Positive Instances of Reinstatement

Dawson and McGaugh (*1*) have reported data that do not confirm that of Misanin, Miller, and Lewis (*2*). Their experiment seems an exact replication, except in one detail. They report that fear conditioning was given to rats in a light grey box and reinstatement in a black box. Our experiment used very different chambers for these two operations, and we went to considerable lengths to make these differences greater than that between grey and black. Dawson and McGaugh state that they are aware of the importance of these differences, yet they fail to maximize the difference between fear conditioning and reinstatement. However, the importance of this failure is not clear.

Failures to replicate an experiment can occur for a variety of reasons, and a single such failure is not convincingly negative to the phenomenon in question. If the phenomenon, or one like it in principle, has been found in other laboratories, then the idiosyncrasies of a negative effort are not important. Fortunately, the phenomenon of reinstatement has been seen in other laboratories. Sherman and Schneider (*3*), for example, found that they could obtain amnesia 6 hours after learning if the foot shock—the occasion for original learning—was reinstated immediately before the convulsive shock. Davis and Klinger (*4*) found that amnesia was produced by intracranial administration of puromycin, acetoxycycloheximide, or potassium chloride 24 hours after learning, if their subjects were replaced in the experimental situation for a brief period just before being injected. An experiment by Robbins (*5*) also found a strong reinstatement effect.

The notion of reinstatement is finding therapeutic application. Rubin (*6*) has reported considerable clinical success in eliminating neurotic symptoms by pairing the evocation of the symptom with a single convulsive current. Success was obtained with patients who had previously undergone a long series of electroconvulsive treatments but without the essential reinstatement of the symptom immediately prior to convulsion. The phenomenon is still a new one, but the confirmations outnumber the denials in *Science*.

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8 September 1969

Canterbury Cathedral: An Alternate Explanation of Its Plan

Borst (*1*) has given an interesting explanation for some of the skewness and geometry found in the plan of Canterbury Cathedral. He proposes that (i) the Trinity chapel preserves the shape and orientation of a megalithic monument originally located under the chapel and that this monument had its main axis aligned with the rising point of Betelgeuse (Alpha Orionis) in 2300 B.C.; (ii) the axis of the choir preserves the alignment of a second, more westerly, and more recent monument aligned on the rising point of Betelgeuse in 1900 B.C.; (iii) the axis of the nave preserves the alignment of yet a third monument aligned on the rising point of Betelgeuse in 1500 B.C. Unfortunately, there are some difficulties with this thesis.

Borst suggests that the present Trinity chapel preserves the shape of an ancient megalithic monument similar to Woodhenge (which is based on a Pythagorean triangle with sides of 12 and 35 and hypotenuse of 37 when measured in megalithic yards; 1 megalithic yard = 0.829 m) but based on a near Pythagorean triangle with sides of 12 and 72 and hypotenuse of 73 megalithic yards. This is a slender triangle, having a ratio of the hypotenuse to the short side in excess of 6.0. Thom (*2*) has surveyed a large number of the megalithic sites in Britain. While many of the sites display the use of Pythagorean triangles, there is not a single example of one with a ratio of hypotenuse to shortest side as great as 3.6.

Further, taking the plan of the crypt printed by Borst and using the inner columns, one finds this ratio of hypotenuse to short side to be about 36. Yet the same ratio for the outer walls is about 21. If we look at the plan of Trinity chapel printed by Clapham (*3*) we obtain for these ratios 38 and 12, respectively. If the plan of the chapel were based on a Woodhenge-type oval, the same triangle would be used throughout. It is also clear that published plans vary, and one would be hard pressed to say which, if any, is sufficiently accurate for the purpose at hand.

Concerning the pillars *p*, *p* in Fig. 1, Borst incorrectly states that (i) they serve no structural purpose, and (ii) they were placed there by William the Englishman about 1180 or 1181. He also believes that their position was dictated by and served only to accent the geometry of the new Trinity chapel. On the contrary, they are very necessary because they support a pair of the main columns in the constricted end of the choir above—a function to which the vault of the aisle of the crypt would be unequal (*4*, p. 62). They were surely in place before these columns, which were erected in the 4th year of the construction (1178) by William of Sens. Their position is dictated by the position of the columns in the choir. According to Gervase the Monk (*4*, pp. 57–58), these columns in the choir are placed so that the aisles maintain a satisfactory width while passing the towers and so that the choir could be smoothly joined to the somewhat narrower chapel.

Betelgeuse was chosen by Borst as the star whose rising point is marked by the alignments in the cathedral ". . . because its declination was −6° in 2300 B.C.; −4° in 1900 B.C.; and −2° in 1500 B.C.; . . ." However, Hawkins (*5*) lists the declination of Betelgeuse as having these values at considerably different dates. Graphic interpretation of the values tabulated gives the declination as −6° at 2690 B.C., −4° at 2280 B.C., and −2° at 1845 B.C. The date 2690 B.C. is six centuries earlier than the oldest megalithic site containing stellar alignments listed by Thom (*2*), if we accept Thom's technique of dating by the indicated declination of stars. Also, there doesn't seem to be any evidence for megalithic man being interested in the rising of Betelgeuse. In Thom's book (*2*), table 8.1 lists those alignments that

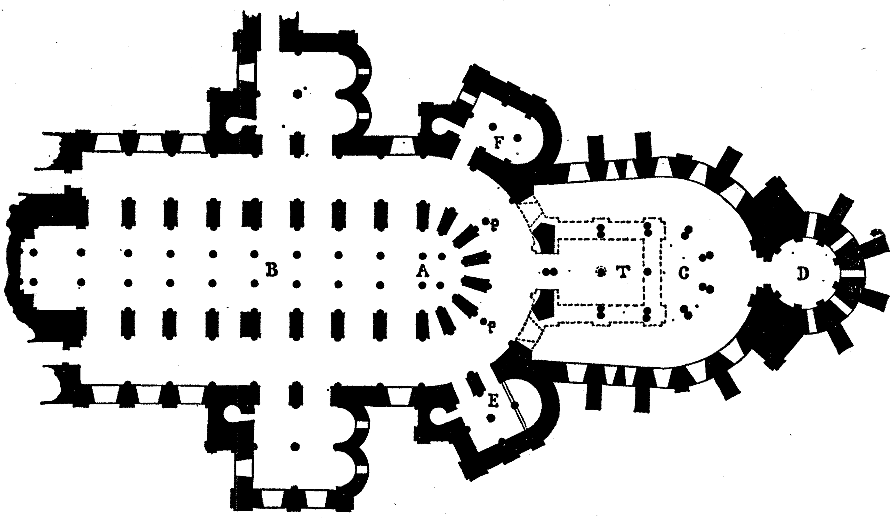

Fig. 1. A simplified plan of the crypt of Canterbury Cathedral about A.D. 1200 based largely on a plan published by Dunkin (*4*). The dotted portion indicates the position of the crypt under the old Trinity chapel based on a plan published by Withers (*11*) which is attributed to Willis. Later modification and adjacent structures have been omitted. All asymmetry and skewness has been deliberately suppressed, and some parts are conjectural. East is to the right. The western portion is referred to as Ernulf's crypt and the eastern portion as the crypt of William the Englishman. In the crypt: (*A*) position of the altar of Our Lady Undercroft, (*B*) Ernulf's crypt, (*C*) William the Englishman's crypt, (*D*) crypt under the Corona, (*E*) St. Gabriel's chapel, (*F*) Holy Innocents' chapel, (*p, p*) columns installed by William of Sens while rebuilding the choir above, (*T*) location of the tomb of St. Thomas from 1170 until 1220. Above the crypt: (*A*) location of the high altar, (*B*) choir and presbytery, (*C*) Trinity chapel, (*D*) Corona, (*E*) chapel and tower of St. Anselm, (*F*) chapel and tower of St. Andrew, (*T*) location of shrine of St. Thomas from 1220 until 1538.

he believes contain solar, lunar, or stellar associations. He does not attribute a single line to Betelgeuse.

The azimuth of none of the three parts of the cathedral (nave, choir, or Trinity chapel) is given by Borst. The plan published in his report indicates that the nave axis lies about E 6.5°S. Fletcher (*6*) shows a plan in which the nave axis lies about E 11°S. These are the only plans I have located which indicate the orientation of the church. Borst does give the difference between the axes of the nave and choir and between those of the choir and the Trinity chapel, both being about 2°. He also states that ". . . the axis of the Trinity chapel points toward the rising point of a star of declination $-6°$; the axis of the choir, $-4°$; and the nave, $-2°$." For azimuths differing by 2° to indicate the rising points of stars differing by 2° in declination would require, at the latitude of Canterbury, an unusual horizon, one worthy of comment. Further, a check of an Ordnance Survey map of the region (topographical, scale of 1 : 63,360) shows no such unusual horizon—it is nearly flat. It seems useless to discuss at what celestial objects the parts of the cathedral point until it is accurately established in what directions they point and the elevation of the horizon at each azimuth.

Where does Trinity chapel get its unusual horseshoe shape if not from a megalithic, Woodhenge-type oval? Perhaps from Norwich Cathedral which was constructed between 1096 and 1145 with a horseshoe-shaped chapel at its eastern end (*3*, *7*). Examination of the plan indicates that the proportions of Trinity chapel, Canterbury, are closer to those of the chapel at Norwich than to those of Woodhenge. At the very least, the chapel at Norwich shows that builders in the 12th century used such geometry in plans and probably did so without inspiration from megalithic monuments.

An alternate explanation of the skewness of the Trinity chapel to the choir is more tenable. The plan of the crypt given by Borst (*1*) shows the entire eastern part of Ernulf's crypt to be skew relative to the main part of the crypt. Gervase (*4*, p. 57) states that the towers of St. Anselm and St. Andrews were originally built skew. It seems reasonable to suppose that the old Trinity chapel was also placed skew. The new Trinity chapel would then be placed skew for several reasons.

1) This would place the center of the new chapel and the planned resting place of the future shrine of St. Thomas directly over his tomb in the old crypt—a place which had already become perhaps the most sacred place in England.

2) The position of the new crypt would most likely be determined from measurements taken from the exterior of the old Trinity chapel and the two towers, not from the axis of the major part of Ernulf's crypt. To establish and use the axis of Ernulf's crypt would have been difficult because of the still-standing and intervening old Trinity chapel and the eastern wall of the crypt (*8*).

3) The old foundation may have been used in the new chapel.

The axis of the new choir was constrained to follow the axis and skewness of the old for two reasons. First, the community of monks wished to preserve the undamaged parts of the cathedral, and the builder had to align his work within the limits this imposed. Second, if the new plan departed very much from the old plan either the pillars in the crypt would have had to be replaced or many additional ones would have had to be installed, increasing the cost, labor, and construction time. As it was, only two additional pillars were required in the crypt.

So we are left with explaining why the axis of Ernulf's crypt deviates from the axis of the nave and why its eastern end is skew. The simplest explanation would be that they resulted from an error by the builder. Fletcher (*6*) gives the plans of 31 English cathedrals. Of these, about 17 display detectable asymmetries or skewness, and 11 contain moderately large errors. It would seem that errors were common. Babington (*9*) comments on an apparently insufficient supply of masons which was a result of building activity in England at the time so that much 11th century work bears the marks of unskilled labor. The counterargument that the builders were capable of greater precision is invalid. One's best effort is rarely one's average effort. Such errors are common even now. The axis of the nave of Washington Cathedral, Washington, D.C., deviates from the axis of the choir by about 2° (*10*), and there is no question of a 20th century engineer's ability to lay out a straight line.

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21 April 1969

The identification of Canterbury Cathedral as successor to a henge monument has been confirmed by a second trip to Canterbury. My earlier analysis (*1*) was based upon published plans and descriptions, in which it is difficult to know what peculiarities of a plan are drafting errors and what values may be relied upon. For example, the azimuth of the nave varies by as much as 5° from one plan to another. At Canterbury, the clerk of the works, Mr. Doughty, provided large-scale surveys which related the Cathedral to the Ordinance Survey grid. On these surveys the amplitude of the nave was 5° south of east, giving an azimuth of 95°. The East Kent grid at the position of the Cathedral is 2°24′ east of true north, thus the true azimuth is 97½°. Large-scale plans of the Cathedral show an angle between nave and choir of 1°40′.

Through the courtesy of Rev. Brasier, chief verger, the crypt was made available for careful measurement, and the following results were obtained. Columns and walls of Ernulf's crypt are straight and parallel to 2.54 cm (1 inch) with the exception of the west end of the north wall. This is bowed outward 10.3 cm. The columns in the semicircle are symmetrically spaced about the center line. The center of the Corona is on the center line of the crypt of William the Englishman within 2.54 cm. The intersection of the center lines of the two crypts occurs at the center of the base of the triangle defining the crypt of William the Englishman (and Trinity chapel above). The angle is 1°35′. The choir above Ernulf's crypt has the appearance of slightly converging walls. The embellishment is such, however, that no reliable measurements may be made.

The distances between the bases of the double pillars in the crypt of William the Englishman were carefully measured, from west to east, at 6.95 m and 7.45 m. The two pairs of pillars are spaced a distance of 6 megalithic yards along the center line. (One megalithic yard is equal to 2.72 feet or 0.829 m.) The eastern pair are 1 megalithic yard from the major center of the Woodhenge oval. The center of curvature is then at a distance of 82 megalithic yards as compared to the predicted distance of $72 + 6$ or 78 megalithic yards.

The columns designated *p, p* in the earlier report are cylindrical and were added after Ernulf's crypt was completed. The earlier choir had burned, but the undamaged crypt was used to support the new choir. At the time the church was extended into the monk's cemetery (*2*) to form Trinity chapel and Corona, extensive reinforcing was done. To withstand the load of the arch between choir and chapel, the free-standing columns were doubled in area. Additional reinforcing arches were added at each side. These modifications are easily identified in the masonry. Comparison of crypt and choir is made difficult by the lack of symmetry in the choir. To determine the exact relation between columns in choir and crypt, measurements must be taken from points which are unambiguous at both levels. The distance from the center of the Corona to columns *p, p* is 31 m. They are 11 m between centers. In the choir above, a pair of double columns stands 32 m from the Corona, and massive columns stand at 27.1 m and 37.2 m. The columns *p, p* support the double columns, although they are not quite centered. The columns *p, p* are, however, accurately positioned on the Woodhenge oval, whose major radius is 12 megalithic yards. They are 1.1 m in diameter as compared to the posts at the henge monument (carbon dated 2490 ± 150 years B.C.) near Arminghall, Norfolk, of 0.9 m diameter (*3*).

The column bases are roughly square, having two parallel sides, but the other sides are curved, one being convex, and the other, concave. The sagitta of the 1.2-m arc is approximately 2.54 cm. The center of curvature is therefore at a distance of 9 megalithic yards. If these bases were part of an earlier structure and retained their original positions, they should have a radius of 10¼ megalithic yards. The concave edges now face each other and are roughly parallel. No justification is to be found in the existing structure. Mineralogical examination would reveal whether the base and column were of the same stone or whether the bases were perhaps from a previous structure.

These observations in the field are not in conflict with the previous suggestion that columns *p, p* preserve positions in a former sanctuary. These columns are analogous to the blue stones at Stonehenge or to the post holes at Woodhenge, the Sanctuary, and Arminghall.

The new data permit better determination of the declination of the celestial object rising above the horizon in line with nave, choir, and Trinity chapel. The elevation of the horizon is 1.5°, so that for Trinity chapel the declination is −5°40′. The rate of change of declination with azimuth for a level horizon is 0.62, so that for a star near the equinox the rate of change of azimuth is 0.9° per century.

Brancazio (*4*) suggests that Bellatrix would be a more appropriate choice than Betelgeuse. It is the first star of the constellation Orion to rise and is therefore its harbinger. The date for Betelgeuse is 2500 B.C., whereas for Bellatrix it is 1900 B.C. and, therefore, nearly contemporary with Woodhenge. The axis of Ernulf's Crypt was established 150 years later, and the nave was established 150 years after that.

More than 40 churches, mosques, and temples have been identified, from Norway to Egypt, all laid out in megalithic yards at 0.829 to 0.840 m. The same Pythagorean triangles recur in various combinations.

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25 July 1969