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Research article

A Statistical Assessment of Early Islamic History and the Qibla: Comparing the Theories of David King and Dan Gibson

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Abstract

Dan Gibson has argued that the first holy city of Islam was Petra. David King has disputed Gibson's conclusions. Using data from Gibson's website, the two theories are tested and contrasted statistically. While King's theory works well for most mosques and other sites after 900 C.E., Gibson's theory seems to work well for sites prior to 900 C.E., especially for sites constructed before 725 C.E. In summary, many early mosques and related structures do appear to face Petra geographically rather than towards Mecca. However, later structures may be related to today's Mecca in a variety of ways other than simple geographical alignment. Because each theory seemed to be more accurate for certain centuries than others, future research should apply a variety of approaches to further assessment of and comparison of the two theories as well as other theories yet to be developed that may surpass both King's and Gibson's qibla theories in accuracy.

Keywords: Islamic history, Petra, Mecca, Dan Gibson, David King, Competing theories, history of Islam

Introduction

Science and religion have often spied each other with a mixture of envy and enmity. Science would seem to lay claim to exclusive ownership of the material world, while religion often lays claim to priority with respect to nonmaterial matters, including spirituality. Thus, it would be reasonable to wonder if science and religion could ever be integrated. Giulio Fanti (2019, 1) has argued that "While many affirm that science and faith must travel on two parallel levels without ever meeting, others, with the author [Fanti], are convinced that they must meet together to compare and enrich each other".[1] Ali Hossein Khani (2020) has discussed the tensions between religion and science within Islam.[2] Some have seen any potential scientific assessment of Islam or Islamic history as unfair and biased,[3] but we see the need for a multidisciplinary, scientific approach to controversial issues involving religion. There is always the danger that any critic of religious history may be classified as just another biased critic of religion in general.[4] Woodford (2017) has discussed the issue of science with a focus on what is or was rather than what ought.[5] Through science we may find out that what is/was may not fit with what people think ought to have been.

Science helps us advance in knowledge in many ways. One way is to develop tests of the null hypothesis. One might propose that religious group A is not more likely to use contraception than a control group; if the null hypothesis was rejected, it might be argued that group A was more likely to use contraception. Another way is to locate a critical test between two contrasting theories. If theory X predicts an outcome A but theory Y predicts outcome B, then not

only might we learn about predictors of different outcomes but we might find evidence favoring one theory over another theory. Being able to contrast and test different theories permits even greater advance in our understanding than simply testing a hypothesis. Therefore, finding critical test opportunities, while often difficult, can be viewed with great anticipation. This can be of interest in the scientific study of religion, as well as other areas of science. Science, using statistical tests, has proven helpful in understanding many historical events, including the sinking of the vessels HMT Birkenhead, the RMS Titanic, and the MV Sewol[6], as well as other historical events such as the attack on Pearl Harbor and the loss of the space shuttle Challenger.[7] Furthermore, previous experience using statistics to research religious issues have proven useful for analyzing paradox in religious doctrines, content of religious sayings, among other issues. Thus, we were hopeful that statistics would prove useful for understanding events in religious history, if and when an opportunity for a critical test might be identified.

General Methodology

We will present a critical test of two theories of religious history. Our specific goal is to statistically compare theories about the early historical development of Islam, according to the contrasting viewpoints of Dan Gibson and David King.[8] First, we will review the background of the conflicting theories regarding the history of early Islam. Second, we will examine the issue of how accurately early Muslims could measure qibla directions. Third, we will assess whether and how qibla patterns may have changed between 620 and 900 C.E. Fourth, we will compare the two theories for their relative accuracy in explaining qibla patterns that deviate from Mecca. Lastly, we will consider some of the implications of our findings.

Early Islamic Architecture and Qiblas: Contrasting Theories

Dan Gibson[9] has proposed that the earliest Islamic mosques (C.E. 622-725) faced Petra geographically rather than facing Mecca. Dr. David King agrees that the early mosques often didn't appear to face Mecca from our modern perspective, but King has argued that it is still possible that no mosque faced Petra, and that the variation in azimuths was a function of poor calculations, some sort of "old" way of calculating direction, and/or a wide range of special bearings that King suggests that early Muslims may have used instead of facing Mecca geographically as we would do it today.[10] In sum, King believes that that early Muslims were not able to measure azimuths to distant cities with much accuracy. More details on the debate, especially with respect to measurement issues, have been published elsewhere.[11] Recently, King has reiterated his position, claiming that Gibson and others have reached"false, nay, ridiculous conclusions".[12]

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1. Giulio Fanti, "Science and the Christian Faith: The Example of the Shroud of Turin," *Global Journal of Archaeology & Anthropology,* 8, no. 1 (2019): 1-7.
2. Ali Hossein Khani, "Islam and Science: The Philosophical Grounds for a Genuine Debate," Zygon, online advance (2020).
3. Aaron W. Hughes, *Situating Islam: The Past and Future of an Academic Discipline* (London: Equinox, 2007).
4. Fahd Mohammed Taleb Al-Olaqi, "Western Polemic Writings about Muhammed's Prophethood," *Advances in Social Sciences Research Journal*, 3, no. 5 (2016): 138-156.
5. Peter Woodford, "The Very Possibility of a Science of Religion: Ernst Troeltch and Neo-Kantianism," *Journal of Religion*, 97, no. 1 (2017): 56-78.
6. Young Lee, Walter R. Schumm, Lorenza Lockett, Kimmery C. Newson, & Kathleen Behan, "Teaching Statistics with Current and Historical Events: An Analysis of Survivor Data from the Sinking o f the HMT Birkenhead, the RMS Titanic, and the Korean Ferry MV Sewol," *Comprehensive Psychology*, 5 (2016): 1-6.
7. Walter R. Schumm, Farrell J. Webb, Carlos S. Castelo, Cynthia G. Akagi, Erick J. Jensen, rose M. Ditto, Elaine Spencer-Carver, & Beverlyn F. Brown, "Enhancing Learning in Statistics Classes Through the Use of Concrete Historical Examples: The Space Shuttle Challenger, Pearl Harbor, and the RMS Titanic," *Teaching Sociology*, 30, No. 3 (2002): 361-375.
8. Walter R. Schumm, "How Accurately Could Early (622-900 CE) Muslims Determine the Direction of Prayers (Qibla)?," Religions, 11, No. 3 (2020): 102. Henceforth, "Direction of Prayers".
9. Daniel Gibson, Qur'*anic Geography* (Vancouver: Independent Scholars Press, 2011); Daniel Gibson, *Early Islamic Qiblas*: *A Survey of Mosques Built Between 1AH/622CE and 263 AH/876CE* (Vancouver: Independent Scholars Press, 2017); see his website, www.nabataea.net.
10. David A. King, "Science in the Service of Religion: The Case of Islam," Impact of Science on Society, 40 (1990): 245-262; David A. King, The Petra Fallacy: Early Mosques Do Face the Sacred Kaaba in Mecca but Dan Gibson Doesn't Know How. Available online: HYPERLINK "http://www.davidaking.academia.edu" www.davidaking.academia.edu (accessed on 26 November 2019); David A. King, Finding the Qibla by the Sun and Stars: A Survey of the Sources of Islamic Sacred Geography. Available online: HYPERLINK "http://www.davidaking.academia,edu" www.davidaking.academia,edu (accessed 13 December 2020); David A. King, "Review of 'Early Islamic Qiblas'," Suhayl: International Journal for the History of the Exact and Natural Sciences in Islamic Civilization, 16-17 (2018-2019): 347-366. Amod Jason Deus, Sura 2: Many Qiblas? The Qibla in the Koran, Abu Lahab, and the Birth of Islam (available online, HYPERLINK "mailto:amod.jason.deus@ajdeus.org" amod.jason.deus@ajdeus.org, downloaded 17 January 2021: 55-57) agrees with King (and Gibson) that most early mosques did not aim toward Mecca but he asserts the early Muslims could aim within .05 degrees.
11. Walter R. Schumm, Direction of Prayers.
12. David A. King, "Islamic Sacred Geography and Finding the Qibla by the Sun and Stars: A Survey of the Historical Sources with an Appendix on Some Recent Fallacies Concerning Mosque Orientations," Zeitschrift fur Geschichte der Arabishch-Islamischen wissenschaften (Journal for the History of Arabic-Islamic Sciences), Volume 22 (Special Issue)(2020): 91-141. Quote from p. 134.

The controversy is of significant importance as Petra is literally "off the map" in the minds of many scholars of Islam; for example, Hazelton did not include Petra on a map of "The Middle East in the late seventh century" while including Medina, Mecca, Jesusalem, Damascus, Cairo, and Constantinople[13]. King believes that Gibson and others "seek to denigrate Islam" and have "no idea about historical qibla determinations".[14] King has read Schumm's research[15] and disagreed with his results, stating that he is an "author with no idea about the ways in which the early Muslims determined the qibla" and who presented "meaningless results of a statistical analysis of Gibson's mosque orientations in the light of the irrelevant modern directions of Petra and of Mecca. Sad!".[16] (David King, 2020, 752).

There is no doubt the two theories by Gibson and King have generated considerable controversy,[17] but more than one author has believed that Gibson's arguments needed some sort of systematic evaluation,[18] which is what is being attempted here, as a critical test of the two theories. However, some scholars have believed that early Muslims never had sufficient technology to measure accurate azimuths in the modern way[19] (M. S. M. Saifullah et al., 2001, 15; Veli Ilci et al., 2018, 1643; David King, 2018/2019, 351). If that were correct, Gibson's theory should not work because the azimuths of his structures should have been random to a large extent. In the past year, Gibson has added new data on his website (www.nabataea.net) for early Islamic structures, as noted in Tables 1 and 2.

Specific Hypotheses

Our goal was to examine the Gibson hypothesis – that the earliest mosques faced Petra, then a location between Petra and Mecca, and then finally Mecca (with a few facing Jerusalem later than most of those that faced Petra) from several perspectives, using statistical tests as well as taking into consideration King's theories. We wanted to repeat the analytic approach used earlier[20] and to add additional procedures to assess whether the apparent qiblas changed over time and whether King's approaches to explaining qibla directions might prove more effective than Gibson's approaches. In other words, we wanted to conduct a comparative test of two explicit theories, using scientific/statistical methods. The basic null hypothesis in this case would be that mosques and other structures in the early centuries of Islam were geographically aimed in random patterns (i.e., no discernable patterns). In contrast to this null hypothesis, Gibson's theory is that there were discernable patterns, starting with Petra, then between, then Mecca, with a few toward Jerusalem and more in parallel to the azimuth between Petra and Mecca. Also, in contrast to this null hypothesis, King's theory also rejects the null but argues that the discernible patterns were based on alignments with the angles of the sacred Ka'ba. As far as we know, no one else has yet statistically tested the null against either Gibson's or King's theories. It might be possible that both Gibson's and King's theories are incorrect, and the null is correct. It might be that both Gibson's and King's theories are correct, in part, but the null would still be rejected. The null hypothesis could be correct and explainable; for example, perhaps mosques were constructed on the foundations of earlier buildings that had random alignments. Possibly mosques were constructed based on convenience, whichever angles helped secure the foundations more securely were the angles chosen. If one were to argue for the null that would not mean that early Islamic architects were rolling dice to determine the angles of construction, only that they were not attempting to align their structures with distant sacred locations or with respect to the angles of the sacred Ka'ba.

13. Lesley Hazleton, After the Prophet: *The Epic Story of the Shia-Sunni Split in Islam* (New York: Doubleday, 2009).

14. David A. King, *The Petra Fallacy,* 5

15. Walter R. Schumm, Direction of *Prayers*.

16. David A. King, The Wind-Catchers of Medieval Cairo and their Secrets – 1001 Years of Renewable Energy, Part 1. Available online: davidaking.academia.edu (accessed 15 December 2020).

17. Michael Lecker, "Review of 'Qur'anic Geography'," *Journal of Semitic Studies* 59 (2014): 465-467.

18. W. Richard Oakes, "Review of 'Qur'anic Geography'," *The Muslim World* 105 (2015): 423-426; Daniel C. Waugh, "Review of 'Qur'anic Geography'," The Silk Road 10 (2012): 201. 19 M. S. M. M. Saifullah, M. Ghoniem, 'Abd al-Rahman, Robert Squires, & M. Ahmed, The Qibla of Early Mosques: Jerusalem or Makkah? Available online: www.islamic-awareness.org/History/Islam/Dome of the Rock/qibla.html (accessed 23 February 2020); Veli Ilci, Ibrahim Murat Ozulu, Ersoy Arslan, & Reha Metin Alkan, "Investigation on the Accuracy of Existing Qibla Directions of the Mosques from Different Periods: A Case Study in Corum City, Turkey," Technical Gazette 25 (2018): 1642-1649; King, Review of "Early Islamic Qiblas," 351.

19. M. S. M. M. Saifullah, M. Ghoniem, 'Abd al-Rahman, Robert Squires, & M. Ahmed, The Qibla of Early Mosques: Jerusalem or Makkah? Available online: www.islamic-awareness.org/History/Islam/Dome of the Rock/qibla.html (accessed 23 February 2020); Veli Ilci, Ibrahim Murat Ozulu, Ersoy Arslan, & Reha Metin Alkan, "Investigation on the Accuracy of Existing Qibla Directions of the Mosques from Different Periods: A Case Study in Corum City, Turkey," Technical Gazette 25 (2018): 1642-1649; King, Review of "Early Islamic Qiblas," 351.

20. Walter R. Schumm, *Direction of Prayers*.

An intermediate step in testing both theories would involve the issue of measurement. One argument might be that early Islamic architects were not technically capable of aiming their structures towards any distant object. While it could be that they were technically capable but chose to not aim their structures in any direction, we would consider that a variation of the null hypothesis. If there were mosques or other structures that for which both theories would claim Mecca as the aiming point, then the measurement hypothesis could be tested in a way to satisfy both Gibson and King as to the technical capabilities (or lack thereof) of early Muslim architects.

Specific Methods

We submitted our proposal for this study to the Committee on Research Involving Human Subjects at Kansas State University and on 29 April 2020 the Committee on Research Involving Human Subjects, the Institutional Review Board (IRB) at Kansas State University, determined that research proposal 10141 "Assessing Early Islamic Qiblas" was a non-research application and did not meet the criteria in 45 CFR 46 for the definition of "research" involving human subjects, and therefore did not require review by the committee.

Close calls

However, a cursory examination of the data in Table 1 would reveal that some qiblas were very close to more than one distant location. Some method of sorting these out was needed. There were seventeen situations in which the qiblas for both Petra and Jerusalem were within four degrees of magnitude from each other and both within ten degrees of the azimuth of the structure under consideration. These include Juma Cheramin, San'a mosque, Qiblatain Mosque (Oman), Bibi Samarkan, Sahi Ramdah (Bowshar, Oman), the Mosque of the Two Qiblas (Medina), Kilwa, Massawa, Mudhmar, Palmyra Central, Barwada, Sultan Yaqub Mosque, Sultan Yaqub Tomb, Ali Shrine, Huaisheng Mosque, Zeila Qiblatain (left), and Palmyra (early). In 15 of the 17 situations, the azimuth of the structure was closer to Petra, with one exact tie (Kilwa), and one closer to Jerusalem (Ali Shrine). How can we use this information statistically? To be conservative, we will count the Sultan Yaqub sites as one. If we were to assume that a random process was at work, then we would assume the probability of either city having a closer azimuth would be 0.50. What would the odds be, then, of having 14 of 16 sites with azimuths closer to Petra? Using a binomial table for n = 16, the chance of 14 of the structures being closer for Petra by chance would be only p = 0.002. Even if the underlying probability was 0.65, the chance of 14 of the structures aiming closer to Petra would be small, p = 0.035. Thus, probability suggests that, despite the closeness of the azimuths, Petra was most likely the target rather than Jerusalem for all of the structures. However, given that three structures clearly are aimed toward Jerusalem and seventeen others could be interpreted that way if one were to rule out Petra, one can see why some might claim that Jerusalem was an early qibla, perhaps before Mecca (if one is given the liberty of ignoring dates of construction).

Changes by Gibson in Assigned Qiblas

Gibson appears to have changed seven of his qibla designations (see Table 3). Cheramin Juma is listed as having an unknown qibla, although earlier it was identified with Petra; we have kept it as unknown because the azimuths assigned originally may have been incorrect. The Mosque of the Two Qiblas in Medina was listed as Petra, now of an unknown qibla, but we are calling it for Petra since that is the general direction it faced when first constructed. The mosque at Kairoun was initially unknown but is now classified as a parallel mosque, with which we agree. The Shrine of Kazmiyya has a qibla toward Jerusalem with an error of nine degrees, the next closest an error of over 19 degrees, but it has been listed by Gibson as unknown, but we are classifying its qibla as Jerusalem because that is the closest site. Qasr Muwaqqar was listed as "between" with an error of 7.5 degrees, the next closest an error of over 18 degrees; Gibson now lists it as unknown, but we classify it as between because its azimuth is not far from a between site. The Huaisheng mosque was listed as "between", though so distant from the Middle East that all potential qiblas were within seven degrees of each other; Gibson now lists it as unknown, but we are calling it for Petra, though we recognize that could be disputed. The Amra Bathhouse could be listed as "between" with an error of over 13 degrees, but Gibson now lists it as unknown, but we are classifying it as between as that is the closest azimuth. While the earliest qibla for the Fustat mosque remains Petra in our classification, Gibson now asserts that it changed from Petra to either "between" or "Mecca" about 714 C. E. However, it's earliest direction was not towards Mecca, so we are keeping its original qibla as Petra. Although Gibson recently listed the "Ka'ba" in Mecca as a site with a qibla of Petra (-4.5) and a date of construction of 697 C.E., it's between qibla is closer (-0.8) while the Meccan qibla (118.6) may not make sense since the site is in Mecca itself; thus, we are not including it in our series of sites.

The Um Walid Mosque is no longer listed by Gibson on his website, so we have deleted it from our database. The Kufa Grand Mosque is still listed on Gibson's website but without the azimuths as of 749 C.E., so we have not included it in our analyses, though it did appear previously to have had a Meccan qibla with 6.0 degrees of error.

With the added and changed sites, including the parallel qiblas, we have a new total in Table 1 of 116 sites with apparent geographically aligned qiblas, with the following counts for: Petra (37), Mecca (16), Between (32), Parallel (27), and Jerusalem (4), along with 30 unknown sites [6, four of which had known azimuths, included in Table 1, and 24 other sites with unknown qiblas previously listed.[21] With the six unknown sites, the total number of sites in our Appendix and our database becomes 122. Restricting the dates to between 620 and 900 C.E. and not counting the six unknown sites, reduces the available sites to Petra (33), Mecca (16), Between (32), Parallel (17), and Jerusalem (3), a total of 84.

Measurement

After our preliminary work, we turned to the question of how could the theories of Gibson and King be tested? First, we turned to the measurement issue to see whether similar levels of accuracy would be obtained for qiblas[22] with the addition of the new structures since it was possible that the addition of new structures might change the apparent accuracy of the qiblas. The results of our re-analyses, for sites with dates between 620 and 900 C.E., not using the unknown or parallel qibla sites, are presented in Table 4, with comparisons of the new results against the former results. The essential results remain the same – that measurement error is near zero for Gibson's and the Mutual theories while it is far more substantial and significantly different from zero for King's theory. In other words, early Islamic architects were quite capable of aiming their structures toward specific distant sites, with relative accuracy; while there may be multiple explanations for the apparent qiblas of Islamic structures, the idea that none of the early Muslim architects were capable of accurate qibla determination cannot be a valid explanation, given the results in Table 3.

Results

Changes over time

Having found that qibla measurement accuracy is essentially unchanged with the addition of the new data, we now turn to the issue of testing Gibson's theory about how mosque qiblas changed over time. Gibson proposed that for the first hundred or so years of Islam, most mosques faced Petra, then there was a "time of confusion" of about 50 years in which General Hajjaj directed that mosques face a point between Petra and Mecca, and then most mosques began to face Mecca[23] In Table 5, the qiblas are broken down by Gibson's time frames and tested with a chi-square test to see if the pattern found is different than what would be expected at random. The results support the idea that the pattern is non-random and that the qiblas did appear to change over the centuries in the general pattern proposed by Gibson. While any non-random pattern of qiblas might have yielded significant results, in Table 4 the significant results match Gibson's theory rather than other possible theories.

It is important to note from Table 1 that for the first 100 years of Islam, none of the Gibson sites were facing Mecca or Jerusalem, with far more facing Petra than "Between". For the next 52 years, there does appear to have been a time of "confusion" where Meccan qiblas were outnumbered by Petran and even more "Between" qiblas. However, after 775 C.E., almost all mosques (71.4%) appear to have faced Mecca. More mosques faced Jerusalem after the time of confusion than during it, suggesting that the idea of having mosques face Jerusalem came long after Muhammad had died and was perhaps a reaction to the material in the Qur'an possibly suggesting that Muhammad had originally prayed toward Jerusalem. Even so, from Table 1, it is seen that some mosques faced Petra as late as 1199-1294 C.E.

It is notable that some recent discoveries place archaeological findings about Islam within Petra's century, including an Islamic inscription from the year of Umar's death (644-645 CE), papyri with hijira dating (643 CE), silver coins with Muhammad's name (689-690 CE)[43], as well as coins with "the definitive symbolic representation of Islam and the Islamic empire (696-699 CE), a Qur'an dating to as early as 672-697 CE, and Islamic inscriptions dating to 653 CE as well as those inside the Dome of the Rock (690)[24]. Nicolai Sinai (2017, 46) has estimated that much of the Qur'an was available by the 650's.[25] In other words, it wasn't like Islam had not yet established itself before mosques began to consistently face Mecca. The great battle of Tours in France occurred in 732 C.E., well within the time frame of mostly Petran mosques. At the same time as Tours, Islam had conquered parts of Afghanistan, including Balkh. Feras Hamza has noted that by the year 711, "the Islamic state had become an empire stretching from Spain to India, heralding the advent of a major world civilization".[26] Discovering that Islam's empire had expanded tremendously while Petra remained its holiest city would be truly a remarkable finding, so remarkable that some may find it unacceptable, no matter the level of statistical/scientific evidence.

21. Walter R. Schumm, Direction of Prayers.

22. Gibson, Qur'anic Geography.

23. Gregor Schoeler, *The Biography of Muhammad: Nature and Authenticity*. (New York: Routledge, 2011).

24. Stefan Heidemann, "The Evolving Representation of the Early Islamic Empire and Its Religion on Coin Imagery," *in The Qur'an in Context: Historical and Literary Investigations into the Qur'anic Milieu*, ed. A. Neuwirth, Nicolai Sinai, & M. Mar (Boston: Brill, 2010).

25. Nicolai Sinai, The Qur'an: *A Historical-Critical Introduction*. (Edinburgh: Edinburgh University Press, 2017).

26. Feras Hamza, "Islam" in Encyclopedia of Islam and the Muslim World, 2nd ed., ed. Feras Hamza (Dubai: University of Wollongong Press, 2015), 537.

However, we were not content to close shop at this point. We believe that scientists should test alternative ideas that might be proposed by their critics. One argument could be that there are a considerable number of mosques whose original qiblas cannot be determined because the original foundations cannot be assessed and a number of parallel qibla mosques. Therefore, we added those mosques for a total of 131 structures rather than 84. Would our results still vary over time with similar patterns?

Table 6 reflects the changes that would result. However, the overall results are still significant statistically and across each time frame, the major qibla changes being from Petra to Between to Mecca. The relative percentage of parallel mosques increases over time while the percentage of unknown qibla mosques decreases over time. Even under this more severe test, the Petra hypothesis receives support. In a further analysis, for 100 sites, we could determine if the structure faced Mecca (k = 16, coded as zero) or not (k = 84, coded as 1; five sites, three for Petra and two for "between" were unclear in terms of facing Mecca or not and were not used here); the zero-order correlation between not facing Mecca and date of construction was -.431 ($p < .001$), a large effect[28] suggesting that in general, Meccan oriented structures were of later construction (using only structures dated between 620 and 900 C.E.) than other structures.

Dates of Construction and Qiblas

Another way to test Gibson's theory is to compare the mean/average dates of construction of the mosques as a function of their qiblas. If Gibson's theory is correct, the mean dates should be oldest for Petra, between for the "Between" mosques, and youngest for the Meccan mosques. We used a one-way analysis of variance to compare the average dates of construction statistically. The results are shown in Table 7.

The analysis of variance test yielded $F(5,125) = 16.02$ ($p < 0.001$) but the heterogeneity of variance was significant by a Levene test ($p < 0.001$), so we also calculated a more robust Welch test with 5, 18.22 degrees of freedom = 13.11 ($p < 0.001$). Thus, the results remained significant, even under more strict assumptions. How did the qiblas compare pairwise? Scheffe post hoc tests indicated that the mean date for Petra was significantly lower than that for Mecca ($p < 0.001$), and Parallel ($p < 0.001$). The mean date for Between sites was significantly lower than for Meccan sites ($p = 0.001$) and parallel sites ($p = 0.068$). The dates for the unknown qibla structures were lower than for the Meccan structures ($p < 0.001$). The mean date for the parallel sites was later than for the unknown sites ($p < 0.001$). The Between dates match the later years of General Al-Hajjaj ibn Yusuf (661-714 C.E.) but the approach of using a "between" qibla survived his passing by some years.

A Closer Examination of King's Theory

However, there is another alternative that must be examined in an attempt to refute Gibson's thesis. King has argued that Gibson and Schumm don't know how Meccan mosques face Mecca. In particular, King has argued that early mosques may have been aimed merely south (180) or west (270), for example, as general directions toward Mecca. Other general directions might have been north (0), east (90), or various rising or settings of the sun at winter (115/245) or summer (65/295); or directions taken from the azimuths of the Ka'ba (155/335)[29]. Altogether, that would lead to ten possibilities which would take up 100/360 degrees or 27.78 percent of possible azimuths, allowing for plus or minus five degrees for measurement error. We will not include unknown qiblas for which we do not have azimuths. Of the 105 qiblas thus used here, 39.05% (41/105) fell into one of the ten of King's possible explanations, which is a significantly larger percentage than 27.78%, $z = 2.58$ ($p < 0.005$)[30] (Charles Brase & Corrinne Brace, 2015, 468-471). Thus, King's theory explains a significantly higher percent of qiblas than would be expected from coincidence from his ten azimuths. If we allow for a twenty-degree range of error (+ 10o), then we would expect 55.56% (200/360) of the cases to fit King's theory but find that 69/105 fit (65.71%), a difference that is significant, $z = 2.09$, $p < 0.02$). Allowing for a thirty-degree range of error (+ 15o), then we must compare 83.33% (300/360) with 82.86% (87/105), $z = 0.13$, which is not significant. A more detailed analysis might include a wider variety of justifiable qibla azimuths (King, 2020: 15) as he shows some cities having five to seven different qiblas[31]; but parsimony must have some value or virtually any azimuth could be explained, within a range of plus or minus 15 to 20 degrees, as a legitimate azimuth for a qibla.

Within the 41 cases that fit King's ten-azimuth model, 43.9% involve a qibla of due south and another 14.6% involve a qibla parallel to the long axis of the Ka'ba or, alternatively, the azimuth from Petra to Mecca. The percentages that fit King's model vary by Gibson's qibla assignments: Petra (11/33, 33.33%), Mecca (3/16, 18.75%), Jerusalem (3/3, 100.00%), unknown (0/4), between (16/32, 50.00%), and parallel (8/17, 47.06%). To improve statistical power, we combined the results for Petra with Mecca and combined the other four qibla sites together. For Petran and Meccan data combined ($n = 49$), the difference from 27.78% (14/49, 28.57%) was not significant, $z = 0.12$, using ten degrees of error. Using up to twenty degrees of error, the difference between 55.56% and our raw data of 51.02% (25/49) remained non-significant, $z = 0.64$. Going up to thirty degrees of allowable error, our raw data (32/49, 65.31%) were less than what would be expected by chance (83.33%). For the other 56 cases, the difference of our raw data, 48.21% (27/56) from 27.78% was significant, $z = 3.41$ ($p < 0.001$). Going to 20 degrees of error, we had raw data of 44/56 (78.57%), $z = 3.46$ ($p < 0.001$); with 30 degrees of error, we obtained raw data of 55/56 (98.21%), with $z = 2.99$ ($p < 0.002$). Thus, King's ten-azimuth model did not work better than chance for Gibson's Meccan/Petran qibla sites but did seem to work better than chance for the other qiblas. Comparing the raw data for the two sets of qiblas, using up to ten degrees of error, we found that the difference between

28.57% (14/49) and 48.21% (27/56) was statistically significant, z = 2.06 (p < 0.02), suggesting that King's ten-azimuth model worked better for the Jerusalem/between/parallel sites than for the Meccan/Petran sites. Moving up to the 20 and 30 degrees of error comparisons, we obtained z = 2.93 (p < 0.002) and z = 4.46 (p < 0.001), respectively, again supporting the King model for the sites other than those deemed Petran/Meccan by Gibson.

Of the 49 cases that Gibson identified as having qiblas facing Mecca or Petra, two were closer to King azimuths by more than five degrees, 12 were tied (within two degrees of each other), and 35 favored Gibson's theory by more than two degrees (30 of which favored his theory by more than five degrees). Recoding the cases into favored King (k = 2), tied (k = 12), or favored Gibson (k = 35), a one-sample Chi-square test (df = 2) yielded a value of 35.06 (p < 0.001), indicating that Gibson's theory appeared to predict the raw data more often than did King's theory. With the other qiblas, excluding three that were not comparable, our split from King by more than five degrees to Gibson by more than five degrees involved 11, 4, 21, 6, and 11 cases, respectively. Using the same one-sample Chi-square test (df = 2) which yielded a value of 1.057, we obtained a non-significant result. Such a latter result may explain why a good argument could be made for King's model since of the 102 comparable tests, King's model worked as well (33 cases) or better (17 cases) in 50 cases whereas Gibson's model worked as well (33 ties) or better (52 cases) for 85 cases. Of the 33 structures that were Petran according to Gibson's theory, eight (24.24%) faced approximately due south, per King's theory; of the 16 Meccan structures, one faced approximately due south. As we did before, if we combine the Petran and Meccan structures, we have 18.37% (9/49) facing approximately south compared to half (28/56) of the remaining structures, a significant difference, z = 3.38 (p < 0.0005). One might object and argue that the Petran structures should be compared to all the rest, which yields z = 1.60 (p < 0.06) for 24.24% versus 40.28%. Either way, it's clear that the rule of "due south" qiblas does not explain away Petran qiblas even though it may help explain non-Petran qiblas, a rule that may explain some ancient Islamic worship sites in the Negev, many of which faced generally to the south[32].

Our analysis of variance test (Table 8) yielded F(6, 76) = 4.76 (p < 0.001) but the heterogeneity of variance was significant in two of four tests (p < 0.02), so we also calculated a more robust Welch test with 6, 14.05 degrees of freedom = 3.73, which remained significant (p = 0.02). Table 8's results indicate that the most common yet fairly early azimuth was due south but the inverse azimuths of 335 and 155 were significantly different in their average ages of their sites. However, the patterns in Table 7 are not as clear as the patterns in Table 6. The 53 cases involving 155 and 180 degree azimuths explain much of the differences among the azimuths as a one-sample chi-square test of all the ten azimuths (df = 9) was 123.23 (p < 0.001) compared to a one-sample chi-square test of eight azimuths (not including 155, 180) with df = 7, of 14.00, which was not significant (p = 0.051), a result that indicates that the azimuths are distributed equally within chance except for 155 and 180.

Can those two most frequent azimuths in King's theory explain away the Petran qiblas? None of the 155 azimuths account for any Petran qiblas. There are eight Petran qiblas that fall under King's 180 azimuth theory, but none better explain the qibla, two are tied, and six are closer to Petra by two or more degrees, five being better by at least five degrees. Thus, while King's theory may have some merit for explaining some qiblas, it does not seem to explain away the existence of some early Islamic structures that do seem to be aimed, geographically, toward Petra rather than toward any other sites.

However, what about the Meccan qiblas? How would King's theory explain those 16 qiblas? Gibson's theory is that the Meccan qiblas represent attempts of Muslim architects to face their buildings geographically towards Mecca. King would presumably argue that the 16 structures are not geographically oriented towards Mecca, but that each would fit one of his ten other possible ways of "facing" Mecca. Given an allowance of plus or minus five degrees, King's theory would expect 27.78% of the cases to fit his theory by chance; given plus or minus ten degrees, it would be 55.56% by chance. Three of the sixteen structures (see Table 1) do fit King's theory (azimuths of 159.46, 265.78, 241.23) within five degrees while five fit within ten degrees (adding 238.0 and 145.4). One would hope that King's results would be better than chance, otherwise his theory would not be explaining better than chance. Therefore, our null hypothesis is that the sample values (.1875 and .3125) are not greater than the expected chance values of .2778 and .5556, respectively. Using one-sample tests of proportion against the chance values, none of the tests rejected the null hypothesis in terms of the actual results being in support of King's theory beyond the chance levels. Another approach would be to conservatively assume that if King's theory worked, then Gibson's theory was false, even if the mosque did seem to point towards Mecca. For the five-degree range of error, we would have 3/16 (.1875) correct for King and 13/16 (.8125) for Gibson, which by a two-sample test of proportions would yield z = - 3.54, p < 0.0005, indicating support for Gibson's theory over King's. For the ten degree range of error, we would have 5/16 (.3125) versus 11/16 (.6875), yielding z = - 2.12, p < 0.04. In both examples, Gibson's theory seems to account for the qiblas at a higher rate. This not only lends weight to Gibson's theory but also suggests that the mosques that do seem to point geographically towards Mecca do so for geographical reasons rather than various qibla alignments with the Ka'ba. Furthermore, when degrees of error are compared, even in the five cases that would fit King's theory, Gibson's method yields smaller levels of error (2.4 vs. 4.22, 1.4 vs. 4.46, 3.2 vs. 3.77, 6.0 vs. 7.0, 9.3 vs. 9.6). If we assumed the chances of error were equal (50/50), the probability that all results (5/5) would favor Gibson are small (p = 0.031) by a binomial test.

Corroborating Evidence

Gibson (2017, 185-272) provides fifty corroborating reasons that are consistent with Petra as the original holy city of Islam.[33] For example, when Muhammad's enemies attacked Medina, they approached from the north (the direction from Petra) rather than from the south, even though they were supposed to be coming from Mecca, which is to the south of Medina. When Muhammad met with some dignitaries in Aqaba (Luce Coma) he was not far from "Mecca", but Petra was less than seventy miles away while Mecca was over nine times further away from Aqaba. Another story says a man rode by horseback to and from "Mecca" to Damascus in four days, which is possible from Petra but not Mecca, which would involve a distance at least three times greater than from Petra. There are numerous characteristics descriptive of "Mecca" that fit the terrain and structures in ancient Petra better than those in Mecca today. Gibson also argues that some of the stories in the history of Islam were slightly modified when Mecca's location didn't make sense in the story but that if Petra's location were used, the story would not have needed modification.

Other scholars have questioned whether Mecca fits the descriptions of the first Islamic holy city, that is, as Durie says "the original location of the Qur'anic community".[34] Crone questions the agricultural environment near Mecca as being suitable for growing the crops mentioned in descriptions of the holy city.[35] Shoemaker claims that the Qur'an's reference to the nativity of Jesus in Surah 19 came from a local Palestinian tradition.[36] Hawting has challenged the role of idolatry discussed in the Qur'an.[37] Sinai has presented similar arguments.[38] Mark Durie has made several similar claims: that "there is no physical evidence that Mecca existed at the time of Muhammad"; that the ancient ruins of Lut's cities were nearby Mecca (which fits Petra better than Mecca); that Roman cities (e.g., Jerusalem, Damascus) were nearby (which fits Petra but not Mecca); that Mecca lacks the winter chill needed for olives to set fruit (Qur'an 6:99, 13:4, 23:19); that Petra's citizens would have been more familiar with earthquakes than those in Mecca; and that the original dialect of the Qur'an reflects "the dialect of Palestina Tertia" rather than later Bedouin dialects.[39]

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30. Charles H. Brase & Corrinne P. Brase, Understandable Statistics: Concepts and Methods, 11th ed. (Stamford: Cengage Learning, 2015).

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Deeper Assessment

Because the material Tables 1-7 were derived from Gibson's theory, it is possible that we were merely fitting a pre-existing idea to the data from which the idea was derived. This is not unusual in science – a scholar observes a pattern and then tests the pattern against a random model to see if the apparent pattern is – or is not - within what might occur simply at random. However, it would be ideal to go beyond merely testing Gibson's theory against Gibson's data and test the theory without making assumptions about which sites were qibla targets. For example, it might be possible that some site not yet tested was the ultimate qibla and we missed it because it wasn't part of either Gibson's or King's theories. A theory that looked for two sites (Mecca and one other) and one angle (155) might find such a location, even if it wasn't mentioned by either Gibson or King. It is possible that in the future, such an approach might be developed. If so, such a model might be able also to reclassify many of Gibson's "between" or "parallel" sites as either Petran or Meccan. However, developing and testing such a model is beyond the scope of this report.

Table 1: Data Used for Analyses For 122 Qibla Sites.

Site name, location	Azimuth	Petra Error	Mecca Error	Gibson Theory	King Theory	Results Gibson v. King	Year (C.E.)
Qasr El-Bai'j, Desert Castle, Jordan	210.2	9.3	46.9	Petra	NA	Gibson/NM	410
Qiblatain Mosque, Medina, Saudi Arabia	335.00	-5.00	-177.00	Petra	335	King/NM	626
Al Mudhmar Mosque, Samail, Oman	293.5	-0.6	26.4	Petra	295	= (NM)	627
Cheraman Juma	304.3	0.26	75.01	Unknown	(295)	(King/NM)	629
Hama Great Mosque, Hama, Syria	193.87	0.6	25.8	Petra	NA	Gibson/NM	637
Palmyra Central Mosque, Palmyra, Syria	215.00	4.7	41.4	Petra	NA	Gibson/NM	640
Amr ibn –Al-As Mosque, Fustat, Egypt	90.00	6.1	-46.0	Petra	90	King/NM	642
Seven Sleepers Mosque, Amman, Jordan	196.03	-0.3	35.1	Petra	NA	Gibson/NM	650
Kilakarai Old Mosque Kilakarai, India				Unknown			650
Palaiya Jumma Palli, Kilakarai, India				Unknown			650
Jerash Umayyad Mosque, Jerash, Jordan	196.32	5.0	35.2	Petra	NA	Gibson/NM	650
Aqaba Umayyad Mosque, Aqaba, Jordan	36.24	10.8	-114.4	Petra	NA	Gibson/NM	650
Qasr Mushash, Desert Castle, Jordan	202.95	-4.1	40.6	Petra	NA	Gibson/NM	650
Zeila Qiblatain Mosque (Left), Zeila, Somalia	339.1	-0.6	-2.2	Petra	335	(Gibson)	650
Kathisma Church, Bethlehem, Israel	174.00	1.9	16.9	Petra	(180)	(Gibson)/NM	650

Massawa Mosque, Eritrea, Eritrea	340.5	-6.1	-22.7	Petra	(335)	= (NM)	650
Husn Umayyad Mosque, Husn, Jordan	190.00	0.0	28.6	Petra	(180)	Gibson/NM	650
Sidi Ghanem Mosque, Mila, Algeria	187.68	92.0	79.7	Parallel	(180)	King/NM	678
Graveyard of Sidi 'Ukba, Biskra, Algeria	127.38	35.6	22.3	Parallel	((115))	King/NM	686
Qasr Humeima, Humeima, Jordan	20.64	8.5	-133.0	Petra	NA	Gibson/NM	687
Zawailah Congregational Mosque, Zawailah, Libya	123.00	50.8	26.4	Parallel	(115)	King/NM	688
Dome of the Chain Mosque, Jerusalem, Israel	172.03	-1.0	14.7	Petra	(180)	Gibson/NM	690
San'a Grand Mosque, San'a, Yemen	333.60	0.4	7.4	Petra	335	=(NM)	705
Khirbat al Minya, Khirbat al Minya, Israel	182.67	0.8	22.1	Petra	180	= (NM)	706
Hajjaj Mosque, Wasit, Iraq	234.98	-26.5	25.3	Between -7.64	(245)	(Gibson)/NM	706
Masjid al-Tarik Khana, Damghan, Iran	249.56	-5.6	25.0	Between 5.0	245	= (NM)	708
Al Aqsa Mosque, Jerusalem, Israel	169.61	-3.4	12.3	Petra	(180)	Gibson/NM	709
Damascus Umayyad Mosque, Damascus, Syria	177.21	-16.0	12.5	Between -1.1	180	= (NM)	709
Qasr Al Kharana, Desert Castle, Jordan	175.01	-37.3	12.1	Between -4.4	180	= (NM)	710
Amman Umayyad Mosque, Amman, Jordan	181.50	-13.2	20.7	Between 7.7	180	King (NM)	710
East Qasr, Um Walid, Jordan	203.00	6.3	42.9	Petra	NA	Gibson/NM	712
West Qasr, Um Walid, Jordan	181.50	-15.1	21.4	Between 8.6	180	King (NM)	712
East Qasr Mosque, Um Walid, Jordan	181.50	-15.3	21.4	Between 8.6	180	King (NM)	712
Khann al Zabib, Qatrana, Jordan	171.93	-33.8	11.1	Between -3.2	(180)	Gibson/NM	712
Humeima Small Mosque, Humeima, Jordan	166.00	153.9	12.3	Between 7.0	((155))	Gibson/NM	712

Khirbat al Mafjar, Jericho, Israel	180.03	-0.6	21.5	Petra	180	= (NM)	714
Anjar Mosque, Anjar, Lebanon	190.76	3.6	27.4	Petra	((180))	Gibson/NM	714
Aleppo Umayyad Mosque, Aleppo, Syria	178.70	-15.5	8.4	Between -5.0	180	(King)	715
Qasr Qastal, Qastal, Jordan	191.74	-5.2	31.2	Petra	((180))	Gibson/NM	720
Mosque of 'Umar, Bosra, Syria	183.63	-18.7	18.4	Between 3.9	180	= (NM)	721
Qasr Muwaqqar, Muwaqqar, Jordan	182.98	-18.2	21.6	Between 7.5	180	(King/NM)	723
Muwaqqar Graveyard, Muwaqqar, Jordan	198.11	-3.03	36.73	Petra	NA	Gibson/NM	723
Palmyra Congregational Mosque, Palmyra, Syria	187.00	-23.3	13.4	Between -5.1	(180)	= (NM)	724
Qasr al Hayr al Gharbi, Desert Castle, Syria	191.01	-13.9	20.3	Between 3.3	((180))	Gibson (NM)	726
Banbhore Mosque, Banbhore, Pakistan	265.78	-22.6	-2.4	Mecca	270	=	**727**
Qasr Hayr al Sharqi, Desert Castle, Syria	192.61	-21.2	15.6	Between -3.7	((180))	Gibson (NM)	728
Amman Umayyad Palace, Amman, Jordan	159.46	-35.2	-1.4	Mecca	155	(Gibson)	730
Jami' al-Zaytuna, Tunis, Tunisia	145.00	45.3	32.4	Parallel	(155)	= (NM)	732
Ba'albeck Mosque, Baalbeck, Lebanon	176.86	-13.4	12.0	Between -0.8	180	(Gibson/NM)	740
Qasr Mushatta, Desert Castle, Jordan	195.13	-4.1	34.3	Petra	NA	Gibson (NM)	743
Qasr Bayir, Desert Castle, Jordan	166.67	-81.6	4.2	Mecca	((155))	Gibson	743
Amra Bathhouse, Desert Castle, Jordan	194.49	-19.5	30.8	Between 13.6	((180))	= (NM)	743
Qasr Tubah, Desert Castle, Jordan	292.02	67.4	129.2	Jerusalem 0.0	295	(Gibson/NM)	743
Harran University & Mosque, Harran, Turkey	191.74	-13.9	14.5	Between -1.5	((180))	Gibson (NM)	744
Um Jimal Later Castellum, Um Jimal, Jordan	203.30	1.1	39.6	Petra	NA	Gibson/NM	749

Yogharta Mosque, Beni Bouabdellah, Morocco	153.65	66.4	55.2	Parallel	155	= (NM)	750
Abdul Qader Yagouri Mosque, Beni Abbes, Algeria	114.65	34.7	21.8	Parallel	115	King (NM)	750
Sahi Ramdah Mosque, Bowshar, Oman	292.79	-0.6	26.2	Petra	295	= (NM)	750
Qiblatain Mosque, Ibra, Oman	294.00	-1.2	24.6	Petra	295	= (NM)	750
Barwada Mosque, Gujarat, India	286.00	-6.5	10.4	Between -1.0	(295)	Gibson (NM)	750
Al-Sawaf Mosque Grounds, Erbil, Iraq	234.35	1.2	39.4	Petra	((245))	Gibson (NM)	750
Masjid Al-Zidani Umayyad Mosque, Tibnah, Jordan	170.50	-16.1	9.8	Between -1.9	(180)	Gibson	750
Yamama Great Mosque, Yamama, Saudi Arabia	280.45	-22.3	30.7	Between -9.3	((270))	= (NM)	750
Um Jimal Ummayad Mosque, Um Jimal, Jordan	180.00	-21.9	16.6	Between 1.4	180	= (NM)	750
Qasr Al Fudayn, Mufraq, Jordan	178.19	-19.9	15.5	Between 1.3	180	= (NM)	750
Qasr Ain as-Sil, Azraq, Jordan	180.30	-37.6	15.3	Between -3.4	180	(King/NM)	750
Azraq Fort Mosque, Azraq, Jordan	184.81	-33.0	19.9	Between 1.3	180	(Gibson/NM)	750
Bazaar Qaisariya, Erbil, Iraq	218.53	-14.6	23.5	Between 0.9	NA	Gibson/NM	750
Qasr Aseikhin, Desert Castle, Jordan	163.89	-55.2	-1.7	Mecca	(155)	Gibson	750
Huaisheng Mosque	291.66	-3.3	7.1	Petra	295	=	750
Bibi Samarkand Mosque, Samarkand, Uzbekistan	261.64	1.8	21.9	Petra	(270)	Gibson/NM	750
Kilwa Mosque, Kilwa, Tanzania	356.00	1.5	-4.6	Petra	0	(Gibson)	750
Kashan Jamia, Kashan, Iraq	248.00	-11.3	25.8	Between 1.6	245	= (NM)	750
Siraf Early Mosque, Siraf, Iran	282.10	-2.2	38.2	Petra	((270))	Gibson (NM)	750

Aydoun Grand Mosque, Aydoun, Jordan	174.00	-15.4	12.6	Between 0.3	(180)	Gibson (NM)	750
Sal Mosque, Sal, Jordan	172.00	-18.3	10.3	Between -2.3	(180)	Gibson (NM)	750
Bushra Great Mosque, Bushra, Jordan	175.00	-15.0	13.4	Between 0.9	180	(Gibson/NM)	750
Mosque of Mansur, Baghdad, Iraq	200.03	-51.1	0.00	Mecca	NA	Gibson	762
Qasr Ukhaydir, Kufa, Iraq	198.24	-57.1	0.40	Mecca	NA	Gibson	764
Ribat Fortress, Ribat, Tunisia	182.59	84.9	71.00	Parallel	180	King (NM)	770
Tauste Graveyard, Tauste, Spain	150.00	50.5	42.1	Parallel	155	= (NM)	772
Raqqa Mosque, Raqqa, Syria	193.90	-15.2	16.9	Between -0.6	((180))	Gibson/NM	772
Cordoba Mosque, Cordoba, Spain	157.12	66.5	56.8	Parallel	155	= (NM)	784
Najaf Graveyard, Najaf, Iraq	256.82	-3.0	55.1	Petra	((245))	Gibson/NM	786
Ali Shrine, Najaf, Iraq	267.00	7.1	65.2	Jerusalem -3.8	270	= (NM)	786
Ghaen Jamia, Ghaen, Iran	253.7	-13.2	14.5	Between -4.1	(245)	(Gibson/NM)	796
Shrine of Kazmiyya, Baghdad, Iraq	269.73	19.3	70.1	Jerusalem 9.0	270	King/NM	799
Dougga Mosque, Dougga, Tunisia	175.55	77.6	64.6	Parallel	180	King/NM	800
Iman Riza Shrine, Mashhad, Iran	228.00	-32.5	-6.6	Mecca	NA	Gibson	817
Al-Asha'ir Mosque, Zabid, Yemen	348.97	11.9	13.1	Unknown	((0)) ((335))	Unknown/ NM	820
Qasr Hallabat Mosque, Desert Castle, Jordan	163.55	-40.0	0.70	Mecca	(155)	Gibson	827
Qasr Hallabat, Desert Castle, Jordan	142.72	-60.8	-20.1	Unknown	((155))	Unknown /NM	827
Moulay Idriss II Tomb and Mosque, Fez, Morocco	167.9	83.0	72.00	Parallel	((155)) ((180))	Unknown/ NM	828
Jami' Uqba ibn Nafi', Kairoun, Tunisia	148.1	51.2	37.3	Parallel	(155)	= (NM)	836

Great Mosque of Samarra, Samarra, Iraq	197.79	-46.0	1.10	Mecca	NA	Gibson	847
Great Mosque of Susa, Susa, Tunisia	161.89	64.2	50.3	Parallel	(155)	= (NM)	850
Great Mosque of Sfax, Sfax, Tunisia	153.5	58.4	43.6	Parallel	155	= (NM)	850
Small Mosque with Graveyard, Houmt Souk, Tunisia	148.0	55.1	39.5	Parallel	(155)	= (NM)	850
Ansaq Friday Mosque, Ansaq, Iran	207.11	-27.8	4.2	Mecca	NA	Gibson	850
Masjid i Jami' Fahraj, Fahraj, Iran	213.4	-56.6	-22.0	Mecca	NA	Gibson	850
Nine Domed Mosque, Balkh Province, Afghanistan	241.23	-24.2	-3.2	Mecca	245	=	850
Al-Balid Mosque, Salalah, Oman	285.05	-26.3	-5.3	Mecca	(295)	(Gibson)	850
Congregational Mosque, Siraf, Iran	238.0	-46.3	-6.0	Mecca	(245)	=	850
University of al-Qarawiyyin Mosque, Fez, Morocco	163.9	79.0	68.0	Parallel	(155)	= (NM)	859
Abu Dulaf Mosque, Samarra, Iraq	191.57	-51.0	-4.60	Mecca	((180))	Gibson	859
Mosque of the Three Doors, Kairoun, Tunisia	158.65	61.7	47.9	Parallel	155	= (NM)	866
Great Mosque of Shibam, Shibam, Aqyan, Yemen	341.12	18.8	36.4	Unknown	(335)	King (NM)	871
Ibn Tulun Mosque, Cairo, Egypt	145.4	61.2	9.3	Mecca	(155)	=	876
Great Mosque of Mahdia, Mahdia, Tunisia	146.19	55.9	44.2	Parallel	(155)	= (NM)	916
Medjes el Bab, Beja, Tunisia	129.8	31.1	18.4	Parallel	((115))	King (NM)	944
Kairoun Great Mosque, Kairoun, Tunisia	144.29	47.4	33.6	Parallel	((155))	= (NM)	1000
Great Mosque of Sale, Sale, Morocco	124.0	40.0	29.4	Parallel	(115)	King (NM)	1028
Udayas Graveyard, Udayas, Morocco	143.0	59.0	48.4	Parallel	((155))	= (NM)	1150
Kasbah Citadel Mosque, Udayas, Morocco	155.00	71.0	60.4	Parallel	155	= (NM)	1151

Koutoubia Mosque, Marrakech, Morocco	159.00	78.7	67.6	Parallel	155	= (NM)	1184
Kasbah Mosque, Marrakech, Morocco	159.00	78.7	67.6	Parallel	155	= (NM)	1184
Hassan Tower Mosque, Rabat, Morocco	155.00	71.0	60.4	Parallel	155	= (NM)	1195
Grand Mosque of Tangier, Tangier, Morocco	137.98	51.0	40.8	Parallel	NA	Unknown/ NM	1196
Sultan Yacoub Tomb, Sultan Yacoub, Lebanon	188.00	1.8	25.0	Petra	(180)	Gibson (NM)	1199
Sultan Yacoub Mosque, Sultan Yacoub, Lebanon	188.00	1.8	25.0	Petra	(180)	Gibson (NM)	1199
Harat Great Mosque, Harat, Afghanistan	271.85	4.5	29.3	Jerusalem 0.8	270	= (NM)	1200
Mansouri Grand Mosque, Tripoli, Lebanon	182.00	-2.8	18.1	Petra	180	= (NM)	1294

Legend:

= indicates that two theories are within two degrees of each other in terms of qibla accuracy

(King) indicates that King's theory is between two and five degrees better than Gibson's theory

(Gibson) indicates that Gibson's theory is between two and five degrees better than King's theory

King or Gibson indicates that the scholar's theory more than five degrees more accurate than the other's theory.

180 indicates that the qibla is within five degrees of the azimuth given.

(180) indicates that the qibla is within ten degrees of the azimuth given

((180)) indicates that the qibla is within fifteen degrees of the azimuth given.

NM indicates that the qibla does not point within ten degrees of Mecca.

Table 2: 34 New Gibson Qibla Sites as of 15 November 2020

Name	DATE (C.E.)	Location	Azimuth/ arest Qibla	Error Petra	Error Mecca	Error Jerusalem	Error Between
Palmyra Congregational Mosque	724	Palmyra, Syria	187/Between	-23.3	13.4	-36.3	-5.1
Najaf Graveyard	786	Najaf, Iraq	256.82/Petra	-3.0	55.1	-13.8	19.9
Kilwa Mosque	750	Kilwa, Tanzania	356/Petra (?)	1.5	-4.6	1.5	0.5
Congregational Mosque, Siraf	850	Siraf, Iran	238/Mecca	-46.3	-6.0	-51.6	-34.0
Ali Shrine	786	Najaf, Iraq	267/Jerusalem	7.1	65.2	-3.8	29.9
Al Mudhmar Mosque	627	Samail, Oman	293.5/Petra	-0.6	26.4	-4.3	7.5

Palmyra Central Mosque	640	Palmyra, Syria	215/Petra	4.7	41.4	-8.3	22.9
Massawa Mosque	650	Eritrea, Eritrea	340.5/Petra	-6.1	-22.7	-6.8	-6.7
Siraf Early mosque	750	Siraf, Iran	282.1/Petra	-2.2	38.2	-7.5	10.1
Husn Umayyad Mosque	650	Husn, Jordan	190/Petra	0.0	28.6	-27.7	16.1
Iman Riza Shrine	817	Mashhad, Iran	228/Mecca	- 32.5	-6.6	-36.5	-23.8
Masjid Al-Zidani Umayyad Mosque	750	Tibnah, Jordan	170.5/Between	-16.1	9.8	-40.4	-1.9
Aydoun Grand Mosque	750	Aydoun, Jordan	174/Between	-15.4	12.6	-42.1	0.30
Sal Mosque	750	Sal, Jordan	172/Between	-18.3	10.3	-44.0	-2.3
Bushra Grand Mosque	750	Bushra, Jordan	175/Between	-15.0	13.4	-40.8	0.9
Barwada Mosque	750	Gujarat, India	286/Between	-6.5	10.4	-9.0	-1.0
Sultan Yacoub Tomb	1199	Sultan Yacub, Lebanon	188/Petra	1.8	25.0	-7.9	13.2
Sultan Yacoub Mosque	1199	Sultan Yacub, Lebanon	188/Petra	1.8	25.0	-7.9	13.2
Mansouri Grand Mosque	1294	Tripoli, Lebanon	182/Petra	-2.8	18.1	-9.0	6.8
East Qasr	712	Um Walid, Jordan	203.00/Petra	6.3	42.9	80.3	30.1
West Qasr	712	Um Walid, Jordan	181.50/Between	-15.1	21.4	-102.0	8.6
East Qasr Mosque	712	Um Walid, Jordan	181.50/Between	-15.3	21.4	-101.70	8.6
Humeima Small Mosque	712	Humeima, Jordan	166.00/Between	153.9	12.3	169.00	7.1
Kashan Jamia	750	Kashan, Iraq	248.00/Between	-11.3	25.8	17.3	1.6
Ghaen Jamia	796	Ghaen, Iran	253.70/Between	-13.2	14.5	-17.4	-4.1
Muwaqqar Graveyard	723	Muwaqqar, Jordan	198.11/Petra	-3.03	36.73	-67.47	22.63
Kilaka-rai Old Mosque	650	Kilakarai, India	Unknown				

Palaiya Jumma Palli, Kilakarai, India	650	Kilakarai, India	Unknown				
Zawailah Congregational Mosque	688	Zawailah, Libya	123.0/Parallel	50.8	26.4	41.1	55.4
Udayas Graveyard	1150	Udayas, Morocco	143.0/Parallel	59.0	48.4	61.3	54.7
Kasbah Citadel Mosque	1151	Udayas, Morocco	155.0/Parallel	71.0	60.4	73.3	66.7
Koutoubia Mosque	1184	Marrakech, Morocco	159.0/Parallel	78.7	67.6	81.0	74.3
Kasbah Mosque	1184	Marrahech, Morocco	159.0/Parallel	78.7	67.6	81.0	74.3
Hassan Tower Mosque	1195	Rabat, Morocco	155.0/Parallel	71.0	60.4	73.3	66.7

Note: The errors for the "between" and Jerusalem qiblas for the other sites in Table 1 were presented previously (Schumm, Direction of Prayers)[46].

46. Walter R. Schumm, "How Accurately Could Early (622-900 CE) Muslims Determine the Direction of Prayers (Qibla)?," Religions, 11, no. 3 (2020): 102.

Table 3: Changes/Reassignments of Qiblas.

Site	Date (C.E.)	Original Qibla Assigned By Gibson/His Latest Qibla Assignment	Our Qibla Assignment Table 1
Cheramin Juma	650	Petra/Unknown	Unknown
Mosque of Two Qiblas	626	Petra/Unknown	Petra
Ugba bin Nafi (Kairoun)	836	Unknown/Parallel	Parallel
Shrine of Kazmiyya	799	Parallel/Unknown	Jerusalem
Qasr Muwaqqar	723	Between/Unknown	Between
Huaisheng Mosque	750	Between/Unknown	Petra
Amra Bathhouse	743	Between/Unknown	Between

Table 4: Measurement Results Using Old and New Gibson Data, Comparing Gibson's and King's Theories with Additional Results For Sites Clearly Facing Only Mecca (Mutual Theory).

Statistics	Gibson's Theory, Old N = 60	Gibson's Theory, New N = 84	King's Theory, Old N = 60	King's Theory, New N = 84	Mutual Theory, Old, N = 14	Mutual Theory , new N = 16
Mean	0.156	-0.065	13.03	12.33	-0.341	-2.08
Median	0.050	-0.450	15.55	15.40	-0.680	-1.55
Standard Deviation	4.07	5.20	33.93	37.13	4.184	6.77
Standard Error	0.526	0.567	4.38	4.05	1.118	1.69
One-Sample t-test versus mean of zero	$t(59) = 0.297$, n.s.	$t(83) = -.114$, n.s.	$t(59) = 2.97$, $p = .004$	$t(83) = 3.04$, $p = .003$	$t(13) = -0.305$, n.s.	$t(15) = -1.23$, n.s.
Percentages						
± 1	26.7	22.6	5.0	3.57	21.4	18.75
± 2	51.7	41.7	10.0	7.14	42.9	37.50
± 3	61.7	50.0	13.3	9.52	50.0	43.75
± 5	81.7	73.8	20.0	15.5	78.6	68.75
± 20	100.0*	98.8**	55.0	51.2***	100.0	93.75

*98.7% were within + 10 degrees; ** 97.6% were + 11 degrees; *** 25.0% were within + 10 degreeS

Table 5: Changes in Qiblas Over Time From 622 To 900 C.E. For 84 Structures.

Time Frame (C.E.)	Petra	Between	Mecca	Jerusalem	Totals
622-722	22 (66.7%)	11 (33.3%)	0	0	33
723-775	10 (27.0%)	20 (54.1%)	6 (16.2%)	1 (2.7%)	37
776-900	1 (7.1%)	1(7.1%)	10 (71.4%)	2 (14.3%)	14
Totals	33	32	16	3	84

Chi-Square (df = 6) = 49.95, p < 0.001

Table 6: Changes in Qiblas Over Time From 622 To 900 C.E. For 131 Structures, Adding Unknown and Parallel Qibla Sites

Time Frame (C.E.)	Petra	Between	Mecca	Jerusalem	Parallel	Unknown	Totals
622-722	22(42.3%)	11(21.2%)	0	0	3(5.8%	16(30.8%)	52
723-775	10(18.9%)	20(34.4%)	6(11.3%)	1(1.9%)	5(9.4%)	11(20.8%)	53
776-900	1(3.8%)	1(3.8%)	10(38.5%)	2(7.7%)	9(34.6%)	3(11.5%)	26
Totals	33	32	16	3	17	30	131

Chi-Square (df = 10) = 60.72, p < 0.001

Table 7: Analysis of Variance Of Dates Of Construction Of Sites as a Function of Qiblas Per Gibson's Theory.

Qibla City	N	Mean (C.E.)	SD	Minimum (C.E.)	Maximum (C.E.)	LSD post hoc tests
Petra	33	696.36	47.54	626	786	A
Unknown	30	705.83	67.89	622	871	A
Between	32	735.06	21.65	706	796	B
Jerusalem	3	776.00	29.31	743	799	B, C
Parallel	17	785.24	64.08	678	866	C
Mecca	16	809.50	53.08	727	876	C
Total	131	735.16	64.55	626	876	

Note: LSD post hoc tests that yielded non-significant differences (p > 0.05) are shown by identical letters; all other comparisons were significantly different (p < 0.05).

Table 8: Analysis of Variance of Dates of Construction of Sites as a Function of Qibla Azimuths Per David King's Theory.

Qibla Azimuth	N	Mean (C.E.)	SD	Minimum (C.E.)	Maximum (C.E.)	LSD post hoc tests
335	5	700.40	99.68	626	871	A
115	3	708.00	36.39	686	750	B
295	8	731.13	72.67	627	850	C
180	37	732.11	40.60	650	859	D
270	6	760.33	26.78	727	799	
245	8	774.50	56.45	706	850	A,D
155	16	801.88	57.80	712	876	A,B,C,D
Total	83	748.81	60.02	626	876	

Note: Only azimuths with at least three cases analyzed. LSD post hoc tests that yielded significant differences (p < .05) are shown by identical letters; all other comparisons were not significantly different (p > .05).

Limitations

Our analyses are limited in that they are testing extant models and are limited to data provided by Gibson (www.nabataea.net). Furthermore, only structures dated between 620 and 900 C.E. were used for most of our analyses. As Gibson continues to add new data to his list of mosques and their qiblas, as well as revising his data internally, the analyses here will become outdated, but can always be re-tested with the latest data. Our analyses assume that Gibson's azimuths have been measured correctly, which would be a limitation to any extent to which his azimuths were not correct.

Overall Conclusion and Implications

We think that our examples can show how science and statistics can be used to challenge traditional narratives in religious history. As another possible example of using statistics with respect to religious history, it might be possible to narrow down some of the possibilities for the author of the letter to the Hebrews using statistics.[40] One might be able to compare the infancy narratives in the gospels according to Matthew and Luke.[41]

Here we have found evidence in favor of both the models of Gibson and of King and against the null hypothesis. That also means that we did not find one hundred percent support for either model. Overall, we think the evidence favors Gibson's model but the key difference may be the issue of parsimony. In King's model, one has to accept a complex set of ways of defining the qibla with up to ten azimuths that might represent a way to define a qibla or align with the sacred Ka'ba. In Gibson's model, one has only to define four sites (Mecca, Petra, Between, and Jerusalem) and one angle (parallel) to fit the directions of structures to a model. In sum, we think that our statistical evidence greatly strengths the arguments in favor of Gibson's theory that the original holy city of Islam was Petra rather than Mecca, that Petra was where Islam was founded.

But that is not the end of the story by any means. Perhaps those who disagree might assemble better statistical evidence in favor of Mecca as the original city – that is, discredit Gibson's theory in a scholarly way. Perhaps there is a better theory than either King's or Gibson's that has yet to be developed. Perhaps future studies of the origins of the Qur'an or of early Islamic military history may shed more light on these theories.

Perhaps those scholars who have made no mention of Petra or have omitted Petra from maps of the Middle East in the seventh century[42] will be proven wise. We did not pinpoint a date from which mosques began to face Mecca geographically, but Deus has asserted that the change occurred between 743 and 745 C. E. Perhaps Deus's theory will also be proven incorrect.

Our findings may also need to be tested in light of military history. If Muslims were based in Mecca or even Medina, then the Byzantines would have had the advantage of interior lines as well as better technology and greater numbers of combatants. Yet if Muslims were based from Petra, then the distance from Constantinople to Aleppo was about the same as from Petra to Aleppo, giving the Muslims, with respect to Palestine and Syria, the advantage of interior lines, as well as their higher morale and more enthusiastic leadership,[44] which together would help explain their rapid conquests of those areas. In particular, the distance from Petra to Jerusalem was over eight times closer than from Jerusalem to Mecca.

For example, the battle of Mu'ta in 629 C. E. occurred only 60 miles northeast of Petra[45], which was much closer than to Medina or Mecca. Likewise the battle of Dathin near Gaza (634 CE) was about 90 miles from Petra, again much closer than to Medina or Mecca. It would also mean, for example, that Muslims had a great advantage with respect to taking Egypt, with Petra closer to Egypt than Byzantine forces in northern Syria would have been. Better interior lines would have improved their logistical support as well as their communications. Furthermore, the population of Petra was likely larger than that of Mecca in the seventh century C.E., which would help explain the size of the Muslim armies more easily than if they had to depend on population sources from further south. In addition, their recruiting pool would have been more "local" and neighboring tribes might have been more reluctant to join with the Byzantine Greeks against their nearby Arab/Semitic neighbors. Given that Petra had been a religious center for a long time, it would have made sense that a great prophet of God would come from there, as opposed to from a more distant site, enhancing the credibility of Islam in the eyes of local, nearby inhabitants. But we have not tested such a theory; it remains speculative. However, it might befit others to test it in a more scientific manner.

40. Walter R. Schumm, "A Discriminant Analysis of Whissell's New Testament Data: On the Statistical Trail of the Author of Hebrews," Psychological Reports, 98, no. 1 (2006): 274-276.

41. Janice C. Anderson, "Mary's Difference: Gender and Patriarchy in the Birth Narratives," The Journal of Religion 67, no. 2 (1987): 183-202; Marie E. Isaacs, "Mary in the Lucan Infancy Narrative," The Way 25 (1975): 80-95; Suleiman A. Mourad, "From Hellenism to Christianity and Islam: The Origin of the Palm-Tree Story Concerning Mary and Jesus in the Gospel of Pseudo-Matthew and the Qur'an," Oriens Christ 86 (2002): 206-216. Walter R. Schumm, Duane W. Crawford, Paul E. Barkey, Daniel Bush, and Daniel W. Bosch, "Using Statistics to Analyze Anthropological/Religious Issues from the Distant Past," Insights of Anthropology 5, no. 1: 337-346.

42. Richard W. Bullet, "The Origins of Islam," in The Earth and Its Peoples: A Global History, 5th ed., Richard W. Bullet ed. (Boston: Wadsworth, 2011); Hazleton, After the Prophet; Alexander Wain and Mohammed Haskim Kamali, The Architects of Islamic Civilization (Selangor, Malaysia: Pelanduk, 2017).

43. Amon Jason Deus, Sura 2: *Many Qiblas*?

44. Peter Boxhall, "Arab Generalships: Part 1: Muhammad the Prophet," Army Quarterly and Defence Journal 122 (1992): 434-440; Peter Boxhall, "Arab Generalships: Part 2: Khalid ibn Walid," Army Quarterly and Defence Journal 123 (1993): 70-77; Peter Boxhall, "Arab Generalships: Part 3: 46. War in the Western Desert," Army Quarterly and Defence Journal 123 (1993): 157-165.

45. Walter E. Kaegi, Byzantium and the Early Islamic Conquests (New York: Cambridge University Press, 1991).

Furthermore, we have not performed more definitive tests. One should be able to select known geographical points or azimuths and determine which of several possible models leads to the greatest reduction in error in terms of explaining known qiblas. It might even be possible to pinpoint the most logical center of early Islam with more complex statistical modeling than used here. Thus, for so many reasons, further research may be appropriate for a continued assessment of Gibson's, King's, or others' theories about early Islamic history and its origins. We hope that our paper serves to encourage others to apply various forms of statistics to critical tests for resolving similar historical problems with other religions and other historical time periods.

Does Gibson's category of "between" mosques make sense? To answer that question, we used the data from Table 1 for all the "between" mosques/sites except for Humeima Small Mosque, which clearly seemed to be an outlier. First, we compared Petran and Meccan errors for 31 "between" mosques and obtained a mean of -18.73 (SD = 7.88) for the Petran error and a mean of 17.41 (SD = 6.07) for the Meccan error, with $t(30) = -21.06$, $p < .001$. Then we averaged the Petran and Meccan errors and compared that mean score against Gibson's error for the "between" mosques. The mean for Gibson's "between" mosque errors was 0.36 (SD = 5.11) compared to our average, mean of -0.66 (SD = 5.16), $t(30) = 1.11$ ($p = .276$), with a correlation of 0.503 ($p = .004$). Thus, on average, Gibson's "between" mosques did face almost exactly between azimuths for Petra and Mecca. We also correlated the dates of construction with Petran and Meccan errors for the "between" mosques, with nonsignificant correlations of $r = 0.135$ and -0.093, respectively, indicating a possible but slight trend towards Mecca and away from Petra for the more recent "between" mosques. The "between" errors correlated -0.191 with dates of construction, a non-significant result, possibly indicating a slight trend for greater "between" accuracy for more recent "between" mosques.

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Conflict of Interest

No conflict of interest.