, on the side panels of Qibla, Faraj, and Clock gates, and on the wall to the right of al-Tosi gate (Fig. 17b). Similar to al-Ayni madrasa, *hazarbaf* technique was incorporated, as well as blue and white glazed tiles.[86]

A different example, with other words, is a tessellation of the words Allah/Allah/Muhammad in a square form, the Shah Mosque, Isfahan (Fig. 17e).[87] Sporadic recent work by contemporary designers encompasses an even wider range of words and phrases.[88]
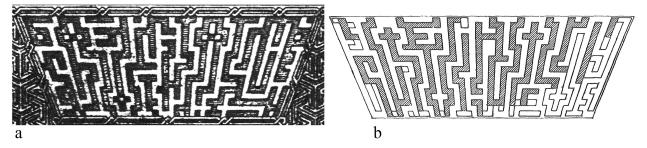
When different words are used in a tessellation design[89] (Fig. 17f), it is not possible to achieve complete symmetry since the words are different to start with. However, there is a small group of unique designs where a complete phrase is used in a tessellation so that both black and white will read the same. Two variations on the phrase *wa-la ghaliba illa Allah* (there is no victor but God), the slogan of the Nasrids encountered often in the Alhambra Palace, are found on buildings in Christian and Muslim Spain. The first was introduced onto the façade of Alcazar Palace in Seville as part of the extensive rebuilding carried out by Pedro the Cruel in 1364 (Figs. 18a and 18b).[90] The Square Kufic slogan, executed in white and blue tile, is repeated four times, two on the right side and two mirror-reflected on the left side of the elevation, and the vertical lines are gently slanted to converge onto the center of the entrance door below. However, considering the fact that the phrase is tessellated, the number of repeats becomes eight rather than four, with four in blue and four in white. I have suggested elsewhere[91] that the shapes of the crosses were perhaps intentionally introduced into the

design since it was commissioned by a Christian ruler and executed by Muslim craftsmen from Toledo, as indicated in an Arabic inscription on the wooden doors of the Hall of the Ambassadors, as well as from Granada.[92]

It is quite surprising to encounter this intricate Square Kufic design at such an early date in Spain where Square Kufic calligraphy was seldom used. It is even more surprising to see that a variation of this design, crosses and all, was again used in the Maristan (Hospital) of Muhammad V constructed between 1365 and 1367 in Muslim Granada which was partially destroyed in 1843 after it was converted to a Royal mint, a convent, a wine store, and a State prison[93] (Fig. 19). Muhammad V, who built the Granada Hospital soon after the Alcazar of Seville, was well aware of the construction work in Seville because he supplied the craftsmen from Granada to his ally, Pedro the Cruel. Furthermore, he 'had lived at the Seville Alcazar while in exile from 1359 to 1362'[94] before he was restored to his throne and consequently built his Maristan. The Maristan Square Kufic is not an exact replica of the Seville design but has several revisions to improve letter proportions, such as the letter *Waw* at the beginning that is now provided with a proper closed loop as can be observed on the top left side of Fig. 19a, and the letter *Beh* in the center of the design that now has a fuller, more typical shape. This supports the likelihood that the Granada design was inspired by that of Seville and corroborates Ruggles' view that 'the respective chronology of the Alhambra and the Alcazar is complicated and occasionally runs counter to the received wisdom that the Alhambra (and by extension, Islamic culture) 'influenced' the Alcazar (Christian culture playing a passive role as receivers),'[95] notwithstanding the fact that Muslim craftsmen did the work in both buildings
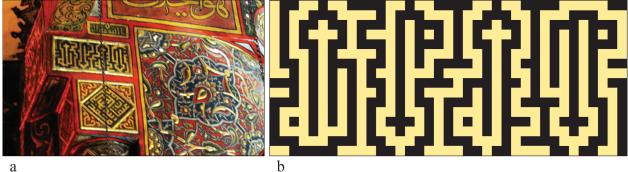
anyway. Unfortunately, it is difficult to create an accurate reconstruction of this design because all its available images are different. The sketch published by G. de Prangey in 1841, two years before the destruction of the building elevation, is rather corrupted and incomplete; it shows that the lower parts of the calligraphy had already been damaged.[96] The most detailed illustration is by F. Enriquez (Fig. 19a) and this illustration differs from L.T. Balbás' illustration published in 1944[97] (Fig. 19b). In 1992, Purificación Marinetto Sànchez from the Museo Nacional de Arte Hispanomusulmàn in Granada informed the author that a plaster cast of this design was in the storage vaults of the National Archaeological Museum in Madrid. The image published by Jairazbhoy of this plaster cast indicates further damage to the calligraphy, as well as possible unskilled restoration.[98]

The influence of the Alcazar Square Kufic tessellation eventually returned to the Middle East where the first part of the *Shahada* (*la ilaha illa Allah*) was designed in the same method for the Shrine of Mevlana Jalal al-Din Rumi (1207–73) in Konya, Turkey (Figs. 20a and 20b).[99] Not only is the concept closely related, the familiar crosses refer to the Andalusian source. All three phrase tessellation examples presented above have minor

a   b

(Fig. 19) Square Kufic tessellations of phrases: Maristan (Hospital) of Muhammad V, Granada
19a, 19b. *Wa-la ghaliba illa Allah* (There is no victor but God) tessellation. Square Kufic band on lintel above main door, Maristan, Granada, 1365–67.
19a. Illustration by F. Enriquez published in G. Nuno (1961), 83;
19b. Illustration by L.T. Balbás published in L.T. Balbás (1944), 494. Note that white and black are reversed in the two illustrations.

a   b

(Fig. 20) Square Kufic tessellations of phrases: Mevlana Rumi Shrine, Konya.
20a. First part of *Shahada* tessellation as it appears on the wall of Mevlana Rumi Shrine built 1512–20 in Konya. Below the *Shahada* is a Muhammad and Rashidoun square design in Square Kufic calligraphy (© Omer Anlas, 2011).
20b. First part of *Shahada* tessellation. Mevlana Rumi Shrine, Konya. Diagram slightly revised to maintain symmetry (© Mamoun Sakkal, 2018)

discrepancies between the white and black parts that prevent one from completely mapping onto the other; however, these differences can easily be corrected (compare photographs, Figs. 18a and 20a, to diagrams in Figs. 18b and 20b).[100]

Conclusion

Tessellated designs based on Square Kufic calligraphy are often structured around very restrictive conditions, so it is not surprising to see only a few of these designs developed over the centuries. Yet, by examining such designs closely, one is amazed by the ability of Muslim calligraphers and designers to create multiple variations of each of these motifs. We realize, through this examination, numerous variations with subtle and bold differences. While variations of a certain visual motif usually reveal the designers' aspirations to transform the design to a more perfect composition, we see that many of the revisions that took place over the years were not successful in creating better designs. This means that the few existing tessellated designs took considerable time and talent to develop in the first place, and thus were initiated in a close-to-perfect state.

Considered the most difficult of Square Kufic compositions as early as the sixteenth century by Qadi Ahmad in his book translated as *Calligraphers and Painters*,[101] Square Kufic tessellated designs, where both black and white can be read as text, come in different varieties. They can incorporate a single word for both text and background, two different words, even phrases with multiple words. This article has provided a general survey of this style of Square Kufic designs and clearly demonstrated the existence of multiple motifs used and reused since the thirteenth century. The most commonly used words in these designs are Ali,

Muhammad, and Allah, but others exist as well. This review clearly indicates that relying only on mathematical proofs in Ahuja and Loeb's article, discussed earlier, is not sufficient for understanding and evaluating the potential of this design concept. Visual culture, calligraphic expertise, intimate knowledge of history, and the skill of individual artists all need to be considered in order to reach informed conclusions.

By documenting the evolution of a specific theme of Square Kufic calligraphy, this study further revealed that Square Kufic was very popular between the thirteenth and fifteenth centuries, which waned over the following years. However, the twentieth century witnessed a renewed interest in this style of calligraphy that continues to our time.

Notes

*   Syrian artist and calligrapher (PhD); mamoun@sakkal.com.

1   This work was produced by M.C. Escher to accompany his only published book *The Regular Division of the Plane* (1957). It is published in *M.C. Escher: His Life and Complete Graphic Work* (Abrams, New York, 1982), cat. no. 417, 314, and reproduced as a full-page illustration, 161.

2   For a brief history of Square Kufic development see M. Sakkal. 'Intersecting Squares: Applied

Geometry in the Architecture of Timurid Samarkand,' *Journal of Mathematics and the Arts* 12, no. 2–3 (2018), 65–95. In Arabic see M. Sakkal, 'Mabadi al-khatt al-Kufi al-Tarbi'i' (Principles of Square Kufic Calligraphy), *Hroof Arabiyya* 4 (2004), 4–12.

3   Text and images in this article are in a section in my PhD dissertation. M. Sakkal, *Square Kufic Calligraphy in Modern Art, Transmission and Transformation* (University of Washington, 2010).

4   Similar to tomb of Mullah Hasan, Sultaniyah, 16th century. See D. Hill and O. Grabar, *Islamic Architecture and its Decorations* (Chicago, 1964), Fig. 247, revised slightly for symmetry.

5   Similar to a carved stone slab, Iran or Central Asia, 14th-15th century, (M.76.174.151) Art of the Middle East: Islamic Department, Los Angeles County Museum of Art. Online https://collections.lacma.org/node/184801 (accessed 29 January 2019).

6   Similar to Shah Ni'matullah Vali Shrine, Mahan, Iran, 1437, with Safavid reconstruction 1601, top of minaret shaft. See H. Zamarshidi, Kashikari-i Iran (Tehran, 1988), 103, without dot in center.

7   See, for example, Sakkal, *JMA* 12: 65–95.

8   A.H. Christie, *Traditional Methods of Pattern Designing: An Introduction to the Study of the Decorative Art* (Oxford, 1910?), 283.

9   See E. Makovicky, 'Symmetrology of Art: Coloured and Generalized Symmetries', in I. Hargittai (ed.), *Symmetry: Unifying Human Understanding* (Pergamon, New York, 1986), 949–80; E. Rózsa, 'Symmetry in Muslim Arts', in I. Hargittai (ed.), *Symmetry: Unifying Human Understanding* (Pergamon, New York, 1986), 725–50; M. Field, and M. Golubitsky, *Symmetry in Chaos: A Search for Pattern in Mathematics, Art and Nature* (Oxford and New York, 1992); I. Hargittai, and M. Hargittai, *Symmetry: A Unifying Concept* (Shelter Publications, Bolinas and Berkeley, CA, 1994); S.V. Jablan, *Symmetry, Ornament and Modularity* (World Scientific, River Edgen NJ, 2002); H. Necefoğlu, 'Crystallographic Patterns in Nature and Turkish Art', *Crystal Engineering* (2003), 153–166; R. Sarhangi, S. Jablan, and R. Sazdanovic, 'Modularity in Medieval Persian Mosaics: Textual, Empirical, Analytical, and Theoretical Considerations', *Visual Mathematics Journal* 7 (2005), 281–92.

10 H. Memmedov, İ. Emıraslanov, H. Necefoglu, and A. Mürselıyev, *Nahişlarin Yaddaşi*, (Istanbul, 1996), 57–59. Of the seven modern designs of names presented in the book, only 'Nasimi' name design by Memmedov (p. 69) and 'Allah' name by Emıraslanov (p. 78) are proper tessellations as defined in this paper. See also K.S. Mamedov, 'Crystallographic Patterns', *Comp. & Maths. with Appls,* Vol. 12B, Nos 3/4 (1986), 511–26, Fig. 6.

11 M. Ahuja and A.L. Loeb, 'Tessellations in Islamic Calligraphy', *Leonardo* 28 (1995), 41–45.

12 B. Wichmann, and J. Rigby, 'Yemeni Squares', *Leonardo* 42 (2009), 156–62.

13 The number of such tessellations, named by the authors 'Yemeni Squares' after the Amiriya example, for squares with 16 (4 x 4 squares on the side), 36 (6 x 6), 64 (8 x 8), 100 (10 x 10), 144 (12 x 12) small squares is 2, 8, 66, 1040, and 34,661 respectively. The number of possible Yemeni Squares for the next square with 196 (14 x 14) small squares is 2,100,000. The proportion of readable words to total obtained in the 100 small squares samples is 2.4%, but this proportion will not be accurate in larger squares because when the string of polyomino cells is long, it becomes less likely that they will be arranged as a proper sequence of letters. Wichmann, *Leonardo* 42, 161.

14 The reading was performed according to the 'Square Kufic alphabet chart' I developed for the script. See Sakkal, *Square Kufic Calligraphy*, 26, also published online at http://www.sakkal.com/instrctn/sq kufi alphabet.html (accessed November 2018). Examples of the words found are *aliya*, *lahd*, *jad*, and *Jana*, each of which can be read in several ways depending on what dots one assumes to add to the different letters.

15 Ö. Bakirer, *Onüç ve ondördüncü yüzyıllarda Anadolu mihrapları* (Ankara, 2000), 136, Fig. 15, pl. 45.

16 A. Ödekan, *Osmanlı* öncesi *anadolu Türk mimarisinde mukarnaslı portal örtüleri* (Istanbul, 1977), 221, R13; A. Tufekcioglu, *Erken donem Osmanlı mimarisinde yazi* (Ankara, 2001), Fig. 396; and H. Stierlin, *Turkey: From the Selcuks to the Ottomans* (Koln, 1998), 64–65.

17 See sketch in K. Erdmann, *Das Anatolische Karavansaray des 13. Jahrhunderts* (Berlin, 1961), Plate 79. I am grateful to Brian Wichmann for bringing this to my attention, and to Hakan Hisarlıgil for providing a photograph of the portal.

18 A carved masonry exterior door lintel in the small part that remains from Sultan al-Zahir Baybars Madrasa built in Cairo, 1262/1263 AH. See Yunus, *et al.*, *Tarikh wa-athar misr al-islamiyya* (*History and Monuments of Islamic Egypt*) (Cairo), vol. 1, pt.3.

19 The Baba Tekkesi built in Tokat Sumbul, Turkey, in 1290, where the design is used twice on the portal in an identical manner to that of Sultan Han. See Ödekan, *Osmanlı öncesi anadolu Türk*, 233, R26.

20 Mosque of Ahmad Bey Kohya built in 1310. See M. Meinecke, *Mitteilungen Des Deutschen Archaologischen Instituts Abteilung Kairo* 28 (2), (1972), pl. LIX *a* and *b* where several repeats of the motif are painted inside circles among other ornamental motifs.

21 Yildirim Mosque and Madrasa built 1391–95. See Tufekcioglu, *Erken donem Osmanlı,* Fig. 401.

22 Tomb of al-Hasan ibn Kay Khusraw, Abarquh, *ca.* 1320. See D.N. Wilber, *The Architecture of Islamic Iran: The IlKhanid Period* (Princeton, 1955), Cat. No. 59, Fig. 123.

23 The Muzzafarid Friday Mosque of Kirman, *ca.* 1349. See D. Pickett, *Early Persian Tilework: The Medieval Flowering of Kashi* (London, 1997), 159 where the author indicates that although there is much Safavid work on this *mihrab*, the part with the 'Six Ali' motif is most likely from the Muzaffarid period. See Fig. 142 in the same publication where a detailed view of the 'Six Ali' motif on the left side of the *mihrab* is shown. The motif is applied in reverse here in order to maintain the symmetry with the right side where it appears in the correct orientation.

24 The Friday Mosque of Yazd, 1375/76. See Pickett, *Early Persian Tilework*, Fig. 122 where the design can be easily missed in the center of the star.

25 The Ilkhanid Tomb of Khwaja Imad al-Din in Qum. This design has one irregular *Yeh* tail end similar to Fig. 3d at its lower part, while all the other pattern repeats are similar to Fig. 3a. See A.U. Pope, *Persian Architecture: The Triumph of Form and Color* (New York, 1965), Fig. 253; M. Tabataba'i, *Turbat-I pakan*, v.2 (Qum, 1976), 56.

26 The existence of this Six Ali design on Bimaristan Arghun's elevation has not been identified previously in the literature. Allen does not mention it in his detailed analysis of the elevation of the Bimaristan. See T. Allen, *Portal of the Bimaristan Arghun. Ayyubid Architecture*. (CA, 1999). http://www.sonic.net/~tallen/palmtree/ayyarch/

Bonner discussed the more elaborate geometric pattern over the main door of this building in J. Bonner, *Islamic Geometric Patterns: Their Historical Development and Traditional Methods of Construction* (Springer, 2017), 58. Despite the extensive destruction of historic buildings in Aleppo during the recent conflict, the Arghun Bimaristan luckily sustained very little damage.

27 As in the Friday Mosque in Varzana of 1443. See B. O'Kane, *Studies in Persian Art and Architecture* (Cairo, 1995), plates 36 and 43a for *minbar*; A. Hutt and L. Harrow, *Iran 2: Islamic Architecture* (London, 1978), pl. 36 for wall panel.

28 As in the Long Bridge (also known as the Ergene Bridge) in the province of Edirne, district of Uzunkopru, built by Sultan Murad also in 1443. Tufekcioglu, *Erken donem Osmanlı,* indicated that there are two photographs, one of which contains the 'Six Ali' design, obtained from the Semavi Eyice archive that were published as numbers 59/6 and 59/7 in Cevdet Culpan's book *Turkish Stone Bridges*. The calligraphy designs shown in these photographs are not found on the existing Bridge so their original location is not known (The author is grateful to Walter Andrews for this translation from Turkish). Tufekcioglu, *Erken donem Osmanlı*, 268–70, Fig. 252, and illustration 21.

29 The Palace of the Shirvanshahs in Baku, Azerbaijan, built in 1435/1436. For the date of the monument, see L. Golombek and D.N. Wilber, *The Timurid Architecture of Iran and Turan* (Princeton, 1988), 368–69, Cat. No. 146. For an image of the elevation, see M.S. Bulatov, *Geometricheskaia Garmonizatsiia V Arkhitekture Srednei Azii IX-XV vv (Geometric Harmonization in the Architecture of Central Asia from the Ninth to the Fifteenth century),* (Moscow, 1978), 256. Golombek includes two photographs of similar gates, Figs. 334–35, where the hexagons above the archway are obliterated and perhaps originally included the same 'Six Ali' hexagon designs as well.

30 G. Michell, and M. Zebrowski, *The New Cambridge History of India,* vol. 1, part 7, *Architecture and Art of the Deccan Sultanates* (Cambridge, 1999), 140–41.

31 Ahuja, *Leonardo* 28, Fig. 2.

32 See G. Necipoğlu, *The Topkapi Scroll: Geometry and Ornament in Islamic Architecture. Sketchbooks &*

Albums, 1st ed., (The Getty Center for the History of Art and the Humanities, Santa Monica, CA, 1995), Cat. nos. 71 and 91.

33 M. Mahir al-Naqsh, *Tarh va ejraye naghsh dar kashikari Iran doreh Islami (The Design and Execution of Drawings in Iranian Tilework)*, (Tehran, 1983), vol. 1, 116.

34 See D. Duda, *Innerarchitektur syrischer stadthäuser des 16. bis 18. jahrhunderts: Die sammlung henri pharaon in beirut* (Beirut; Wiesbaden, 1971), pl. 15.

35 The design was replaced by a portrait of Ayatollah Rohallah Khomeini in 1989 but the 'Six Ali' design continued to be minted in several following years. See image in S.A.H. Minoofam, M.H. Dehshibi, A. Bastanfrard and P. Eftekhari, 'Ad-hoc Ma'qili Script Generation Using Block Cellular Automata', *Journal of Cellular Automata*, vol. 7 (2012), 321–34, Fig. 1.

36 Ahuja, *Leonardo* 28, 43.

37 Ahuja, *Leonardo* 28, 44.

38 Ahuja, *Leonardo* 28, 45.

39 More detailed information about the geometry and mathematical properties of these Square Kufic tessellations can be found in Brian Wichmann's online patterns database at http://www.tilingsearch.org/sim/sim17.htm (accessed 22 January 2019).

40 S.M.S. Al-Radi, and R. Barnes, *The Amiriya in Rada: The History and Restoration of a Sixteenth-Century Madrasa in the Yemen*, ed. Robert Hillenbrand (New York, 1997), Fig. 75.

41 See D. Hill and O. Grabar, *Islamic Architecture and its Decoration, AD 800–1500, A Photographic Survey* (London: Faber and Faber, 1964), Fig. 247.

42 M. Mahir al-Naqsh, *Kashikari Iran* (Tehran, 1982). For date of monument, see W.B. Fisher, ed., *The Cambridge History of Iran* (Cambridge, 1968), 808.

43 See rendering in H. Massoudy, *Calligraphie Arabe Vivante* (Paris, 1998), 87.

44 W. Ali, and Ibn Nayif, *Al-umawiyun, al-Abbasiyun, al-andalusiyun* (Amman, 1988), 96.

45 C. Humbert, *Islamic Ornamental Design* (New York, 1980), Fig. 891.

46 https://www.flickr.com/photos/camdiary/2182737036 in/album-72157600706779191/ (accessed October 2018). This image is part of Sir Cam Collection on flicker.com.

47 Mahir al-Naqsh, *Kashikari iran*, vol. 4, 175; E. Makovicky, *Symmetry: Through the Eyes of Old Masters* (Berlin/Boston, 2016), Fig. 1.2.

48 There is also a repeat pattern based on the 'Six Ali' motif on the facade of the *iwan* in Isfahan's Friday Mosque where the motifs are connected to each other starting with the letter *Lam*, thus obscuring the word Ali since the final *Yeh* is omitted. The pattern is located on a square above the niche containing the phrase *Muhammad rasoulu Allah al-sadiq al-amin*, and has a 'Four Ali' diamond design in the center. See, for example, the cover of U. Scerrato, *Islam* (New York, 1976).

49 See T. Majeed, *The Phenomenon of the Square Kufic Script: The Cases of Ilkhanid Isfahan and Bahri Mamluk Cairo* (PhD dissertation, University of Oxford, 2006), 64 where she quotes J. Jakeman, *Religious architecture in thirteenth century Cairo with special reference to epigraphy* (1990), 15 describing this type of Square Kufic design as communicating at a level between script and abstract form.

50 J. Sauvaget, *Les monuments historiques de damas* (Beyrouth, 1932), 98–100; E. Herzfeld, *Matériaux pour un corpus inscriptionum arabicarum. deuxième partie, syrie* (Cairo, 1956), Fig. 43; Majeed, *The Phenomenon of the Square Kufic Script*, vol. 2, 101, 112.

51 Majeed, *The Phenomenon of the Square Kufic Script*, 185.

52 Majeed, *The Phenomenon of the Square Kufic Script*, 178.

53 In addition to Madrasa al-Rukniyya built 1224–27, there is Sultan Qalawun complex, 1284–85, and Qubbat Shaikh Zayn al-Din Yusuf, 1298, both in Cairo. For Qalawun see M. Meinecke, 'Das Mausoleum des Qala'un in Kairo: Untersuchungen zur Genese der mamlukischen architekturdekoration', *Mitteilungen Des Deutschen Archaologischen Instituts Abteilung Kairo* 27 (1) (1971), 47–80, pl. XIc and d; S. Blair, *Islamic Inscriptions* (Edinburgh, 1998), Fig. 7.40; Majeed, *The Phenomenon of the Square Kufic Script,* vol. 2, 72. These 'Four Muhammad/Ali' panels are in numerous publications but their most comprehensive treatment is in S.A.A. Imam, *Al-khatt al-kufi al-handasi al-murabaa: hilya kitabiya bi-munsha'at al-mamalik fil-qahira* (Alexandria, 1991), 106–14. This book also has detailed information on almost all the other examples in Cairo. For Zayn al-Din see K.A.C. Creswell, *The Muslim Architecture of Egypt* (Oxford, 1952), 233 and pl. 114d; L.A.

Ibrahim, 'The Zawiya of Saih Zain al-Din Yusuf in Cairo', *Mitteilungen Des Deutschen Archaologischen Instituts Abteilung Kairo* 34 (1978), 79–110, pl. 21c; D. Behrens-Abouseif, *Islamic Architecture in Cairo: An Introduction* (Leiden, 1989), 112; Majeed, *The Phenomenon of the Square Kufic Script*, vol. 2, 77. For a discussion of the date of this Zawiya see S.A.A. Imam, *Al-khatt al-kufi al-handasi,* 114–16.

54 Qubbat Baybars al-Jashangir, Cairo, 1307–10; Madrasat al-Burtasi, Tripoli, Lebanon, 1310–24, is a specimen where the design is not standard and the letter *Dal* of Muhammad was revised unsuccessfully perhaps to avoid the turned position of the letter in the original design; Amir al-Maridani Mosque, Cairo, 1337–40; Aqsunqur Mosque, Cairo, 1347; and al-Rumi (Menkali Bugha) Mosque, Aleppo, 1365.

For Baybars see D. Abd Allah, *Ma'ahid tazkiyat al-nufus fi Misr fi al-asr al-Ayyubi wa-al-Mamluki* (Cairo, 1980), Fig. 17b; Majeed, *The Phenomenon of the Square Kufic Script*, vol. 2, 77. For al-Burtasi see H. Salam-Liebich, *The architecture of the Mamluk City of Tripoli* (Cambridge, 1983), 37; R. Saliba, *Tripoli, the Old City: Monument Survey–Mosques and Madrasas: A Sourcebook of Maps and Architectural Drawings* (Beirut, 1994), monument 19; Majeed, *The Phenomenon of the Square Kufic Script*, vol. 2, 104. For Al-Maridani and Aqsunqur see M. Meinecke, 'Die moschee des Amirs Aqsunqur an-Nasiri in Kairo', *Mitteilungen Des Deutschen Archaologischen Instituts Abteilung Kairo* 29 (1), 13–38 (1973), pl. XI d and pl. XI c respectively; Majeed, *The Phenomenon of the Square Kufic Script*, vol. 2, 84, 85 respectively. For al-Rumi see M. Abd el-Razik, 'Al-Rumi "Menkali Bogha" Mosque in Aleppo: Architectural Archaeological Study', *EJARS*, vol. 6, No. 2 (December 2016), 136.

55 Hadji Beyler Mosque, Karaman, 1358; Madrasa Khatuniye, Karaman, 1382; Sultan Kasem Madrasa, Mardin, 1385; Firuz Bey Mosque, Milas, Turkey, 1394; and Yildirim Bayazid I Mosque (Külliyesi), Bursa, 1391–95.

For Hadji Beyler and Firuz Bey see O. Aslanapa, *Yüzyillar Boyunca Türk Sanati* (Istanbul, 1977), 123 and 97 respectively. For Khatuniye see E. Herzfeld, 'Damascus Studies in Architecture–III', *AI* 11–12 (1946), 1–71, Fig. 44. For Firuz Bey see Tufekcioglu, *Erken donem Osmanlı*, Fig. 44. For

Yildirim Bayazid see image at Archnet.org: https://archnet.org/sites/1905/media_contents/7458.

56 El-Rizk Mosque, Hasankeyf, 1409; Yesil Mosque, Bursa, 1419; Saad al-Din bin Ghurab Madrasa and Khanqah, Cairo, 1406; and Muhammad al-Saghir Mosque, Cairo, 1426/27.

For El-Rizk see Tufekcioglu, *Erken donem Osmanlı*, Fig. 418; M. Meinecke, *Patterns of Stylistic Changes in Islamic Architecture: Local Traditions Versus Migrating Artists* (New York and London, 1996), pl. 25.b. For Yesil see Tufekcioglu, *Erken donem Osmanlı*, Fig. 113. For Ibn Ghurab see S.A.A. Imam, *Al-khatt al-kufi al-handasi,* 197–201 and Pl. 57. For al-Saghir see S. Mahir, *Masajid misr wa-awliya'uha al-salihoun* (Cairo, 1983), vol. 2, 20. The author is grateful to Tarek Elsharif for providing the images and background information.

57 Mosque of Khvaf, Khorasan, Iran, 1502/3. See E. Baer, *Islamic Ornament* (New York, 1998), Fig. 90.

58 Khanqah of Sultan al-Ghouri, repeated twice inside the *mihrab* niche, Cairo, 1504/5. See H. el-Basha, *Encyclopedia of Islamic Architecture, Arts & Archeology* (Cairo, 1999), vol. 4, Fig. 232.

59 Mosque of the Favorite, Istanbul, 1538/39, and Suleimaniye Mosque, Alanya, Turkey (*ca*. 1550). For the Favorite see H. Aksu, *Istanbul yapilarindaki bazi dekoratif kûfi hatlar* (Istanbul, 2001), 52. For the Suleimaniye see Tufekcioglu, *Erken donem Osmanlı*, Fig. 417.

60 The author is grateful to Tarek Elsherif for uncovering the Square Kufic designs in this house, and for providing the images and background information. This exquisite building is lavishly decorated internally and externally, and is not registered as an important historic monument in Cairo, which The author believes should be included soon in order to preserve it.

61 Linen kerchief, Ottoman, nineteenth century. See A. Welch, *Calligraphy in the Arts of the Muslim World* (Austin, 1979), 104–5.

62 Inlaid wood table, Ottoman Egypt, nineteenth century. This is an octagonal side table with the standard 'Four Muhammad/Ali' design inlaid on four of the eight leg sides. It was featured on amirmohtashemi.com website archive section between 2006 and 2008. Its current whereabouts are unknown.

63 See S.A.A. Imam, *Al-khatt al-kufi al-handasi,* pl. 101.

64 See H.A. Fazaili, *Atlas-i khatt: Tahqiq dar khutut-i islami* (Isfahan, 1971), 160–61 for classification where he lists a number of monuments that include complex Square Kufic designs. He shows this 'Four Muhammad/Ali' design as one of the examples of complex designs on page 171, where he also includes the hexagonal design the author of this paper reproduced in Figure 11k.

65 The 'Four Muhammad/Ali' design is used in single, double, or triple panel arrangements, but the design itself always appears the same, except for the omission of the central dot in some cases.

66 Another irregular design where the letters *Hah* and *Yeh* in the name Muhammad were extensively modified thus obscuring the name Ali can be found in *Sabeel* Ashqatmar, now *Sabeel* al-Sakakini, in Aleppo. Built 1369/70, it has two panels each of the 'Four Ali' and 'Four Muhammad/Ali', revised as indicated above, all incorporated into a wide decorative band of interlacing 8-pointed stars located below the foundation inscription panel. See F. el-Hussiny, *Diwan al-khatt al-Arabi fi Suriya, nuqush al-ama'ir al-Mamlukiya* (Alexandria, 2018), Fig. 178.

67 Topkapi Saray Library, Istanbul, 786/1384, fol. 239b. See P. Soucek, 'The arts of calligraphy', in B. Gray, O.F. Akimushkin (eds.), *The Arts of the Book in Central Asia, 14th–16th Centuries* (Boulder; Paris, 1979), 10, 20.

68 The motif is carved in masonry, painted and gilded, and is repeated twice over the main entrance door. See Aksu, *Istanbul yapilarindaki*, 48. İ.A. Yüksel, *Osmanli Mimarisinde II. Bayezid Yavuz Selim* (Istanbul, 1983), 250–53.

69 This reflects Ahmad's assessment of himself expressed in his published lecture to the Association of Muslim Youth in Cairo, 1933. Y. Ahmad. *Al-khatt al-kufi: Muhadara an al-khatt al-kufi fi Jami Atwarih* (Cairo, 1933), 14, 31.

70 Ahmad, *Al-khatt al-kufi*, 15. Yusuf Ahmad also made pencil tracings of the 'Four Muhammad/Ali' tessellation, among other Square Kufic designs, that appeared in M.E.T. Rogers-Bey, 'Mémoire sur certaines inscriptions en caractères coufiques carrés' (notes on some inscriptions in Square Kufic characters), in *Bulletin De L'Institut* Égyptien*, Deuxième Série. no 2, Année 1881* 2 (2), (1883),100–106. The purpose of these vellum tracings, now in the private collection of M.A. Almir in Abu Dhabi, is not known and may

have been in preparation for the publication of another book by Ahmad.

71 Yusuf Ahmad's 'Four Muhammad/Ali' design was published in Ahmad, *Al-khatt al-Kufi*, 22 where it is signed and dated 1349 AH or 1930 CE. It is possible that this date was the date of preparing the illustration for use in a lecture and later in this book, and not the date of the original design because the Palace construction work was completed by this date.

72 As seen on the Museum website: http://friendsmanial.org (last accessed October 2018).

73 Mazar Shah Ala al-Din Husain, Shiraz. See Fazaili, *Atlas-i khatt*, 171.

74 Design by Hasan Qasim Habash in 1974 (the author's illustration is slightly revised). See H.Q. Habash, *Al-khatt al-Arabi al-kufi* (Beirut, 1990), 57.

75 Persian standard, sixteenth century. Topkapi Museum, Istanbul.

76 Majeed, *The Phenomenon of the Square Kufic Script*, 189–96.

77 Majeed, *The Phenomenon of the Square Kufic Script*, 199.

78 Majeed, *The Phenomenon of the Square Kufic Script*, 40–41.

79 Majeed, *The Phenomenon of the Square Kufic Script*, 204.

80 The author is grateful to Sheila Blair for this insight. In al-Qubba al-Mansuriyya analyzed by Majeed, the design was implemented twice, once where the negative space in the design was filled with patterns, the other where the negative space was in solid and the lines themselves were filled with patterns to clearly indicate their awareness of the double reading of the motif (Figures 12a and 12b in the present paper).

81 N.Z.D. Masraf, *Badai al-khatt al-Arabi* (Baghdad, 1972), 455. Masraf also confirms the existence of the word Ali within this motif in his previous publication published originally in 1968, N.Z.D. Masraf, *Musawwar al-khatt al-Arabi* (Baghdad, 1968), 90, 340.

82 See J. Bourgoin**, *Précis de l'art arabe et matériaux*, vol. 2 (1892), pl. IV; Fazaili, *Atlas-i khatt*, 172; A.H. Christie, *Traditional methods*, 105; Masraf, *Musawwar,* Fig. 292. H. Massoudy published

his own rendering of this illustration as well in *Calligraphie Arabe Vivante*, 86.

83 For C. Humbert see *Islamic Ornamental Design*, Fig. 35. For Musa see *Al-kanz al-mawsuf bi-ihya al-khatt al-kufi (Prescribed treasure in the revival of Kufic calligraphy)* (Kuwait, 1985), pl. 70.

84 L. Ibrahim and B. O'Kane, 'The Madrasa of Badr al-Din al-Ayni and its Tiled Mihrab', *Annales Islamologiques* 24 (1988), 267.

85 See S.A.A. Imam, *Al-khatt al-kufi al-handasi*, Figs. 100–101.

86 The Square Kufic brick facing on these walls were added in the seventies of the past century by Najaf architects/builders from the Beit Sharif tribe, known for carrying out most of the design and construction work in the Shrine complex. Ahmed Hassan al-Bakr's name was included as the patron, which was replaced later by the name of Saddam Hussein, which was eventually removed. The author is grateful to Ali al Kindy for providing this information. The exterior walls of this large complex also incorporate another Square Kufic tessellated design of Muhammad/Ali in various locations including the wall shown in Figure 17b. See *Daleel al-Ataba al-Alawiyya al-Muqaddassa: Tarikh wa-Imar* (*The Holy Shrine of Ali: History and Construction*), (Najaf, 2011). Photographs can be accessed on the complex's website www.ali.net (accessed 22 January 2019).

87 Allah/Allah/Muhammad tessellation square, Shah Mosque, Isfahan. See Fazaili, *Atlas-i khatt*, 172.

88 This includes the work of Shakil Akram Khan, Mamoun Sakkal, and work by Hudu Memmedov and Eddin Emıraslanov mentioned earlier in footnote 10. Although much of the Square Kufic and geometric scripts artwork by Lebanese artists Samir Sayegh and Joumana Medlej is based on tiling various words, the author has not seen any pieces based on tessellation as defined in this article: making the space between text letters read as text as well. For Khan see: http://islamicartsmagazine.com/magazine/view/square_kufic_tessellations/ (accessed October 2018). For Sakkal see 'Omer Anlas Studio' monogram in K. Furuya *et al.*, *Logo A Lot* (Tokyo, 2006), 182, and 'Escher/Escher' Arabic name http://www.sakkal.com/art/escher/arabic_name_no1.html (accessed October 2018); other unpublished tessellation designs include variations on Allah/Allah, Allah/Ali, Muhammad/

89 Muhammad, Six Muhammad/Ali, Four Ali, Eight Ali, and *Wa-la ghaliba illa Allah*.

89 Muhammad, Muhammad, Allah, Ali, Hakim Masjid, Isfahan, 1641–63. See Fazaili, *Atlas-i khatt*, 172; for a photograph in color see http://www.kufic.info/architecture/hakim/hakim.htm (accessed October 2018).

90 The date of the facade is indicated in its inscription. The interior finishing was completed in 1367 as indicated on the wooden doors of the Salla of the Ambassadors. F.D. Ruggles, 'The Alcazar of Seville and Mudejar Architecture', *Gesta 43* (2), 87–99 (2004), 91.

91 M. Sakkal, 'Mysteries of Square Kufic', *Future Vision* 12 (2003), 16–18. A reprint is available at: https://independent.academia.edu/MamounSakkal

92 Ruggles, *Gesta 43* (2), 91.

93 D.J. Galton, 'Destruction of a Hospital', *Journal of the Royal Society of Medicine* (1997), 408.

94 Ruggles, *Gesta* 43 (2), 91.

95 Ruggles, *Gesta* 43 (2), 92.

96 G. de Prangey, *Essai Sur L'Architecture des Arabes et des Mores, en Espagne, en Sicile, et en Barbarie* (Paris, 1841), pl. 24, where the building was identified as the 'Exchange House' in the plate description.

97 F. Enriquez illustration was published by L.T. Balbás along with his own illustration, 'El maristán de Granada', *al-Andalus* IX, 2 (1944), pl. 42, 494; Enriquez illustration was also published in G. Nuño, J. Antonio, *La arquitectura Española en sus monumentos desaparecidos* (Madrid, 1961), 83.

98 See image in R.A. Jairazbhoy, *An Outline of Islamic Architecture* (New York, 1972), pl. 49.

99 See Mevlana Museum in http://www.archnet.org, for additional images of other Square Kufic designs in this building including a *Shahada* Square, a *Muhammad* and *Rashidoun* square painted on the Shrine walls, and two carved wood door panels of the *Semahane* (*dhikr* ritual hall) reading 'Subhan dhi al-mulk wal-malakout' and 'Subhan al-hayy alladhi la yamout.' The author is grateful to Omer Anlas for providing images of these designs.

100 In addition to the differences between the black and white, the Maristan design has an extra *Alif* in the last word *Allah* that should be amended as well.

101 Qadi Ahmad, son of Mir-Munshi, *Gulistan-i Hunar* (the Rose Garden of Art), translated as *Calligraphers and Painters*, V. Minorsky (ed.) (Washington, 1959).